An Innovative Technology-based Intervention to Address Childhood Obesity

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Statement of originality

I hereby certify that the work embodied in the thesis is my own work, conducted under normal supervision. The thesis contains no material which has been accepted, or is being examined, for the award of any other degree or diploma in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made. I give consent to the final version of my thesis being made available worldwide when deposited in the University's Digital Repository, subject to the provisions of the Copyright Act 1968 and any approved embargo.

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Thesis by publication

I hereby certify that this thesis is in the form of a series of papers. I have included as part of the thesis a written declaration from each co-author, endorsed in writing by the Faculty Assistant Dean (Research Training), attesting to my contribution to any jointly authored papers.

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Author’s notes

People’s first language for Obesity

Person-first language is the standard for respectfully addressing people with chronic conditions. Person-first language is used throughout the thesis when discussing individuals with overweight or obesity. For example, person-first language requires that the young people discussed herein are never described as “overweight children” or “obese children”, but rather “children with overweight” or “children with obesity”.

Thesis navigation using cross-references

To facilitate navigation of this thesis, cross-referencing feature was applied when referring to chapters, sections, tables, figures and appendices throughout the thesis. Keyboard controls listed below can be used to navigate to cross-referenced content and return to previously viewed position within the PDF document.

Functions	**Keyboard controls**
Go to a cross-referenced content	Left click (mouse)
Return to previously viewed position	Hold down Alt + Left arrow

Publications arising from this thesis

My thesis is presented with the inclusion of 6 peer-reviewed manuscripts and 1 policy brief report. My thesis comprises of five of these manuscripts (Chapters 2 to 6) and the remaining one manuscript (protocol paper) is included in the Appendices. I am the lead author on all manuscripts and the report.

Manuscripts in peer-reviewed journals: Published

Chai LK, Burrows T, May C, Brain K, Wong See D, Collins C. Effectiveness of family-based weight management interventions in childhood obesity: an umbrella review protocol. *JBI Database System Rev Implement Rep*. 2016;14(9):32-9.

Chai LK, Collins C, May C, Brain K, Wong See D, Burrows T. The effectiveness of weight management interventions for families of children with overweight or obesity: an Umbrella Review. *JBI Database System Rev Implement Rep*. 2019. doi: 10.11124/JBISRIR-2017-003695

Chai LK, May C, Collins CE, Burrows TL. Development of text messages targeting healthy eating for children in the context of parenting partnerships. *Nutr Diet*. 2019 Nov;**76**(5):515-520. doi: 10.1111/1747-0080.12498

Chai LK, Collins CE, May C, Ashman A, Holder C, Brown LJ, Burrows TL. Feasibility and efficacy of a web-based family telehealth nutrition intervention to improve child weight status and dietary intake: a pilot randomised controlled trial. *J Telemed Telecare*. 2019 Jul 31:1357633X19865855. doi: 10.1177/1357633X19865855.

Chai LK, Collins CE, May C, Brown LJ, Ashman A, Burrows TL. Fidelity and acceptability of a family-focused technology-based telehealth nutrition intervention for child weight management. *J Telemed Telecare.* 2019 Aug 7:1357633X19864819. doi: 10.1177/1357633X19864819

Chai LK, Collins CE, May C, Holder C, Burrows TL. Accuracy of parent-reported child height and weight and calculated body mass index compared to objectively measured anthropometrics. *J Med Internet Res.* 2019 Sep 16;21(9):e12532. doi: 10.2196/12532.

Presentations arising from this thesis

During my candidature, I presented results arising from my thesis at 2 national and 4 international conferences. This resulted in 3 oral and 3 poster presentations.

Conference abstracts: Published in conference proceedings

1. **Chai LK**, Collins C, May C, Holder C, Burrows T. Are parents accurate reporters of their child's height, weight, and calculated Body Mass Index? And does their accuracy change between pre- and post-intervention? *International Society of Behavioral Nutrition and Physical Activity Conference, Prague, Czech Republic, 4-7 June 2019.* [Poster presentation]
2. **Chai LK**, Collins C, May C, Ashman A, Holder C, Brown L, Burrows T. An online telehealth nutrition intervention to support parents in child weight management - a randomised feasibility controlled trial. *26th European Congress on Obesity, Glasgow, Scotland, 28 April - 1 May 2019*. [Poster presentation]
3. **Chai LK**, May C, Collins C, Burrows T. Development of text messages with a focus on healthy eating that target both mothers and fathers. *Dietitians Association of Australia 35th National Conference, Sydney, Australia, 17-19 May 2018*. [Oral presentation]
4. **Chai LK**, Collins C, May C, Burrows T. A randomised controlled pilot study of a tailored web-based nutrition intervention to support parents in child weight management. *International Society of Behavioral Nutrition and Physical Activity Conference, Hong Kong, China, 3-6 June 2018*. [Oral presentation]
5. **Chai LK**, Burrows T, May C, Brain K, Wong See D, Collins C. Effectiveness of family-based weight management interventions in childhood obesity: an umbrella review (systematic review of reviews). *Dietitians Association of Australia 34th National Conference, Tasmania, Australia, 18-20 May 2017*. [Oral presentation]
6. **Chai LK**, Burrows T, May C, Brain K, Wong See D, Collins C. Effectiveness of Family-based Childhood Obesity Interventions with Parental Involvement: An Umbrella Review. *International Society of Behavioral Nutrition and Physical Activity Conference, Victoria, Canada, 7-10 June 2017*. [Poster presentation]

Additional publications co-authored during candidature

During my candidature, I worked as a Research Assistant at the University of Newcastle and contributed to 4 additional publications. The publications are consistent with my research focus, however they sit aside from the research included within this thesis and were therefore not included. Details of the additional publications to which I contributed are listed below.

Additional manuscripts in peer-reviewed journals: Published

1. Burrows T, Hutchesson M, **Chai LK**, Rollo M, Skinner G, Collins C. Nutrition Interventions for Prevention and Management of Childhood Obesity: What Do Parents Want from an eHealth Program? *Nutrients* 2015, 7(12):10469-10479. doi:10.3390/nu7125546.
2. Yoong SL, **Chai LK**, Williams CM, Finch M, Wiggers J, Wolfenden L. A systematic review of the impact of interventions involving a sleep component on child body mass index, diet and physical activity. *Obesity* 2016, 24(5):1140-7. doi: 10.1002/oby.21459.
3. May C, **Chai LK**, Burrows T. Parent, partner, co-parent or partnership? The need for clarity as family systems thinking takes hold in the quest to motivate behavioural change. *Children* 2017, 4(4), 29.
4. Brain K, Burrows T, Rollo M, **Chai LK**, Hayes C, Hodson F, Collins C. A systematic review and meta-analysis of nutrition interventions for chronic non-cancer pain. *J Hum Nutr Diet* 2018. doi: 10.1111/jhn.12601

Awards received during candidature

During my candidature, I was supported by 4 scholarships to cover tuition fees and living expenses, 2 travel grants for international conference attendance, and 1 pilot grant for my PhD project. I also received 4 awards which recognise my contribution in the field of nutrition research and innovation.

Scholarships

University of Newcastle International Postgraduate Research Scholarship 2015

University of Newcastle Research Scholarship (Central) 2015

The Barker PhD Award Top Up Scholarship 2016

Emlyn and Jennie Thomas Postgraduate Medical Research Top Up Scholarship 2017

Travel/Project grants

Faculty of Health and Medicine Strategic ECR Pilot Project Grant 2016

Dietitians Association of Australia's ICD LEAP Travel Grant 2018

Jennie Thomas Travel Grant 2019

Awards

Dietitians Association of Australia's Emerging Researcher Award 2016

University of Newcastle Best Higher Degree Research Confirmation Award 2016

Priority Research Centre in Physical Activity & Nutrition Innovation Award 2018 - *Development of text messages targeting healthy eating for children in the context of parenting partnerships*

Priority Research Centre in Physical Activity & Nutrition Best Paper Award 2019 - *Accuracy of parent-reported child height and weight and calculated body mass index compared to objectively measured anthropometrics*

Glossary of terms and abbreviations

ABS	Australian Bureau of Statistics
ADG	Australian Dietary Guidelines
AES	Australia Eating Survey
APD	Accredited Practising Dietitian
B2BF	Back2basics Family
BCW	Behaviour Change Wheel
BMI	Body mass index
CCC	Concordance correlation coefficient
CDC	Centers for Disease Control and Prevention
COM-B	Capability, opportunity, motivation for behaviour
EDNP	Energy-dense nutrient-poor
FFQ	Food frequency questionnaire
GRADE	Grading of Recommendations Assessment, Development, and Evaluation
IOTF	International Obesity Task Force
IVR	Interactive voice response
MM	Modified Monash
NSW	New South Wales
PAL	Physical activity level
QOE	GRADE quality of evidence
RCT	Randomised controlled trials
SES	Socioeconomic status
SMS	Short message service (mobile text messaging)
SR	Systematic review
T2DM	Type 2 diabetes mellitus
TDF	Theoretical Domains Framework
WHO	World Health Organization
zBMI	Body mass index z-scores

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Abstract

Childhood overweight and obesity currently impacts one in four children aged 5-17 years in Australia. Compared to peers with a healthy weight, children with overweight and obesity commonly experience bullying or teasing at school, have poorer mental health, including depression, anxiety, and in some cases disordered eating, exacerbated by weight bias and stigma. These children also have greater risk of having myocardial infarction and stroke in adulthood, and are at elevated risk for developing type 2 diabetes mellitus (T2DM). Given 90% of cases of T2DM are preventable through healthy lifestyle interventions that incorporate improvements in dietary patterns and physical activity levels, accessible programs are needed.

Current Australian public health services for personalised child overweight and obesity treatment have limited geographical reach. Given the prevalence of childhood obesity, Australian public health services need more timely and cost-effective methods to efficiently address high levels of demand for personalised child weight management consultation, advice and support. This is particularly crucial to those who have difficulty accessing currently available services. One of the challenges in the field is translating research findings into evidence-based public health and clinical practice in partnership with health services in order to actively disseminate them and with wide uptake. My thesis presents a series of research studies that aimed to develop and evaluate the feasibility and acceptability of a novel technology-based intervention that was developed alongside current services in New South Wales (NSW) and that has the potential to be translated into health services widely in Australia to support families in improving child weight status and dietary outcomes.

Firstly, an umbrella review was conducted in order to synthesise the existing evidence from systematic reviews and meta-analyses of experimental studies on the effectiveness of family-based behavioural weight management interventions for children with overweight or obesity. The umbrella review included 14 systematic reviews, consisting of 47 independent trials which were rated as being of low to moderate methodological quality. The review highlights that family-based interventions targeting parents, alone or with their child, are effective for child weight management. Five reviews highlighted that parent-only interventions have similar (n=4) or greater (n=1) effectiveness compared to parent-child interventions. However, there was a lack of high quality evidence, especially in the emerging parent-only interventions area. Effective interventions employed parent-targeted strategies, including nutrition and physical activity education sessions, positive parenting skills, role modelling, and child behaviour management to encourage positive healthy eating/exercise behaviours in children and/or whole family.

The second study presented in my thesis reports the development of a set of evidence-based text messages, targeted to mothers and fathers, which is complementary to a family-focused nutrition intervention and guided by the Theoretical Domain Framework and COM-B model of behaviour change. The study fills a gap to address the lack of reporting in existing research as to how text message interventions were developed and whether the text messages content was endorsed by the intended recipients. The study used a systematic process in developing text messages which were grounded in behaviour change theory and research evidence concerning the importance of the relationship that parents share in raising children, the parenting partnership. The study used a co-design approach to develop the text messages by involving key stakeholders and end-users (i.e. parents, dietitians, researchers) who reviewed and provided feedback on the clarity, usefulness, and relevance of a total of 97 messages from the initial draft. A final set of 48 messages (36 messages targeting both parents, six messages targeting fathers and six messages targeting mothers) were selected for use within a lifestyle intervention to support parents in improving the dietary behaviours of their children. The set contained a combination of messages which can be implemented in combination with additional behavioural interventions to prompt parents on healthy eating within the family while simultaneously leveraging the influence of parenting partnerships to support lifestyle change.

The third study applied findings from the umbrella review and the text message development study into an innovative family-focused online telehealth nutrition intervention. The study aimed to test the feasibility and acceptability of the novel intervention in improving child weight status and dietary intake, and the impact of the addition of evidence-based text messages targeted to mothers and fathers. Findings from the 12-week pilot study demonstrated that a tailored family-focused online telehealth nutrition intervention was highly feasible and acceptable among families with children aged four to 11 years. Children in the intervention groups had significantly improved dietary intakes at week 12 (reduced energy intake from energy-dense nutrient-poor foods, and increased energy intake from healthy core foods) compared to control group. However, change in weight outcomes were not significantly different within or between groups. The study being a feasibility and pilot trial, which was underpowered, had insufficient sensitivity to detect statistically significant between-group differences in child weight outcomes. A sample size of 104 children per group was recommended to be able to detect two unit of difference in BMI at 80% power based on post hoc sample size calculation.

A process evaluation of the pilot study was conducted to evaluate intervention fidelity in accordance with the National Institutes of Health Treatment Fidelity Framework. Results demonstrated that an online telehealth intervention delivered by trained Accredited Practising Dietitians (APDs) had good adherence with ≥83% of planned content delivered as intended.

Results also indicated that parents who completed the program found the telehealth intervention convenient and easy to use and would recommend telehealth to other parents. Overall, a technology-based child nutrition and weight management intervention using telehealth, website, Facebook and SMS can be delivered by trained APDs with good fidelity and attain high acceptability and satisfaction among families with children aged four to 11 years in NSW, Australia.

The final study was a secondary analysis of data to assess the level of agreement between parent-reported child height, weight, and researcher-calculated BMI compared to the same data objectively measured by trained researchers. The study used Lin's concordance correlation coefficient, which is superior to Pearson's correlation coefficients which only measures the correlation between two data variables, but not how close or far the data fall from the line representing perfect agreement. This is a unique component of my thesis because for researchers and clinicians to have confidence in the integrity of eHealth interventions, knowing whether parent-reported measures online are valid is critical to interpreting data on health measures collected via online means. It is also essential to understand the nature of bias within parent-reported data to allow for adjustment in eHealth research ahead of translation to practice settings. Results demonstrated that parents under-reported child height and weight among a group of children aged four to 11 years, and were generally more accurate in reporting child weight compared to height. The under-reporting of child height and weight in the study resulted in poor agreement between the BMI calculated by researcher using parent-reported and researcher-measured data. However, the weight category (i.e. underweight, healthy weight, overweight, obesity) derived from parent-reported data of the majority of children were in agreement with researcher-measured data. Therefore, online parent-reported child height and weight may be a valid method of collecting child weight category information ahead of participation in a web-based program.

The results presented in my thesis demonstrate that personalised technology-based child weight management intervention has high feasibility and acceptability among families with children aged four to 11 years. This novel intervention, underpinned by findings from an umbrella review and a text message development study, has the potential to be translated more broadly to other health services and scaled up to complement existing weight management services in Australia. The results, in addition to findings reported in manuscripts, were collated into a policy brief to communicate the major findings from this trial to key stakeholders and policy developers and to highlight key implications to the wider health services in Australia. This policy document was written in collaboration with representatives from the NSW Office Preventive Health and Children's Health Queensland Hospital and Health Service. The innovative eHealth approach was complemented by promising results showing

that online parent-reported child height and weight were relatively reliable for deriving the weight category of the child. Health practitioners can work with parents as the agents of change and focus on fostering positive parenting skills, such as monitoring, reinforcement, role modelling, and providing a nurturing environment, in order to support health behaviours in their children. Given children with obesity may experience a range of health complications and co-morbidities that reduce their quality of life and adversely impact their health and wellbeing, the results presented in my thesis provide both clinical practice and research recommendations for child weight management using technology-based nutrition interventions, and have implications for parents, clinicians, health research and policy.

Chapter 1: Background and literature review

This chapter provides background information on childhood obesity (Section 1.1) and a literature review on management of childhood obesity (Section 1.2) based on existing research and health practices. This chapter also highlights gaps in evidence and practice (Section 1.5) which underpin the rationale for my overarching research question and thesis aims (Section 1.6). My thesis structure presented in Section 1.7 provides a complete explanatory overview that links the publications that have been generated from this research and places them in the context of this thesis and current literature.

1.1 Overweight and obesity in children

The global epidemic of childhood obesity is of major public health concern.[1] In 2019, The Lancet published a commission report on the global syndemic, or synergy of epidemics, of obesity, undernutrition, and climate change because they co-occur in time and place, interact with each other to produce complex sequelae, and share common underlying societal drivers. The Lancet report also highlighted that no country to date has successfully reversed the obesity epidemic despite that many evidence-based policy recommendations to end obesity have been available for decades.[2]

1.1.1 Prevalence and disease burden

The world's prevalence of obesity in children and adolescents aged five to 19 years has increased more than tenfold over the past four decades, from <1% (11 million) in 1975 to nearly 6% in girls (50 million) and nearly 8% in boys (74 million) in 2016.[3, 4] An additional 213 million children and adolescents have overweight but not obesity in 2016.[3] The World Health Organization (WHO) estimated that over 340 million children and adolescents aged five to 19 years and 41 million young children under the age of five years across the world have overweight or obesity in 2016.[5] The prevalence has doubled since the International Obesity Task Force (IOTF) previous estimates in the year 2000 when 155 million children aged five to 17 years were reported to have overweight or obesity.[6, 7] Australia has one of the highest prevalence of childhood and adolescent obesity[4] with national data indicating that one in four (27%) children and adolescents aged five to 17 years had overweight (20%) or obesity (7%) in 2015.[8] Almost one quarter (25%) of children aged five to 17 years have overweight (17%) or obesity (8%) in 2017-18.[9] The rates for boys and girls were similar and have remained stable over the past ten years, however, the high rates remain a concern.[9] The Population Health Survey of New South Wales, the most populated state in Australia, reported that 21% children aged five to 16 years in New South Wales have overweight or obesity in 2017.[10]

The growing prevalence of obesity threatens to shorten life expectancy in many countries, including the United States, and bankrupt the health care system.[11] The 2017 Global Burden of Disease analysis indicated that the rates of high body mass index (BMI) between 2007 and 2017 increased by 37%, and accounted for almost five million deaths and 148 million disability-adjusted life-years globally in 2017.[12] The 2016 Australia Burden of Disease Study reported that high BMI related to overweight and obesity was the second highest contributor to the National disease burden in 2011.[13] In the same year, overweight and obesity accounted for 7% of the total burden of disease, 53% of the burden of type 2 diabetes mellitus (T2DM), 45% of the burden of osteoarthritis, and 38% of the burden of cardiovascular disease (27% in coronary heart disease and 10% in stroke) among Australians.[8, 13] Furthermore, the issue of overweight and obesity has major economic implications. In 2015, nearly 125 000 procedures related to weight loss surgery were billed to Medicare, a government scheme that gives Australian residents access to healthcare.[8] These Medicare-billed procedures costed almost $63 million overall; about $26 million paid by Medicare in reimbursements and about $37 million paid by patients and/or health insurers.[8] An estimation from Access Economics indicated that the total cost of obesity in 2008 was $58 billion, comprising $50 billion in lost wellbeing and $8 billion in financial costs, such as lost productivity, health care and carer costs.[14] While these estimates have included adults and children, it is important to note that without a successful intervention children with obesity are likely to continute to have obesity into adulthood.[8] The current trend for, and increasing prevalence of, childhood obesity indicates that these costs will continue to rise into the foreseeable future.[8]

1.1.2 Definitions

The WHO defined overweight and obesity as “abnormal or excessive fat accumulation that may impair health”.[5] The most common method of assessing overweight and obesity is by calculating a person’s BMI using the standard formula: weight (kg)/height (m^2).The WHO BMI reference is an internationally recognised measure which has been used in clinical practice and research to assess weight status of adults based on standard reference range presented in Table 1-1.

Table 1-1 *World Health Organization Body Mass Index reference for adult weight statuses*

Weight status	BMI reference range (kg/m^2)
Underweight	<18.5
Healthy weight	18.5 - 24.9
Overweight	25.0 - 29.9
Obesity	≥30

Adapted from World Health Organization.[15]

Unlike adults where a single BMI reference can be applied across all ages, interpretation for overweight and obesity in children depends on age, sex and stage of growth. Thus, several standards are available to assess weight status of children, including WHO Child Growth Standards,[5, 16] United States Centers for Disease Control and Prevention (CDC) Growth Charts,[17, 18] and IOTF child cut-offs.[19] The WHO Child Growth Standards were developed based on the growth of 8440 healthy breastfed infants and young children from Brazil, Ghana, India, Norway, Oman and United States, representing widely diverse ethnic backgrounds and cultural settings. The CDC charts are based on a snapshot of children's weights and heights in the United States. These standards assess weight status of children based on different reference ranges presented in Table 1-2.

Table 1-2 *Growth charts reference for child weight statuses*

Weight status	WHO Child Growth Standards	CDC Growth Charts	IOTF child cut-offs (kg/m^2)
Overweight	BMI-for-age >1 SD	≥85th percentile	BMI ≥25 at age 18 years
Obesity	BMI-for-age >2 SD	≥95th percentile	BMI ≥30 at age 18 years

WHO: World Health Organization; CDC: United States Centers for Disease Control and Prevention; IOTF: International Obesity Task Force; SD: standard deviation above the WHO Growth Reference median. Adapted from WHO,[5, 16] CDC,[17, 18] and IOTF.[19]

The IOTF child cut-offs were developed using Cole's LMS method to derive age- and sex-specific BMI ranges for children that correspond to a given BMI value (e.g. 25 kg/m^2) at age 18 years.[19] The IOTF child cut-offs reference population were children and adolescents aged 2 to 18 years from Brazil, Netherlands, Singapore, Hong Kong, United Kingdom and United States.[19] Given that the IOTF child cut-offs were based on pooled international data and corresponded to adult BMI cut-offs for overweight and obesity, it has been widely used in research to allow study comparison in research to allow study comparison between countries.[19] Across this thesis, overweight and obesity in children are defined using the IOTF child cut-offs presented in Appendix 1.

1.1.3 Health consequences

Childhood obesity has been acknowledged by the WHO and the Australian Government as a public health priority for the prevention of noncommunicable diseases.[20, 21] Childhood obesity has been shown to track into adulthood and is associated with a greater risk of premature death and disability in adulthood.[5] Furthermore, children affected by overweight or obesity are more likely to experience breathing difficulties,[5] early markers of cardiovascular disease including elevated cholesterol and hypertension,[22-24] increased risk of fractures[5] and chronic health conditions including T2DM, insulin resistance and heart disease at a younger age into adulthood.[25-27] Compared to their peers with a healthy weight, children who had overweight or

obesity have a greater risk of developing preventable diseases, such as T2DM and heart disease, at a younger age.[28, 29] In addition, obesity carries a social stigma that adversely affect children and their families.[30] Overweight and obesity is one of the main reasons that children are bullied or teased at school.[31] Evidence indicates that weight-related discrimination was more prevalent in school than those related to disability, religion or ethnicity.[31] Among children with overweight or obesity, weight- or appearance-related teasing is frequent and upsetting.[32] A study of 156 children aged 10 to 14 years reported that teasing occurred more frequently (50% vs 30%) and was often weight-related (89% vs 31%) in children who have overweight or obesity compared to their peers.[32] Teasing usually involves disrespectful name calling by peers in general rather than by a specific peer, and the majority (57%) of children who have overweight or obesity found the experience moderately to extremely upsetting.[32] Moreover, child victims of bullying who have obesity may experience negative emotional consequences, academic failure, peer rejection,[31] and increased risk of depression and low self-esteem.[32] Many children who have overweight or obesity suffer from significant mental health issues including anxiety, depression, and eating disorders compared to their peers.[30] These children may experience a range of health issues and co-morbidities that reduce their quality of life.

1.1.4 Contributing factors

Obesity can develop from a range of factors, however, in many individuals the condition develops through a prolonged excessive energy imbalance with an energy intake through eating and drinking that exceeds an individual's energy expenditure through physical activity.[21] Overtime the excessive energy imbalance will lead to increased body weight due to accumulation of body fat to an extent which health and quality of life are likely to be affected.[33]

The aetiology and pathogenesis of overweight and obesity involve complex interactions between genetic makeup (non-modifiable factor) and behavioural aspects (modifiable factors). Energy imbalance may result from a range of contributors which may include: a person's appetite, satiety, metabolism, and body fat distribution which are influenced by their genetics and epigenetic changes, and are non-modifiable factors.[8] However, energy imbalance may also result from modifiable behaviours, including consuming energy-dense nutrient-poor (EDNP) foods and drinks, eating behaviours such as snacking, inadequate physical activity, and insufficient sleep.[21] Adoption of sedentary lifestyle combined with excess caloric consumption are examples of modifiable behaviours which may be influenced by social environmental factors, such as exposure to an obesogenic environment, influences from family and peers, and socioeconomic status (SES). Globally, increased food processing, distribution, marketing, fast-food chains, and larger food portion sizes have a major influence on childhood obesity.[34] Complex interactions between these factors complicate efforts to address the issue of overweight and obesity.

Furthermore, parents' attitudes, beliefs and dietary behaviours can influence their child's risk of developing overweight and obesity, especially for pre-adolescent children whose parents are the main gate keepers of food choices and provision.[35-37] Parental characteristics such as elevated BMI, alcohol consumption, smoking, and low SES and education level have been linked to overweight in their children.[38] Moreover, parents are the key mediator of the obesogenic environment within the family particularly for young children who consume most meals at home.[39] Most parents decide the type of foods that are available and how the food is prepared in the home.[40] Parents' decisions can have an impact on their children's food preferences which later are shaped into eating habits.[41, 42] Family meal times, if they occur, provide a potential opportunity for parents to model healthy food choices and appropriate food-related behaviours, while promoting a positive atmosphere around healthy eating for better diet quality.[40] For these reasons, parents are often targeted in intervention for management of overweight and obesity in children.

1.2 Management of childhood obesity

The WHO Commission on Ending Childhood Obesity called for all countries to remedy obesogenic environments and improve the treatment of children who have obesity.[43] In 2017, the Commission released the following six recommended key areas for actions to address childhood obesity:[43]

- Promote intake of healthy foods and reduce the intake of unhealthy foods and sugar-sweetened beverages
- Promote physical activity
- Preconception and pregnancy care
- Early childhood diet and physical activity
- Promote healthy school environments, health and nutrition literacy and physical activity for school-age children
- Provide family-based, multicomponent services on lifestyle weight management for children and young people with obesity

Effective behavioural intervention for childhood obesity should be family focused due to the influence that families have on dietary and physical activity habits in children.[44] Therefore, the below sections present current evidence on the management of childhood obesity in the context of family-based behavioural interventions (Section 1.2.1); diet (Section 1.2.2) and physical activity (Section 1.2.3); behaviour change theory (Section 1.2.4); and weight management services for children who have overweight and obesity in Australia (Section 1.2.5).

1.2.1 Family-based behavioural interventions

Family-based behavioural intervention is the recommended best practice for management of childhood obesity with energy imbalance attributed in part to an alternation in the proportion of EDNP foods versus nutrient-rich healthy core foods consumed.[41, 45, 46] Systematic reviews in both obesity prevention and treatment in children and adolescents have reported that family-based behavioural interventions, often with direct parental involvement (mainly for primary school aged children), improved child outcomes in weight, BMI and other measures of body fat composition.[37, 41, 47-52] These interventions generally targeted behaviour change for both the child and parent by focusing on gradual reductions in total energy intake and increases in moderate intensity physical activity.[53] Greater effectiveness was demonstrated in multicomponent interventions for child weight management in improving child metabolic and anthropometric measures,[54, 55] when compared to single component interventions focused on physical activity, diet, education, pharmacological, or surgical approach.[56] Interventions with higher intensity or greater parental involvement were usually more effective in improving child weight outcomes.[40, 50] Research has also indicated that effective behavioural interventions for child weight management were usually delivered by trained specialised interventionists.[57]

The importance of parental involvement in child weight management has been highlighted in reviews of the role of family members in childhood obesity interventions.[58, 59] However, current evidence of child weight management is heavily skewed towards maternal involvement in interventions as the majority of family-based interventions were participated by children and mothers only while fathers were generally underrepresented.[60-64] A systematic review seeking to evaluate father involvement in childhood obesity prevention trials found that only 6% of parents in studies that were limited to one parent participation were fathers (N=123).[64] While only 2% of included studies identified a lack of paternal participation as a potential limitation, 99% of included studies did not explicitly attempt to engage fathers.[64] The lack of paternal engagement in interventions is in contrast to home environments where evidence shows that fathers are often involved in feeding, cooking, shopping and determining food choices,[65] as well as other aspects of parenting that influence child health and wellbeing.[62] Paternal BMI has been reported to be more strongly linked to childhood obesity than maternal BMI.[66] A recent meta-analysis of parenting interventions reported that interventions which included both mothers and fathers resulted in more positive changes in child behaviour, such as compliance and cooperation, compared to those which included mothers only.[67] Evidence demonstrating the influence of both mothers and fathers on child health outcomes supports the rationale for increasing paternal participation and targeting both parents in family-based interventions.[68]

The parenting partnership (Figure 1-1) is defined as the relationship that parents share in the course of raising children and is often referred as ‘co-parenting’ in current literature. (Figure

1-1).[69-71] Children of parents with higher quality parenting partnerships are expected to have enhanced social and emotional skills including stronger impulse control.[72-74] This points to the importance of supporting parenting partnerships for optimising child and family outcomes. However, there are no reports of studies exploring the connection between the parenting partnership and childhood obesity, or the effect of interventions designed to work with the parenting partnership on childhood obesity. Understanding how parents work together in parenting practices related to child's eating behaviour and family food environment remains understudied in the area of childhood obesity. Moreover, existing evidence is limited to inform how mothers and/or fathers should be involved or targeted and their roles in childhood obesity intervention.[36, 41, 52] This gap will be discussed further in an umbrella review in Chapter 2 which aimed to explore whether parents-targeted childhood obesity interventions are effective, and if yes, how parents were involved or targeted in the interventions.

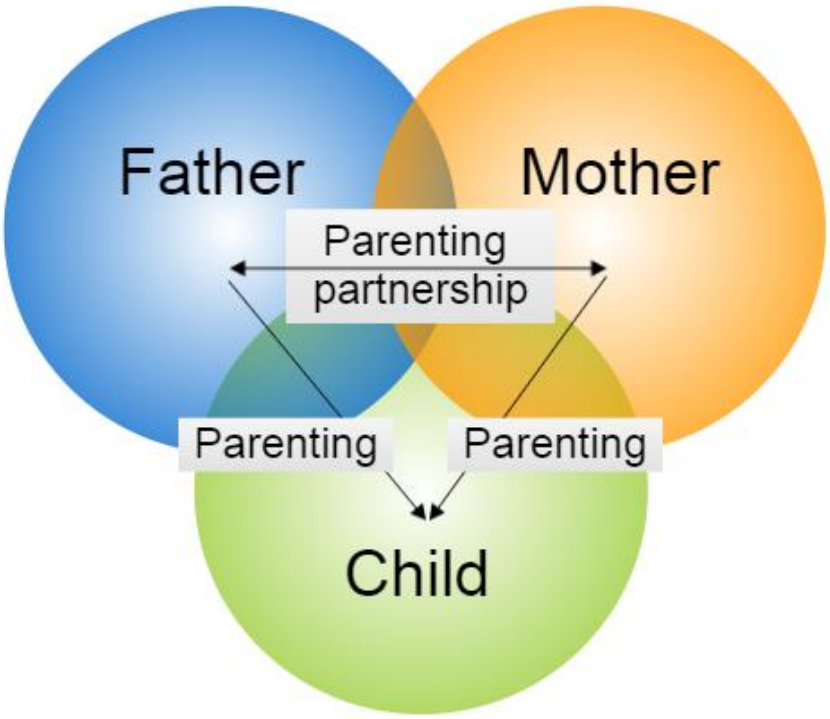


Figure 1-1 Parenting partnership is a dyadic relationship between parents

In recent decades, the family structure has changed with an increase in divorce, remarriage, and non-marital childbearing in Australia. Non-traditional family structure such as single-parent families, step and blended families, same-sex couples with children, and foster families, are becoming increasingly common.[75] The Australian Institute of Family Studies reported that 43% of children aged under 13 years were living in non-traditional families, with a single parent, a non-biological parent figure, step- or half-siblings, or a grandparent, in 2016.[76] A recent Australian Bureau of Statistics (ABS) report indicated that 19% of families with children aged under 15 years in 2017 were one parent families (16% were single mothers and 3% were

single fathers).[77] In 2012-13, among children aged 0-17 years who had a natural parent living elsewhere, 50% met with that parent at least once per fortnight (31% daily or weekly; 19% fortnightly; 6% monthly; 16% quarterly or yearly), and 27% stayed overnight with that parent (16% spent one to 35 nights; 11% spent at least 110 nights per year).[78]

Evidence suggests that the family structure or household type were associated with children's eating habits and adiposity outcomes. A study in 12350 children aged seven to nine years in eight European countries (Italy, Belgium, Cyprus, Estonia, Germany, Hungary, Spain and Sweden) found that family structure, referred to as the number and type of cohabiting adults or the number of siblings, is associated with the degree of adiposity in children.[79] The study found that having more siblings or living with both parents compared to grandparents were associated with lower BMI z-scores (zBMI). A different study in 3217 children aged 3-18 years found that family structure was associated with 'Fruits,' 'Milk and Dairy products' score and mean scores of food group scores.[80] Another study in 14493 children in kindergarten, third, and fifth grades found that family structure was associated with children's risk of obesity and recommended that health care providers should plan and monitor their care for children with overweight or obesity in the context of family circumstances.[81]

1.2.2 Dietary intake

In the effort to address overweight and obesity, the WHO recommended individuals to limit energy intake from total fats and sugars; increase consumption of fruit and vegetables, as well as legumes, whole grains and nuts.[5] These dietary recommendations are consistent with the Australian Dietary Guidelines (ADG) which encourage people to drink plenty of water and consume a variety of food from the five core food groups, which are (i) bread/cereals, mostly wholegrain and/or high fibre varieties; (ii) fruit; (iii) vegetables and legumes/beans; (iv) dairy products, such as reduced fat milk yoghurt, and cheese; and (v) lean meats/alternatives, such as poultry, fish, eggs, nuts, and legumes, with additional allowances for small amounts of EDNP foods.[82]

The ADG include age- and sex-specific recommendations on the minimum number of serves daily from each food group for healthy children and adults, to make sure they get the full amount of nutrients their body needs.[82] However, the latest Australian Health Survey 2017-18 showed that just 6% children aged 2-17 years met the ADG recommended number of serves of both fruit and vegetables.[9] Among children aged 2-17 years who consume sugar sweetened beverages, around 41% consume at least once a week, almost 31% consume one to three days per week, and 7% consume them daily.[9] The Australian Health Survey 2011-12 identified that in children aged 2-18 years, the average proportion of total daily energy intake derived from free sugars was 13%.[83] The major (81%) source of free sugars intake was from EDNP

foods and beverages, such as confectionary (9%), cakes/muffins (9%), soft drinks, electrolyte and energy drinks (19%), fruit and vegetable juices and drinks (13%) and cordial (5%).

A range of strategies have been implemented to improve child dietary behaviour for weight management and generally encourage reductions in energy intake through dietary modification.[84, 85] Systematic reviews reported that interventions which include diet therapy for children who had overweight or obesity have resulted in significant short-term weight loss.[84, 86] However, the reporting of dietary intervention components and post-intervention dietary outcomes have been shown in systematic reviews to be limited and inconsistent in existing studies; therefore, hindering the synthesis of which intervention strategies were more effective than the others.[84, 85, 87] One of the early dietary modification interventions, and most studied and widely adopted dietary interventions, was the Traffic Light Diet by Epstein et. al. dating back to the 1980s.[35] The behavioural intervention involved sorting food into three colour coded categories (i.e. green, yellow, red) based on their nutrient values, and set goals to swap red foods (>5g of fat per serving; e.g. EDNP foods such as, chips, cookies, pizza, and sweetened beverages) for green foods (<2g of fat per serving; e.g. fruit and vegetables) and yellow foods (between 2g and 5g of fat per serving and should be eaten in moderation; e.g. poultry, skim milk, pasta, and eggs).[88] Many behavioural interventions with a dietary focus have adapted similar strategies and generally aimed to increase fruit and vegetables intake and/or decrease EDNP foods consumption which has shown effectiveness in improving child weight and adiposity outcomes.[85, 89] A recent systematic review indicated that dietary interventions for child weight management which involved personalised dietary advice were more effective in long term maintenance of improved dietary outcomes compared to specific or general dietary advice strategies.[85]

1.2.3 Physical activity

The WHO[5] and Australia's Physical Activity and Sedentary Behaviour Guidelines for Children (five to 12 years)[90] both recommend that children should engage in regular physical activity for 60 minutes every day. Children are recommended to include a variety of aerobic activities, including some vigorous intensity activity, and engage in activities that strengthen muscle and bone on at least three days per week.[90] The recent Australian 24-Hour Movement Guidelines for the Early Years recommended that pre-schoolers aged two to five years should spend at least 60 minutes throughout the day in energetic play including; running, jumping, kicking, and throwing, and to limit screen time to no more than one hour per day.[90] A systematic review of family-based interventions targeting childhood overweight and obesity also suggested that children engage in 60 minutes of moderate to vigorously intense physical activity on most days of the week, and limit screen time (leisure television and computer use) to no more than two hours per day.[91] However, the Australian Health Survey 2017-18 identified that less than 2%

of children aged 15-17 years met the physical activity guidelines; 10% engaged in 60 minutes of exercise (excluding workplace physical activity) every day, and around 16% did strengthening or toning activities on at least three days over the previous week.[9]

1.2.4 Behaviour change model

Evidence suggests that behavioural interventions underpinned by theoretical frameworks are more likely to result in the desired behaviour change.[92] In the context of family-focused childhood obesity management, behavioural interventions were classified as those that aim to change parents' and/or children's weight related thinking patterns and actions, including dietary intake and physical activity, which subsequently determine a family's food and physical environment.[37] Evidence-based guidance on management of childhood obesity has consistently recommended the use of behaviour change strategies to tailor interventions to individual needs with family-based, age appropriate content.[58, 93, 94]

Family is a basic unit of society which involves social interaction between family members and inevitably gives an impact on one another.[80] Previous research on family systems has suggested that an ecological perspective should be taken on family systems, whereby the social and cultural layers that may influence children's social, emotional, and intellectual development are considered.[68] Evidence also points to the importance of family systems in determining children's weight related behaviour and weight related outcomes, as discussed previously in Section 1.2.1. From a dietary behaviour perspective, family is a proximal food environment and has an impact on child food choices, intake and preferences through mechanisms such as parent role modelling, social support, and social norms.[95] A systematic review on behaviour change techniques contained within physical activity and dietary mobile applications for children and adolescents found that modelling appropriate behaviour, prompting practice, and social support were the most effective behaviour change techniques for improving child and adolescent physical activity and dietary intake.[96] Evidence also supports the effectiveness of childhood obesity interventions that set goals for behaviour change, such as consuming five servings of fruits and vegetables each day and replacing sugar sweetened beverages with sugar-free beverages.[91]

Behaviour change is a complex process and behaviour change theories present a systematic way of understanding behaviours and the context in which they occur.[97] A systematic review of family-based behavioural interventions reported that the commonly used theories were Social Cognitive Theory, Transtheoretical Model of Behavioural Change, Theory of Planned Behaviour, Self Determination Theory, Cognitive Behavioural Theory, and Behavioural Determinants Model.[58] However, these behaviour change theories generally focus on intra-individual mechanisms (i.e. reflective cognitive processes) as opposed to wider social

environmental and inter-individual mechanisms (i.e. interpersonal influence between parent-child dyad, and interactions within family systems).[98] The limited capacity of these behaviour change theories in supporting behaviour change beyond intra-individual level can be addressed using the Theoretical Domains Framework (TDF) which is an overarching holistic theoretical framework comprises of 14 theoretical determinants of behaviour, such as 'Knowledge', 'Skills' and 'Emotion', derived from 33 behaviour change theories, and has been successfully used to identify important theoretical determinants of behaviour in a wide array of contexts.[102-104] The TDF can be integrated within a behaviour change model, which characterises behaviour change as the results of interactions between *Capability*, *Opportunity* and *Motivation* (the COM-B model),[99] and identify specific domains that are likely to be important in influencing target behaviours (Table 1-3).

Table 1-3 COM-B model and Theoretical Domain Framework

COM-B component	COM-B sub-component	Theoretical Domain Framework
Capability	Psychological	Knowledge
		Skills
		Memory, Attention and Decision Processes
		Behavioural Regulation
	Physical	Skills
Opportunity	Social	Social influences
	Physical	Environmental Context and Resources
Motivation	Reflective	Goals
		Social/Professional Role & Identity
		Beliefs about Capabilities
		Optimism
		Beliefs about Consequences
		Intentions
	Automatic	Social/Professional Role & Identity
		Optimism
		Reinforcement
		Emotion

COM-B: Capability, opportunity, motivation for behaviour. Adapted from Michie S, van Stralen MM, West R. The behaviour change wheel: a new method for characterising and designing behaviour change interventions. Implement Sci. 2011;6:42; Cane J, O'Connor D, Michie S. Validation of the theoretical domains framework for use in behaviour change and implementation research. Implementation Science. 2012;7(1):37.

1.2.5 Weight management services in Australia

Despite increasing in research and the development of priorities to address the global rising prevalence of childhood obesity,[1] it remains a challenge for healthcare professionals to work effectively with the complex dynamics of family systems and to actively engage parents to

elicit behaviour change to improve child health outcomes.[64, 105, 106] The WHO Commission on Ending Childhood Obesity 2016 reported that global progress in combating childhood obesity has been slow and inconsistent, and that more effort was needed to address childhood obesity.[21] The Commission released six recommendations for actions to address childhood obesity in 2017 and one of them is to "*provide family-based, multicomponent services on lifestyle weight management for children and young people with obesity*". However, personalised child weight management services (defined as individually tailored treatment sessions with accredited health professionals, including but not limited to physicians, dietitians, exercise physiologists, social worker, psychologist) for families with children who are overweight or have obesity remain scarce within Australian public health services.[107-109]

Nationally in Australia, there are only nine identified tertiary child weight management services, some of which have waiting lists of up to 12 months, while several states/territories do not provide such services at all.[108, 110] In New South Wales, Australia, access to tertiary child weight management services is extremely limited with only three tertiary children's hospitals (i.e. John Hunter Children's Hospital (in Newcastle),[111] The Children's Hospital at Westmead (in Sydney) and Sydney Children's Hospital)[112] offering paediatric dietitian services. This is insufficient to meet the needs of urban families and particularly restrictive for rural families who are required to travel to major metropolitan areas for services (Figure 1-2). The lack of access to tertiary child weight management services may be attributed to a shortage of professional training opportunities as well as leadership and professional advocacy, absence of referral pathways, reduced local service capacity, and insufficient resources in public health services.[108, 109] Considering the current state of Australian tertiary child weight management services, the scale of the childhood obesity problem far exceeds the capacity of currently available public health services to address the epidemic of childhood obesity across the nation.[108]

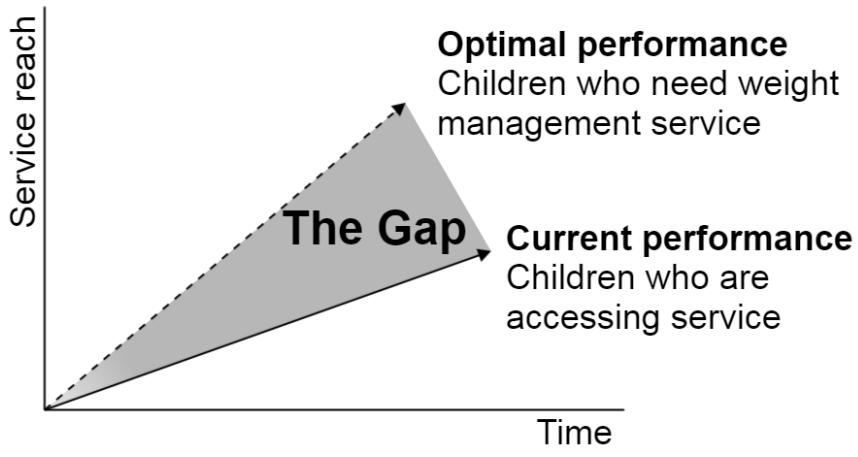


Figure 1-2 A model of gap in service delivery

A case study using John Hunter Children's Hospital as one of the nine identified tertiary child weight management services across Australia for children with overweight and obesity who were referred to a paediatric dietitian for weight management service and were offered one of the following options (described in Sections 1.2.5.1 to 1.2.5.3):

1.2.5.1 Go4Fun program

The Go4Fun program is a 10-week after-school program funded by the Ministry of Health under the New South Wales Healthy Children Initiative. Go4Fun is a suitable option for families with children aged seven to 13 years who are overweight.[17] However, the program only runs in a small group of 10 families during school terms in selected locations around the Hunter region. Go4Fun was run in eight sites during 2015 and 2016; on average two sites per school term and offered to around 10 children in each site. Given the high intensity and commitment required for the 10 weekly sessions, and limited flexibility around session times and locations, only a small proportion of eligible children are able to participate and complete the Go4Fun program. Evaluation reports (unpublished data obtained from Go4Fun program manager) for program ran in 2016 indicated high dropout rates at 40% by week 5; and 50% by week 10, plus high rates of absenteeism with approximately 50% children attended ≤4 sessions throughout the program. Evaluation reports for program ran from May to November 2018 indicated a total of 58 families enrolled across six sites and 74% attended at least seven out of 10 weekly sessions.

When my PhD project was underway between 2015-2018, Go4Fun online was launched in 2017. The Go4Fun online program involves ten weekly online reading modules for families and ten weekly phone coaching calls (15-30 minutes each) with a facilitator for families to ask questions and discuss challenges and achievements throughout the program. Evaluation reports for Go4Fun Online program ran between January and June 2018 indicated a total of 193 families enrolled and 65% and 68% completed at least seven weekly online modules and phone coaching calls, respectively. Based on the 2016 ABS report, there were 951,988 children aged 5-14 years living in NSW, and among them 25% (n=237,997) were above a healthy weight. Therefore, the program had reached only about 5% of this population.

1.2.5.2 Paediatric outpatient program

The paediatric outpatient program offered through John Hunter Children's Hospital is suitable for those who cannot participate or fall outside the age group for Go4Fun. Families referred to this service join the previously described waiting list to see a paediatric dietitian. The paediatric outpatient program currently runs for four hours per week and sees four patients each week based on the priority of their health conditions. For example, children with failure to thrive, and food allergy/intolerance are of higher priority compared to those simply referred for weight

management. The numerous referrals and limited capacity of the service have resulted in an extensive waiting list which is up to two years for many referrals. The prolonged waiting time to see a paediatric dietitian for child weight management can be concerning for parents as their children will usually continue to gain weight, experience stigmatisation and ongoing poorer quality of life. Due to the long waiting period, there are high rates of fail-to-attend (>50%). The clinical waiting list presents an opportunity for recruiting children (Figure 1-3) to early intervention and to trial novel, scalable models of care which, if successful, could be employed in other services trying to address obesity concerns.

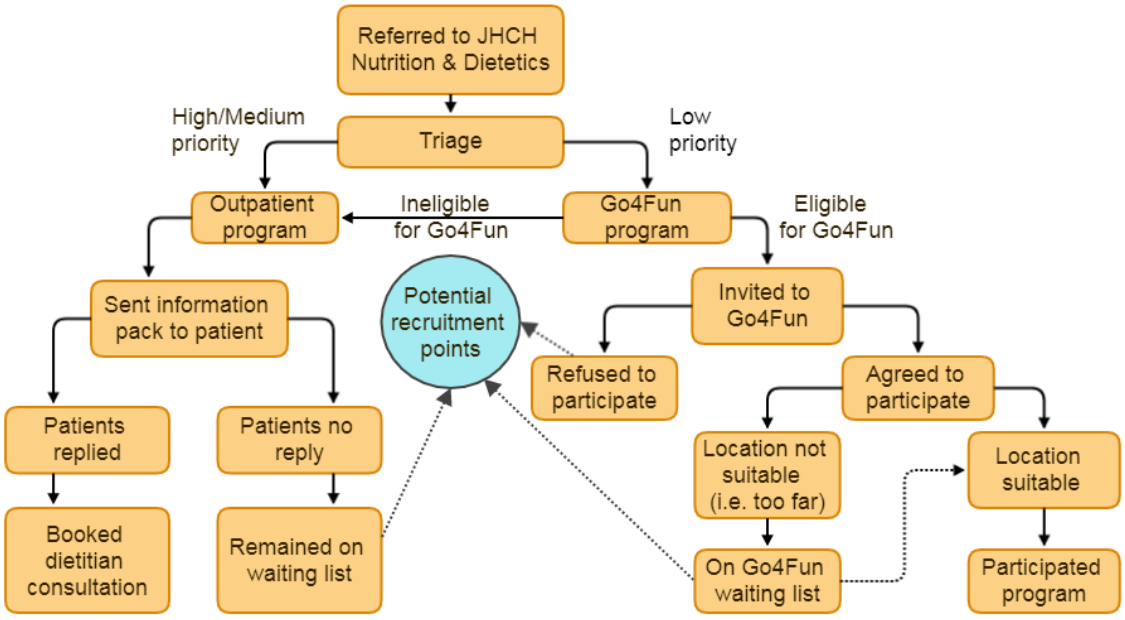


Figure 1-3 *Standard care pathways at John Hunter Children's Hospital and potential recruitment points for weight management interventions*

1.2.5.3 Private practice dietitian services

Families with overweight children who wish to see a dietitian sooner can access private healthcare services. Compared to public health services, private consultations are substantially less affordable. Families may be able to claim Medicare rebates for five allied health appointments per year only if the following conditions are met: the child was referred by a general practitioner to allied health professionals, the child has a chronic medical condition (Medicare do not consider obesity a disease but a risk factor), and requires ongoing care from a multidisciplinary team (three or more healthcare professionals).[113, 114] This means that families with children who are overweight but generally healthy are not eligible to receive financial support when accessing private services.

1.3 Technology-based childhood obesity intervention

Research has identified the common barriers to family participation in child weight management intervention, including geographical limitations, time and transportation to clinic appointments, and non-traditional family structure which complicates shared care where a child regularly lives in multiple households due to separation of parents.[115, 116] Moreover, interviews with families to investigate reasons for not engaging with childhood obesity services found that the clinic environment was viewed as not age-appropriate for some children and did not match the expectations of some families.[117] Technology-based approaches may be used to address some of the barriers to family participation in child weight management interventions.

National data shows that 97% of Australian households with children under 15 have access to the internet, with 99% accessing the internet using a mobile or smartphone in 2016-17.[118] The technology use is not limited by socioeconomic status or geographical boundary, with 88% and 77% of households in major cities and remote areas, respectively, have internet access at home.[118] A needs assessment[115] with 75 Hunter families identified that parents are highly interested in participating in an online healthy lifestyle program specific to child weight management. Parents reported a desire to receive dietary feedback from a dietitian through online video calls or face-to-face sessions.[115] Parents also interested in using an online platform to enter family goals, weight record, and food diary for self-monitoring.[115] An innovative eHealth intervention that allows flexibility appears to have the potential to actively engage busy families and enhance intervention participation by both parents.

A systematic review[58] on technology-based interventions (n=18 studies) to improve nutritional behaviours and weight status in children and adolescents indicated that technology is an acceptable and feasible means for improving the health of children and adolescents. Parents generally participated in interventions by attending educational sessions focused on increasing parental knowledge about healthy behaviours and strategies to support their children or by assisting their child with the technology component of the intervention.[58] The majority of included studies (n=13) were conducted in adolescents aged 12 to 18 years and only five of these studies involved children aged five to 10 years.[58] There were various forms of technology used in family-based behavioural interventions, including mobile applications (apps), websites, and mobile text messaging (SMS).[58] Most studies involved one mode of technology while few studies (n=3) involved a combination of these technologies.[58] The variability in participant characteristics, length of intervention and specific components of each intervention in the review hindered determination of which mode of technology-based intervention (i.e., mobile application, text message, or website) was most effective for improving healthy behaviours and weight status in children and adolescents.[58] However,

studies that conducted a process evaluation reported that participants found technology-based interventions helpful.[58] Additionally, the incorporation of SMS in the intervention in particular increased adherence to interventions, especially among adolescents.[58] Another systematic review reported eHealth interventions (n=7 studies), where parents are an agent of change (i.e. having an active role in intervention and being responsible for implementing change), were effective in improving BMI or zBMI in children and adolescents.[42] Five studies used an web-based intervention, two used IVR (interactive voice response; computerised voice prompts over the telephone, which participants respond to via the telephone keypad), and one used telehealth. There was no report of studies which use social media platforms (e.g. Facebook, Twitter). Only one study used eHealth as the sole modality, making it difficult to determine the true effect of eHealth on obesity.[42]

1.3.1 Text messages

Previous studies have successfully engaged fathers and mothers in family interventions using SMS.[119, 120] This technology addresses many of the barriers to paternal participation by taking intervention to the fathers in a non-threatening format that has the potential to engage parenting partnerships.[121] Research has reported that the use of SMS in combination with additional behavioural interventions (e.g. in-person weekly group sessions) are effective in supporting parents with preschool children[120] as well as adolescents who were overweight or have obesity[122] in improving weight related behaviours. Evidence indicates that mothers and fathers are likely to engage with interventions delivered via SMS that provide relationship focused information, encouragement, support, and links to supplementary resources.[123, 124] Mobile text messaging technology has the potential to engage both parents by communicating corresponding health messages in family interventions and especially addresses barriers to paternal participation by taking intervention to fathers or the parent who may not be able to attend the intervention in a non-intrusive, temporal manner.[125] However, there is a lack of reporting on how SMS content were developed in interventions and whether the development of SMS content was ad hoc or informed by theoretical frameworks of behaviour change or involved feedback from the intended recipients.[101, 126, 127] There is a need for the development of SMS interventions underpinned by behaviour change theory. This gap will be discussed further in Chapter 3 which describes development of a series of SMS targeted at mothers and fathers as an intervention component complementary to a family-based behavioural intervention.

1.3.2 Telehealth

The International Organisation for Standardisation defined Telehealth intervention as the ‘use of telecommunication techniques for the purpose of providing telemedicine, medical education, and health education over a distance’.[128] For example, the use of Telehealth in clinical settings

will enable clinicians to connect with patients virtually using online videoconferencing technology to provide health consultations without being restricted by the geographical distance between patients' home and clinics' location. However, research using telehealth intervention for childhood obesity is scarce.[129] A recent review on the use of telehealth in childhood obesity treatment found only four studies (one randomised controlled trial (RCT), three observational studies) and all were published after 2008.[129] The only RCT included in the review examined the feasibility of an eight-week lifestyle intervention delivered in a school setting.[130] The intervention involved four telehealth sessions delivered by a psychologist to a group of parents while their children participated in face-to-face activity-based sessions delivered by the school nurse.[130] Both parents and children groups included the same topics on nutrition, exercise and behaviour change.[130] The study found that the feasibility and parents' satisfaction of telehealth intervention were positive.[130] However, the differences in BMI outcome and dietary and exercise behaviours were small and not statistically significant compared to usual care controls.[130]

The use of telehealth weight management consultations where parents provide proxy-reported weight records and food diaries through online platforms seem to be promising as this modality of treatment can increase the uptake of intervention. New South Wales Hunter New England Health currently provides clinical care using telehealth services.[131] However, the service is in its early state wherein a New South Wales Strategic Telehealth report indicated that implementation of telehealth has been slow and fragmented across the state.[132] In New South Wales, telehealth is mainly used for teleconference meetings between clinicians dialling in from different health sites, and for connecting medical specialists in major cities to patients who live in remote regions or those who have difficulties in mobility.[131] When implemented at its full potential (e.g. increase adoption in regional health services and allied health departments), telehealth offers an alternative mode for healthcare provision, improves accessibility for rural locations, and reduces costs associated with commuting to services. Due to the limited research in the use of telehealth intervention for management of childhood obesity, the feasibility of a solely online childhood weight management intervention with family-initiated telehealth connection using household electronic devices is not known. This gap will be discussed further in Chapter 4 and Chapter 5 which describe the development and evaluation of a novel telehealth intervention aiming to support parents in improving child weight status and dietary outcomes.

1.4 Web-based data collection for childhood obesity interventions

Web-based platforms are increasingly used for data collection alongside delivery of web-based health interventions.[42] Using web-based technology enables healthcare providers to reach a large number of clients instantaneously and collect population data at a large scale.

Web-based technology also enhances healthcare service access for clients who live in rural and remote locations where healthcare facilities and infrastructure are limited.[133] Evidence indicated that web-based intervention delivery and data collection is more cost effective compared to traditional face-to-face methods.[134] However, a limitation of web-based data collection is that it usually relies on self-reported data which may result in social desirability bias and are therefore not as reliable as objective measures.[58]

Parents of young children usually proxy-report their children's health, growth and lifestyle behavioural information. In view of the advancement of technology-based interventions which are delivered online, participants' data are likely to be collected using web-based approaches instead of traditional face-to-face interviews or paper-based surveys during home or clinic visits. However, data collection may differ between remote non–person-to-person methods (e.g., Web-based, posted paper surveys) and direct person-to-person methods (e.g., home visits, clinic visits, telephone interviews). Moreover, limited studies have assessed parental accuracy in proxy-reporting anthropometrics of their children remotely without the presence of clinicians or researchers using web-based approaches. The few existing studies have also used limited measures to assess agreement, such as the Pearson's correlation coefficients or paired t-tests. However, these measures were unable to adequately detect levels of agreements (i.e. accuracy and precision) and, instead are associations between parent-reported and measured data.[135] This gap will be discussed further in Chapter 6 which describes the accuracy of parent-reported data such as child height, weight and calculated BMI.

Although weight loss or BMI reduction is commonly the end goal, behaviour changes, such as increasing physical activity and improving dietary intake, are necessary to achieve a healthy weight. Current best practice guidelines recommend that interventions for children with overweight or obesity aim for weight maintenance over time, which eventually leads to a BMI reduction as children grow in height. Dietary intake was considered improved when the percentage energy intake from healthy core food was increased and/or intake from discretionary choices was decreased. The evaluation of behavioural change outcomes is therefore crucial to advance research and practice in the management of childhood obesity.[58] A web-based tool to collect parent-reported child dietary intake is the children and adolescent version of Australia Eating Survey (AES) which is a validated 120-item semi-quantitative food frequency questionnaire (FFQ).[136] The AES uses child-specific serving sizes and the following nutrient databases: Australian AusNut 1999 database (All Foods) Revision 14 and AusFoods (Brands) Revision 5 (Xyris Software (Australia) Pty Ltd, 2004: Brisbane Australia).[137] The AES can be administered online and an individual response is required for each food item in the AES, with frequency options ranging from 'never' to 'four or more times per day'; and for some

beverages up to 'seven or more glasses per day'. Once the AES is completed, the web-based tool will generate a personalised dietary report that details the proportion of total energy intake from major and minor food groups, as well as a comparison of mean nutrient intake to the Nutrient Reference Values (NRVs).[138, 139] A sample of AES personalised dietary report is included in Appendix 2.

1.5 Summary

While current services for child weight management exist, there is a need to increase the level of personalisation in nutrition consultation to ensure more effective and sustainable behaviour change. Australian public health services need more timely and cost-effective methods to efficiently address high levels of demand for personalised child weight management consultation, advice and support. However, one of the challenges in the field is translating research findings into evidence-based public health and clinical practice in partnership with health services in order to actively disseminate them and wide uptake.[140] Key gaps in evidence and practice, discussed previously in Section 1.2, are summarised below:

- Family-based behavioural intervention is recommended as best practice for management of childhood obesity. However, effective intervention strategies were unclear due to heterogeneity of studies.
- Parental involvement in child weight management is strongly recommended in evidence-based guidance and behaviour change mechanisms. However, few studies have looked at recruitment and involvement of the whole family unit (i.e. mother, father, and child) in childhood obesity interventions.
- Parents have expressed their interest in receiving personalised nutrition and dietetics intervention for child weight management using online technology. Given the wide accessibility of Internet and ownership of smart devices (i.e. laptop, smartphone) among Australian families, regardless of their demographic background, technology-based solutions may potentially address common barriers to conventional health service access and delivery. However, such technology-based interventions remain in emerging stage and have low uptake in Australian public health services and an evidence-based scalable approach is needed to facilitate implementation.

1.6 Research aims

The overarching purpose of the research presented in my thesis was to develop and test a novel technology-based approach to providing families with a timely, comprehensive and personalised child weight management intervention that has the potential to be translated to health services and up-scaled to complement existing services in Australia.

Five specific aims were proposed to address the overarching purpose of my research:

Aim 1. To synthesise the evidence from systematic reviews of experimental studies on the effectiveness of family-based behavioural weight management interventions for children with overweight or obesity. (Chapter 2)

Aim 2. To identify the key strategies employed in family-based weight management programs for children with overweight or obesity that may result in weight loss and/or behaviour change. (Chapter 2)

Aim 3. To develop a set of evidence-based text messages, targeted to mothers and fathers, that is complementary to a family-focused nutrition intervention to improve child weight status and dietary intake. (Chapter 3)

Aim 4. To develop and test the feasibility, acceptability, and efficacy of a novel family-focused online telehealth nutrition intervention in improving child weight status and dietary intake, and the impact of the addition of evidence-based text messages targeted to mothers and fathers. (Chapter 4 and Chapter 5)

Aim 5. To assess the accuracy of parent-reported child height, weight and calculated BMI to be able to interpret online parent-reported child anthropometrics. (Chapter 6)

1.7 Thesis structure

My thesis comprises of five peer reviewed manuscripts with each presented as a chapter and one additional manuscript (protocol paper) included in the Appendices. To date, three of these manuscripts have been published, and the remaining three have been submitted to peer-reviewed journals and are under review. An overview that links the separate manuscripts and places them in the context of this thesis is presented in Table 1-4.

1.7.1 Background and literature review

Chapter 1 presented background information of childhood obesity (Section 1.1) and a literature review on management of childhood obesity (Section 1.2). This chapter also highlights gaps in evidence and practice (Section 1.5) which underpinned the rationale for the overarching purpose, research questions, and aims of this thesis (Section 1.6).

1.7.2 Umbrella review of weight management interventions for families of children with overweight or obesity

Chapter 2 presents an umbrella review (i.e. a systematic review of systematic reviews) that synthesised systematic reviews of weight management interventions for families of children with overweight or obesity. There is an abundance of literature on family-based childhood obesity interventions, however, the intervention effectiveness has been inconsistent and have included an array of diverse strategies. While existing systematic reviews have not been able

to draw a clear conclusion due to quality of primary studies, the umbrella review addresses the literature gaps through Thesis Aims 1 and 2. The novel contribution of the umbrella review was that I was able to compare seven intervention categories (e.g. parent-child interventions vs. usual care) and recommend parent-related intervention strategy and type of parental involvement that may enhance intervention effectiveness based on a greater number of primary studies overall. The umbrella review findings were appraised using GRADE assessments and we were able to determine the strength of the evidence. The umbrella review and its protocol (included in Appendix 3) have been published in *The Joanna Briggs Institute Database of Systematic Reviews and Implementation Reports*. Learnings from the umbrella review were applied in the development of the pilot study described in Chapters 4 and 5.

1.7.3 Development of text messages targeting healthy eating for children in the context of parenting partnerships

Chapter 3 presents the development of a set of SMS, targeted to mothers and fathers that is complementary to a family-focused nutrition intervention and guided by behaviour change frameworks. The SMS development study aligns with Thesis Aim 3 and has been published in the journal *Nutrition and Dietetics.*

1.7.4 Pilot study of a technology-based nutrition intervention for families of children with overweight or obesity

Chapter 4 presents a pilot study that used a novel family-focused telehealth nutrition intervention to support families in improving child weight status and dietary intake. The study also evaluated the impact of additional SMS targeted to mothers and fathers (presented in Chapter 3) when delivered in conjunction with telehealth intervention. The pilot study aligns with Thesis Aim 4 and is currently under review with the *International Journal of Obesity.*

1.7.5 Process evaluation of a technology-based nutrition intervention for families of children with overweight or obesity

Chapter 5 presents the process evaluation of the pilot study (presented in Chapter 4) with a focus on intervention fidelity and acceptability. The process evaluation study aligns with Thesis Aim 4 and is currently under review with the *Journal of Telemedicine and Telecare.*

1.7.6 Accuracy of parent-reported anthropometrics of their children

Chapter 6 presents a study that assessed the level of agreement of parent-reported child height, weight, and calculated BMI compared to researcher-measured data using Lin's concordance correlation coefficient and Cohen's kappa coefficient. The study aligns with Thesis Aim 5 and is currently under review with the *Journal of Medical Internet Research.*

1.7.7 Thesis Discussion and Conclusions

Chapter 7 presents a summary of the key findings related to the research aims, strengths and limitations of each of the studies, discussion of the overall findings in relation to current literature, followed by implications and future directions for research and practice. These have also been written as a policy brief to outline and communicate about the research findings of this thesis.

Table 1-4 Thesis structure by aims and chapters

<table>
<tr><th colspan="4">Problems</th></tr>
<tr><td colspan="4">Overweight and obesity in children (Chapter 1)
High prevalence of childhood obesity and health consequences
Limited access to child weight management services within Australian public health service</td></tr>
<tr><th colspan="4">Literature review</th></tr>
<tr><td colspan="4">Exploring recommendations and solutions to support the need for a timely and accessible approach that is cost-effective and scalable within Australian public health settings. (Chapter 1)</td></tr>
<tr><td>Family-based behavioural intervention is recommended as best practice for management of childhood obesity. However, effective intervention strategies were unclear due to heterogeneity of studies.</td><td>Parental involvement in child weight management is essential. However, few studies have looked at recruitment and involvement of the whole family in childhood obesity interventions.</td><td colspan="2">Parents expressed their interests in receiving personalised intervention for child weight management using online technology. However, such technology-based interventions remain in emerging stage and have low uptake in Australian public health services.</td></tr>
<tr><th colspan="4">Purpose</th></tr>
<tr><td colspan="4">To develop and test a novel technology-based approach to providing families with a timely, comprehensive and personalised child weight management intervention that has the potential to be translated to health services and up-scaled to complement existing services in Australia. (Chapter 1)</td></tr>
<tr><th colspan="4">Questions</th></tr>
<tr><td>What interventions and strategies are effective?</td><td>How to engage the whole family in interventions?</td><td colspan="2">Would technology-based interventions work in a family-based program?</td></tr>
<tr><th>Aims 1 & 2</th><th>Aim 3</th><th>Aim 4</th><th>Aim 5</th></tr>
<tr><td>To synthesise the evidence from systematic reviews of experimental studies on the effectiveness of family-based behavioural weight management interventions for children with overweight or obesity.

To identify the key strategies employed in family-based weight management programs for children with overweight or obesity that result in weight loss and/or behaviour change.</td><td>To develop a set of evidence-based text messages, targeted to mothers and fathers, that is complementary to a family-focused nutrition intervention to improve child weight status and dietary intake.</td><td>To develop and test the feasibility, acceptability, and efficacy of a novel family-focused online telehealth nutrition intervention in improving child weight status and dietary intake, and the impact of the addition of evidence-based text messages targeted to mothers and fathers.</td><td>To assess the accuracy of parent-reported child height, weight and calculated BMI to be able to interpret online parent-reported child anthropometrics.</td></tr>
<tr><td>Chapter 2</td><td>Chapter 3</td><td>Chapters 4 and 5</td><td>Chapter 6</td></tr>
</table>

Chapter 2: Umbrella review of weight management interventions for families of children with overweight or obesity

This chapter aligns with Thesis Aims 1 and 2 and presents an umbrella review (i.e. a systematic review of systematic reviews) that synthesised systematic reviews of weight management interventions for families of children with overweight or obesity.

Aim 1. To synthesise the evidence from systematic reviews of experimental studies on the effectiveness of family-based behavioural weight management interventions for children with overweight or obesity.

Aim 2. To identify the key strategies employed in family-based weight management programs for children with overweight or obesity that result in weight loss and/or behaviour change.

The content of this chapter has been published in The Joanna Briggs Institute Database of Systematic Reviews and Implementation Reports. This publication requires the use of US spelling, e.g. behavior. Supplementary materials are included in Appendix 5 to Appendix 8.

The work presented in this chapter were completed in collaboration with the co-authors (Appendix 4). The published protocol paper of the umbrella review is included in Appendix 3 with permission granted by the publishers to reproduce the published protocol.

Suggested citations:

Chai LK, Collins C, May C, Brain K, Wong See D, Burrows T. The effectiveness of weight management interventions for families of children with overweight or obesity: an Umbrella Review. *JBI Database System Rev Implement Rep*. 2019 Jul;**17**(7):1341-1427. doi: 10.11124/JBISRIR-2017-003695.

Chai LK, Burrows T, May C, Brain K, Wong See D, Collins C. Effectiveness of family-based weight management interventions in childhood obesity: an umbrella review protocol. *JBI Database System Rev Implement Rep*. 2016;**14**(9):32-9.

2.1 Abstract

Objectives: To synthesize the effectiveness and strategies used in family-based behavioral childhood obesity interventions in improving child weight-related outcomes.

Introduction: Family-based interventions are common practice in the treatment of childhood obesity. Research suggests that direct parental involvement can improve child weight-related outcomes. However, challenges remain in assessing the effectiveness of family-based interventions on child weight and weight-related behavior due to the lack of quality programs and diversity of treatment strategies.

Inclusion criteria: Systematic reviews and/or meta-analyses of family-based behavioral interventions in children aged ≤18 who were classified as being overweight and/or obese, and reported child weight related outcomes, such as Body Mass Index (BMI), body fat percentage, and waist circumferences were included.

Methods: Seven databases were searched from 1990 to May 2016 to identify English language publications. Reference lists of included reviews and relevant registers were also searched for additional reviews. All included systematic reviews were critically appraised by two reviewers independently. Data extraction including characteristics of included systematic reviews and weight-related outcomes reported. Data synthesis involved categorizing interventions into seven categories and presented findings in narrative and tabular format. Quality of evidence was assessed using the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) approach.

Results: The umbrella review comprised 14 systematic reviews (low to moderate methodological quality), published between 2004 and 2015, including 47 independent trials ranging from one month to seven years follow up conducted in over 16 countries. The majority of reviews (93%) reported weight outcomes of children aged six to 13 years. All reviews except one indicated that family-based interventions were successful in improving child weight and/or weight-related behavior. Five reviews highlighted that parent-only interventions have similar (n=4) or greater (n=1) effectiveness compared to parent-child interventions. Effective interventions employed parent-targeted strategies, including nutrition and physical activity education sessions, positive parenting skills, role modelling, and child behavior management to encourage positive healthy eating/exercise behaviors in children and/or whole family.

Conclusions: Family-based interventions targeting parents, alone or with their child, are effective for child weight management. Due to the lack of high quality evidence, especially in the emerging parent-only interventions, further research are warranted. Health practitioners can work with parents as the agents of change and focus on fostering positive parenting skills,

such as monitoring, reinforcement, role modelling, and providing a nurturing environment, in order to support health behaviors in their children. Future research needs to explore whether parent-only interventions are more cost-effective compared to parent-child interventions, and to include larger populations, longer intervention duration and follow-up.

Keywords: Children; parent; intervention; obesity; umbrella review

2.2 Introduction

The rising prevalence of childhood obesity has created a worldwide public health crisis.[1] According to the World Health Organization (WHO) approximately 41 million (6%) young children under the age of five years across the world were overweight or obese in 2014.[1, 21, 141] While global prevalence data available for obesity in older children are currently being verified by WHO,[21] the International Obesity Task Force (IOTF) (2000) estimated that approximately 155 million children aged five to 17 years were overweight (10%) or obese (3%).[6, 7] The Australian Health Survey (2011-12) showed that one in four Australian children were overweight (18%) or obese (7%) placing these children at increased risk of chronic disease from a young age.[142] The Australia Burden of Disease Study (2011) indicates that high Body Mass Index (BMI), related to overweight and obesity, was the second highest contributor to disease burden.[13] In Australia, overweight and obesity accounted for 5.5% of the total disease burden in 2011, including 49% of endocrine disease, and 21% of cardiovascular disease.[13] Early intervention for weight management is essential for disease prevention, as obesity tracks from childhood to adulthood.

Extensive research has been conducted in child obesity. This has included several systematic reviews (SRs)[39, 41, 45, 143, 144] in both obesity prevention and treatment in children and adolescents, with evidence suggesting that parental involvement (mainly for primary school aged children) has increased intervention effectiveness in relation to improved weight outcomes and lifestyle behaviors. Systematic reviews of childhood obesity show that family-focused behavioral lifestyle interventions, often with direct parental involvement, can lead to positive outcomes in weight, BMI and other measures of body fat composition of the children.[37, 41, 47-52] Behavioral interventions were classified as those that aim to change parents' and/or children's weight related thinking patterns and actions – including dietary intake, physical activity and sedentary behaviors – which go on to determine a family's food and physical environment.[37]

Parents' attitudes, beliefs and behaviors have an effect on their child's risk of being overweight.[38] Parental characteristics such as increased BMI, high alcohol intake, regular smoking, low socioeconomic status, and low education level have all been linked with greater possibility of their children being overweight.[38] Moreover, parents are the key mediator of the

obesogenic environment within the family home; particularly for young children who consume most meals at home. Parents usually control decision making about the types of food that are available in the home and how food is prepared for family meals. Parental decisions can have an impact on the development of child food preferences and eating habits. Family meal times, if they occur, provide a potential opportunity for parents to model healthy food choices and food-related behaviors, while promoting a positive atmosphere around healthy eating for better diet quality. For these reasons, parents are often targeted in intervention for child weight management.

Despite increasing research into obesity, the prevalence of overweight and obesity has risen globally, in both developed and developing countries, over the last decade.[1] It remains a challenge for healthcare professionals to work effectively with the complex dynamics of family systems to improve child health outcomes; noting that this can require the active engagement of both parents to achieve effective behavior change.[64, 105, 106] There is an abundance of literature on childhood obesity interventions with parental involvement.[36, 145, 146] However, the effectiveness of interventions to reduce a child's weight and/or change their weight-related lifestyle behaviors has been inconsistent, due in part to the lack of high quality, effective programs[37, 147] which have included an array of diverse strategies.[148] A Cochrane review[37] acknowledged that the heterogeneity of current literature in the area of childhood obesity treatment makes it difficult to conclude that one intervention component is more effective than the other. As parental influences are closely associated with child's weight or weight-related behavior, especially in young children, the parental role in child obesity treatment is likely to be an essential element for effective intervention.[35, 36] However, there is limited evidence to inform how parents should be involved or targeted in interventions aiming to achieve behavior changes in their children.[36, 41, 52]

Given a number of SRs have already been completed in the area of parental involvement in childhood obesity intervention, a comprehensive review of these SRs is sensible to map and analyze the available evidence. This umbrella review summarized current strategies that are effective in supporting parents with an overweight child to better manage their child's weight and/or weight-related behavior change. To the authors' knowledge, this is the first systematic review of SRs on obesity interventions involving parents with overweight children.

2.3 Review questions

What is the effectiveness of family-based behavioral or lifestyle weight management interventions for overweight children? What are the strategies or characteristics of effective interventions in combating child obesity?

2.4 Inclusion criteria

2.4.1 Types of participants

Participants of interest were children aged 18 years and under who were classified as overweight or obese, based on WHO Child Growth Standards, Centers for Disease Control and Prevention (CDC) Growth Charts, or International Obesity Task Force (IOTF).[19, 149, 150] Systematic reviews were excluded where study participants included children of all weight status, and/or results were not reported separately for overweight children.

2.4.2 Types of intervention(s)

The umbrella review included SRs which had a focus on behavioral and/or lifestyle interventions for child weight management. Interventions of interest are those that aim for weight loss as a primary outcome through changes to behavioral or lifestyle habits, including, but not limited to, dietary intake, physical activity, sedentary behavior, mealtime patterns and sleep. Interventions were included if they were family-based, which was defined as the direct involvement (i.e. attendance or participation in intervention sessions) of first- or second-degree relatives or caregivers cohabiting under one roof in interventions adapted from McLean et al.[47] The interventions must have included a comparator group, such as a control group not receiving an intervention (usual care), or a control group receiving an alternative intervention. There were no limitations regarding frequency, duration, intensity, and setting of interventions.

2.4.3 Types of outcomes

Published systematic reviews that reported a synthesis of child weight outcomes were considered for inclusion in this review. Primary outcomes of interest include change in body weight or BMI of the index child, measured from baseline to intervention-end and/or post-intervention follow-up. Where available, ‘‘behavior change’’ such as dietary intake or physical activity were included as secondary outcomes of interest.

2.4.4 Types of publications

Systematic reviews and meta-analyses of quantitative studies (randomized controlled trials (RCTs), quasi-experimental, and pre-post design) were included in the umbrella review. Mixed-method studies (i.e. both quantitative and qualitative) were included if the quantitative component could be extracted clearly. Systematic reviews of solely qualitative studies or studies that did not include an active intervention (e.g. cohort study, case study and cross-sectional study) were excluded as these studies were unlikely to report quantitative results; which were the outcomes of interest. An eligible SR must have a protocol describing the review question/s, search strategy, and inclusion criteria, which are often referred to as ‘PICO’ (Participants, Interventions, Comparisons, and Outcomes).[151] Therefore, narrative literature reviews were excluded. For SRs that did not explicitly limit inclusion criteria to intervention

study designs, only results from relevant intervention trials were extracted for inclusion in the umbrella review. If results were not reported or not separable between intervention and non-intervention studies, the SR was excluded.

2.5 Methods

The umbrella review was conducted according to the protocol which was developed based on the Methodology for JBI umbrella reviews[152] and published in September 2016 (doi: 10.11124/JBISRIR-2016-003082).[153]

2.5.1 Search strategy

Database searches were completed in May 2016 by an experienced academic medical librarian. Seven databases were searched, including MEDLINE, EMBASE, CINAHL, PsycInfo, Scopus, Database of Abstracts of Reviews of Effects, and the Cochrane Database of Systematic Reviews, using keywords and index terms (Appendix 5) identified by several experienced authors (LKC, TB, CC). Searches were limited to English language, and publications between 1990 and May 2016. As there were very few SRs published prior to 1990,[152] the search period was deemed appropriate to capture existing SRs on family-based childhood obesity treatment given SRs only began to emerge from the year 2000.[50] Reference lists of included SRs and additional databases including PROSPERO and JBISRIR were searched to identify any existing SRs on the same topic. The authors believe that it is unlikely that a comprehensive SR in this area of research will have been undertaken and not be published. Therefore, the umbrella review did not search for unpublished/grey literature consistent with the previously published SR protocol,[153] as opposed to the JBI Umbrella Review methodology chapter.[152] All references were managed using EndNote X8 (Clarivate Analytics, Philadephia, PA, USA).

2.5.2 Study screening and selection

Two reviewers (LKC, and one of either TB, CM, KB, DWS, CC) independently reviewed the titles and/or abstracts of all records retrieved from the search. All potentially relevant full texts were retrieved and assessed independently by two reviewers (LKC, and one of either TB, CM, CC). Any discrepancies were resolved through consensus or a third reviewer (TB, CC).

2.5.3 Assessment of methodological quality

All included SRs were critically appraised by two reviewers (LKC, TB) independently using the standard JBI Critical Appraisal Instrument for Systematic Reviews and Research Syntheses.[152] Conflicts were resolved through discussions to reach consensus. All eligible SRs (based on PICO inclusion criteria) were included regardless of methodological quality in order to summarize the current literature and quality of existing studies within SRs to date.

2.5.4 Data collection

The JBI Data Extraction Form for Review for Systematic Reviews and Research Syntheses was used for extracting information including characteristics of included systematic reviews and weight-related outcomes.[152] Relevant information on characteristics of included SRs was extracted and presented in line with the study protocol which has been published previously.[153] As per the protocol, primary weight outcomes and weight-related anthropometric indicators were extracted. In addition, changes in child/parental weight outcomes or weight-related behaviors such as dietary intake, physical activity, sedentary behavior, were also extracted when they were reported as these were deemed important secondary outcomes in the context of family-based interventions with parental involvement. When results reported within SRs were not clear (e.g. values reported in narrative synthesis were different from results tables), the original primary studies were referred to extract the correct data in order to enhance the accuracy of umbrella review synthesis. Adverse consequences that arose as a result of interventions were also documented if reported in SRs. In cases where SRs included more detailed outcomes, such as population groups (e.g. children, adults), intervention contexts (e.g. family-, school-, clinical-based), and intervention components (e.g. behavioral, pharmacological, surgery), only that subset of relevant studies (e.g. children; family-based; behavioral) were extracted for synthesis; provided that the results of the subset of studies were reported separately in the SRs. In cases where an original research study was included in multiple SRs, the number of overlapping studies included in SRs were described in the report – full details of these are presented in Appendix 6. For primary studies that were included in multiple reviews, results related to the primary study were cross-checked across multiple reviews for accuracy (when same outcomes were reported) and consolidated for reporting in the current umbrella review (when different outcomes were reported) to avoid duplicates of results.

2.5.5 Data summary

The effectiveness of interventions were extracted as results of meta-analyses conducted within the included SRs, or as reported in the results of included SRs. Quantitative findings were categorized by authors into seven intervention categories and presented in tables describing effect estimates within groups, and between groups, at the end of intervention and at the longest follow up time.

The seven intervention categories were:

1. Parent-child interventions vs. Waitlist/no intervention control
2. Parent-child interventions vs. Usual care
3. Parent-only interventions vs. Waitlist/no intervention control

4. Parent-only interventions vs. Usual care
5. Parent-only interventions vs. Parent-child interventions
6. Parent-only interventions vs. Child-only interventions
7. Parent-child interventions vs. Child-only interventions

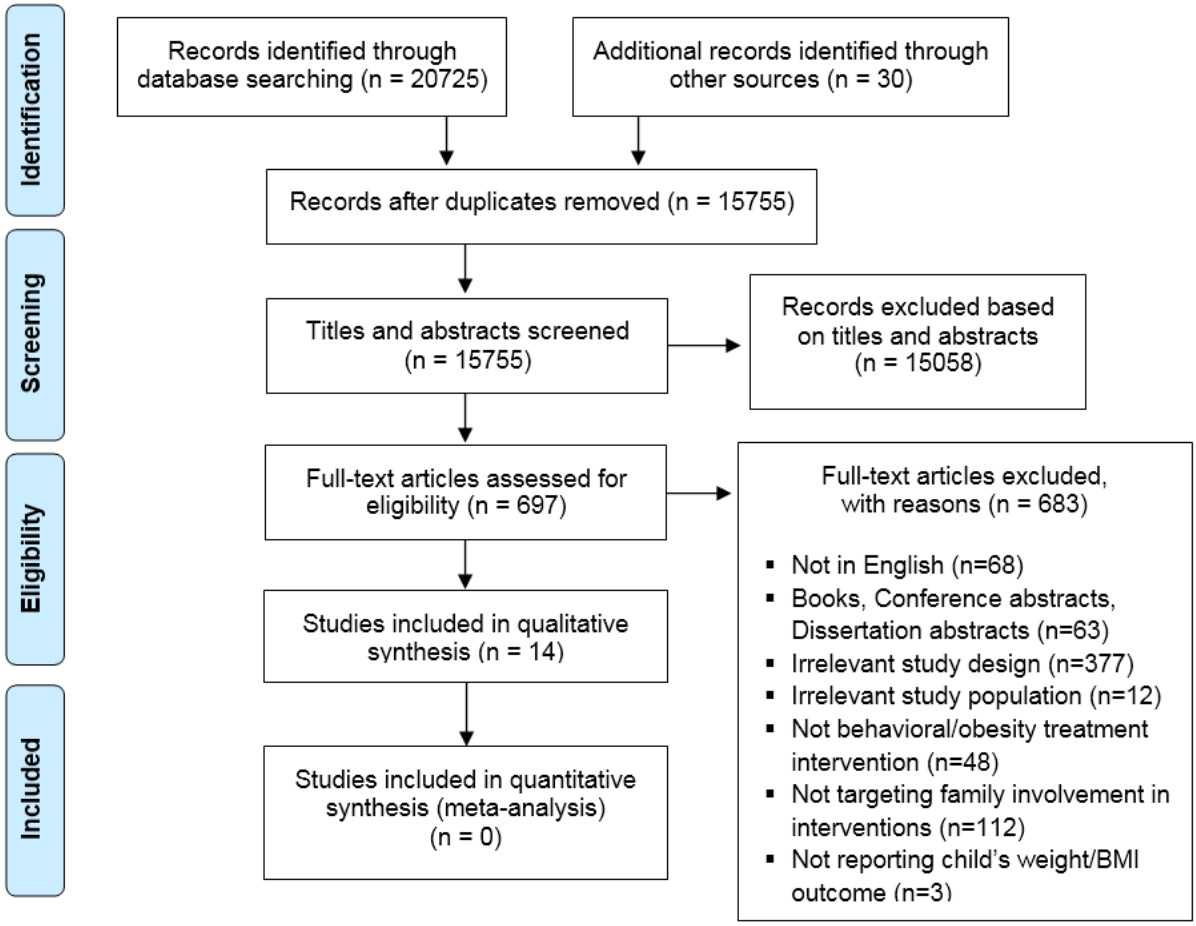
The quality of evidence for each intervention category against weight-related outcomes was assessed using the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) approach.[154] The GRADE framework includes evaluation of the following five criteria: (i) quality of primary studies (e.g. risk of bias and methodological limitations); (ii) inconsistency (e.g. direction of intervention effects, magnitude of statistical heterogeneity measured by I^2; low (I^2 <40%) , moderate (I^2 40-60%), high (I^2 >60%); (iii) indirectness (e.g. direct comparisons with populations, interventions, and outcomes relevant to context); (iv) imprecision (e.g. magnitude of the number of included studies: large: >10 studies, moderate: 5-10 studies, small: <5 studies; and median sample size: high >300 participants, intermediate 100-300 participants, low <100 participants); and (v) publication bias.[56, 154]

The strengths of overall intervention effectiveness are presented in a table using a ”stop-light” indicator, where green indicates an effective or beneficial intervention; amber indicates no intervention effect or no difference when compared to the comparator, or unclear effect due to insufficient information; and red indicates a detrimental or less-effective intervention when compared to the comparator.

2.6 Results

2.6.1 Study inclusion

The process of study selection is presented as an adapted PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) flow diagram (Figure 2-1). The database searches identified 15755 records; 697 potentially relevant full texts were retrieved and assessed after excluding 15058 records following the examination of title and abstract against inclusion criteria. Of the 697 full texts, 14 SRs[39-41, 45, 46, 49, 50, 52, 91, 144, 155-158] met the inclusion criteria and were included. The majority of the excluded articles were primary studies and/or SRs with irrelevant study designs, such as cohort study, cross-sectional study, or intervention trials without family involvement. A list of excluded studies with reasons is summarized in Appendix 7.



From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 6(6): e1000097. doi:10.1371/journal.pmed1000097

Figure 2-1 PRISMA 2009 flow diagram

2.6.2 Methodological quality

Of the 11 quality appraisal criteria listed in the JBI Critical Appraisal Instrument for Systematic Reviews and Research Syntheses, seven criteria (64%) were met by all 14 included SRs (Table 2-1). The remaining four criteria (item 5, 6, 7, 9) were not met or rated as unclear due to the lack of reporting in SRs. Six SRs[40, 46, 50, 155-157] did not provide information on whether risks of bias were assessed by more than one reviewer independently, whereas one SR[144] was conducted by only one author with no second reviewer. Four SRs[40, 46, 91, 144] did not mention about risk of bias assessment tools used nor the results of the quality appraisal. One SR[49] mentioned that included studies had methodological weaknesses but did not specify the use of an appraisal instrument for formal quality assessment. Three SRs[45, 49, 157] did not provide information about the data extraction tool used or specify the pre-determined study characteristics to be extracted. Three SRs[46, 50, 155] did not mention whether two or more independent reviewers performed extraction or additional examinations. Only two SRs[41, 50]

reported assessment for the likelihood of publication bias against weight outcomes, which found a low probability of publication bias as indicated by fail-safe N exceeded Rosenthal's recommendation (5k+10; with k=n of included studies).[50]

Table 2-1 Critical Appraisal Results for Included Systematic Reviews

Systematic reviews	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11
Barr-Anderson (2013)	Y	Y	Y	Y	Y	U	Y	Y	N	Y	Y
Berge (2011)	Y	Y	Y	Y	Y	U	Y	Y	Y	Y	Y
Berry (2004)	Y	Y	Y	Y	U	Y	U	Y	N	Y	Y
Ewald (2014)	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y
Jang (2015)	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y
Jull (2013)	Y	Y	Y	Y	Y	U	Y	Y	U	Y	Y
Kelishadi (2014)	Y	Y	Y	Y	U	U	Y	Y	N	Y	Y
Kitzman-Ulrich (2010)	Y	Y	Y	Y	U	U	U	Y	U	Y	Y
Knowlden (2012)	Y	Y	Y	Y	U	Y	Y	Y	U	Y	Y
Kothandan (2014)	Y	Y	Y	Y	Y	N	U	Y	U	Y	Y
Loveman (2015)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Sung Chan (2013)	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y
Upton (2014)	Y	Y	Y	Y	Y	Y	U	Y	N	Y	Y
Young (2007)	Y	Y	Y	Y	U	U	Y	Y	U	Y	Y

Y: Yes, N: No, U: Unclear, NA: Not applicable, Q1. Is the review question clearly and explicitly stated? Q2. Were the inclusion criteria appropriate for the review question? Q3. Was the search strategy appropriate? Q4. Were the sources and resources used to search for studies adequate? Q5. Were the criteria for appraising studies appropriate? Q6. Was critical appraisal conducted by two or more reviewers independently? Q7. Were there methods to minimize errors in data extraction? Q8. Were the methods used to combine studies appropriate? Q9. Was the likelihood of publication bias assessed? Q10. Were recommendations for policy and/or practice supported by the reported data? Q11. Were the specific directives for new research appropriate?

In general, trials included in the SRs were rated as being of low quality with a large proportion rated as unclear or at high risk of bias on individual risk of bias criteria due to not, or under-reporting within primary intervention trials. The high risk of bias was for incomplete outcome data due to higher dropout in parent-only interventions, failure to conduct intent-to-treat analysis, while most studies reported limited information about allocation concealment and randomization procedure. It was uncommon for trials to report power calculations. In a SR of eight trials, only three trials reported sample size calculations and of these trials, two did not meet target sample size.[52] This limited the power and sensitivity to detect significant differences between groups resulted from the interventions. GRADE assessment of the outcomes pooled in this umbrella review have led to trials being downgraded for risk of bias, and imprecision owing to the small number of trials and small sample sizes (n=8 to 80). Therefore, the overall interpretation of the data was synthesized more cautiously. Further details on appraisal instrument used and methodological quality are presented in Table 2-2.

2.6.3 Characteristics of included studies

The 14 included SRs[39-41, 45, 46, 49, 50, 52, 91, 144, 155-158] were published between 2004 and 2015 with four undertaking meta-analyses.[40, 41, 50, 156] The majority (n=13 SRs) had searched at least

three databases, with the databases most commonly searched being Medline, CINAHL, PsycINFO, and PubMed, and with publications retrieved from 1967 to May 2015. While all SRs included intervention studies, eight SRs[39, 41, 49, 52, 91, 144, 156, 158] specifically included RCTs only, with two SRs[49, 52] including only RCTs with at least six months follow up. Two SRs also incorporated specific inclusion criteria for countries including UK[45] and USA[155] or ethnicity such as African-American girls.[155] While the study populations were predominantly primary school age children, the most commonly included child age range was six to 13 years (n=13 SRs),[39-41, 45, 46, 49, 50, 91, 144, 155-158] with some also reporting on children aged less than six years (n=9 SRs)[39-41, 45, 46, 50, 91, 157, 158] or above 13 years (n=10 SRs).[45, 46, 50, 52, 91, 144, 155-158] One SR[52] specifically described results of children aged 8-11 years only. The included SRs[39-41, 45, 46, 49, 50, 52, 91, 144, 155-158] have included 47 independent trials that were relevant for the umbrella review. Of the 47 trials, which were conducted in over 16 countries and published between 1975 and 2015, 22 trials (47%) were included in two or more SRs included in the umbrella review. Two trials were included in seven SRs; one trial was included in five SRs; two trials were included in four SRs; three trials were included in three SRs; and 14 trials were included in two SRs. All four trials included in the meta-analysis conducted by Jull et al.[156] were also included in the SR by Loveman et al.[41] which included 20 trials (see Appendix 6). Intervention durations ranged from one month to two years, with longest post-intervention follow up time points ranging between three months and seven years. The most common primary outcome measures reported were BMI z-scores (zBMI) (n=13 SRs),[39-41, 45, 46, 50, 52, 91, 144, 155-158] BMI (n=8 SRs),[40, 41, 45, 49, 52, 144, 155, 158] percent overweight (n=7 SRs),[40, 46, 50, 52, 91, 144, 157] BMI percentile (n=6 SRs),[39, 46, 50, 52, 91, 157] and body weight (n=6 SRs).[40, 41, 49, 144, 155, 158] Several SRs also reported on secondary outcomes related to behavioral changes such as diet (n=7 SRs),[41, 46, 50, 91, 144, 155, 157] physical activity (n=5 SRs),[41, 50, 91, 144, 155] sedentary behavior (n=2 SRs),[50, 91] and/or parental outcomes (n=4 SRs).[41, 91, 144, 157]

Table 2-2 Findings of Included Systematic Reviews and Meta-analysis

Author (Year)	Appraisal instruments and rating	Outcomes assessed	Main results and findings of systematic reviews	Strategies of effective interventions and recommendations	Conclusion and implications for research and practice
Barr-Anderson (2013)	Instruments: Delphi list (6 criteria), Green and Glasgow (7 criteria) A total methodological quality score was created by summing the validity criteria met (maximum 13). The scores for the 6 relevant studies were 4, 5, 6, 7, 7, 8.	▪ Weight ▪ BMI ▪ BMI z-score ▪ % body fat ▪ Diet ▪ PAL	Most family members served to support behavior change goals of the child. 5 of 9 treatment studies engaged family members to change their own behavior were non-significant possibly due to the pilot nature of most studies. 3 of 4 studies assessed diet reported null or opposite to expected results. 3 of 5 studies assessed PAL positively impacted this behavior.	Unable to draw clear inferences regarding the most promising strategies. No clear pattern emerged related to family member involvement, goal of the family member, format of the intervention delivery and age of child. Encouraging participating family members to change their own behavior and lose weight may be an effective strategy for overweight children to loss excess weight/prevent additional weight gain.	• Optimal approach with African-American girls are still unclear. • Type and level of family involvement seems unclear/unsystematic, hence difficult to make definitive conclusions. • Need rigorous interventions to test effects of family member attendance (separate, jointly with child) • Overall quality of evidence was low methodologically. Most studies were pilot studies with small sample and short duration. Study design needs more attention, technological approaches, use of social networking and mobile devices. • Future research may examine obesity in both genders as prevalence is high in both genders.
Berge (2011)	Instruments: NR Publication bias was assessed using fail-safe N for main outcomes and suggesting a low probability of publication bias. All available studies were included without	▪ BMI percentile ▪ BMI z-score ▪ % overweight ▪ Diet ▪ PAL ▪ Sedentary behavior	Most studies (70%) showed significant moderate to large effect size in child BMI change post-intervention. Of these, 50% showed significant child weight loss at 6 months, 1 year, and/or 2 years follow up with modest effect sizes (small to moderate).	Interventions had at least one of the three main components: nutritional and physical activity education; psychoeducational parenting groups; and behavioral control/monitoring of diet and exercise. Intervention targeted both parenting skills and nutrition/physical activity PAL	• Preliminary evidence suggesting family-based childhood obesity interventions are successful in short and long term weight loss. This warrants to include families in weight loss treatment of childhood obesity. • There is a need to investigate the importance of parent sex, parent-only treatment and sibling Involvement. • Implication for future research: increasing sample diversity,

Author (Year)	Appraisal instruments and rating	Outcomes assessed	Main results and findings of systematic reviews	Strategies of effective interventions and recommendations	Conclusion and implications for research and practice
	excluding based on variation in study quality due to the relatively small amount of family-based intervention studies.		Attrition was significant in 25% (5 of 20) of included studies. Non-completers were families from lower SES households, with children who were more overweight/obese, and ethically/racially diverse. There was significant degree of heterogeneity among study designs.	education showed significant and larger effect sizes compared to intervention with education only or education+ behavioral control/ monitoring. Important to teach parents both structure/setting limit skills and empathic/caring skills in child weight intervention.	measurement of BMI, need for theory driven research, need for long-term follow up studies, importance of sex comparisons, and a need for more family-based research conducted by various researchers.
Berry (2004)	Instruments: NR Most studies were methodologically inadequate. None of the studies reported power calculations. Most studies did not report randomization procedures, had small sample sizes (8 to 22 participants per group), and did not report ethnicity and/or SES of participants.	▪ Weight ▪ % weight ▪ BMI	Behavioral modification interventions and behavioral therapy are effective in weight loss when targeting children and parents together or separately. Problem solving interventions are effective when targeting parents only, but not when both parents and children were targeted together or child alone.	Studies on families need to include one or both parents or siblings, with interventions designed differently for parents, children, and adolescents because of differences in cognitive development.	• Difficult to draw conclusions across studies due to the majority were methodologically inadequate. • Future research need to use theoretical framework based in family theory with the intervention design and outcome measures linked. • There is a need for an addition of family system approach that is rooted in general systems theory.
Ewald (2014)	Instruments: Risk of bias tool of the Cochrane Collaboration Most studies were at unclear risk of bias due	▪ BMI ▪ BMI percentile ▪ BMI z-score ▪ % overweight ▪ Waist circumference	Parent-only groups are similarly or more effective than child-only or parent–child interventions, in the change in degree of overweight.	Overall, interventions content comprised nutrition, physical activity and behavior modification or cognitive behavioral therapy. The parent-only arms received	• Parent-only interventions appear to be as effective as parent–child interventions in the treatment of childhood overweight/obesity. • Further investigation needed to explore whether parent-only interventions are

Author (Year)	Appraisal instruments and rating	Outcomes assessed	Main results and findings of systematic reviews	Strategies of effective interventions and recommendations	Conclusion and implications for research and practice
	to non-/under- reporting. None reported measures to minimize contamination bias. High risk of bias was for incomplete outcome data due to higher dropout from parent-only interventions, and allocation concealment. Other potential biases included small sample size (12 to 72 participants per group). Of 3 studies reported sample size calculations, 2 did not meet target sample in recruitment.	▪ Diet ▪ PAL	Dietary behavior (related to presence of unhealthy foods in the home, the child taking and buying snacks without permission and the family eating style) were better in the parent-only group compared with the child-only group. However, when comparing a parent-only intervention with a parent-child intervention, the only significant difference was the presence of unhealthy foods in the home, in favor of the parent-only intervention. Change in children's PAL was not different between parent-only and parent–child groups and between parent-only and child-only groups.	similar content and duration of intervention as the comparator arms.	more cost-effective, may lead to better mental health in parents, weight status in fathers, and some improvement in family eating habits. • Future qualitative research may examine the complexities behind higher attrition rates in parent-only interventions.
Jang (2015)	Instruments: Risk of bias tool of the Cochrane Collaboration All studies were at unclear or high risk of bias for most domains. Most studies reported limited information about	▪ BMI percentile ▪ BMI z-score ▪ Waist circumference ▪ Diet ▪ PAL	Most intervention programs demonstrated improvement in child BMI or BMI z-score. Children improved their health behaviors, including healthy eating, physical activity, eating psychopathology, negative	Primary strategies included providing education on healthy eating and PA and fostering the development of parenting skills to promote positive health behaviors of children. 1 study assessed potential predictors of program success (greater reduction in child BMI)	• Intervention programs targeting parents have the potential to be effective in improving childhood overweight and obesity in the short-term and there is suggestion that this effect may remain up to 2 years. • However, intervention programs targeting parents for childhood overweight and obesity have not

Author (Year)	Appraisal instruments and rating	Outcomes assessed	Main results and findings of systematic reviews	Strategies of effective interventions and recommendations	Conclusion and implications for research and practice
	allocation concealment. Some studies did not conduct intent-to treat data analysis, which is associated with attrition bias. Only 3 out of 7 studies addressed power analysis for sample size.		thought patterns, and self-efficacy. Significant improvement of parenting skills and health behaviors in parents was also demonstrated in some studies, however findings were inconsistent. The mean attrition rate across all studies was 39%, ranged from 18% to 67.9%.	were higher parental motivation, lower baseline BMI percentile in children, higher parental attendance, younger children, lower SES.	reached high-risk populations and have demonstrated high attrition. • Future research may assess adoption rate and cost-effectiveness, improve the reach and implementation of intervention programs, and examine efficacy or effectiveness in families of diverse race/ethnicity and low socioeconomic status. • Researchers should also consider reporting the reach, adoption, implementation, and maintenance of programs in addition to program efficacy.
Jull (2013)	Instruments: Risk of bias tool of the Cochrane Collaboration Overall, the included trials were at unclear or high risk of bias and no individual trial was clearly at lower risk of bias than the other trials. Studies had small sample size (37-80 participants).	▪ BMI z-score	Parent-only interventions are similarly effective as parent-child interventions. Studies showed no significant difference between groups in BMI z-score from baseline to end of treatment (3 trials) or to end of follow up (2 trials). Higher attrition rate in parent-only condition compared to parent-child condition at the end of treatment (52% vs 19%), and at 6-months follow up (72% vs 35% loss to follow up). Heterogeneity I^2 was less than 40% (moderate).	Dietary habits were addressed by the aim to increase consumption of healthy food through use of traffic light diets or similar. Activity was addressed by the aim to increase physical activity and decrease sedentary activity, either through stated targets, or through individualized goal setting. Behavioral approaches to change were common, as was training in parenting skills to cope with difficult situations.	• A small number of underpowered trials suggest that parent-only interventions might have a similar effect as parent-child interventions for weight loss in children. • There is an absence of high quality evidence regarding the effect of parent-only interventions for weight loss in children compared to parent-child interventions, suggesting the need for further research.

Author (Year)	Appraisal instruments and rating	Outcomes assessed	Main results and findings of systematic reviews	Strategies of effective interventions and recommendations	Conclusion and implications for research and practice
Kelishadi (2014)	Instruments: NR Authors reported the main limitation of family-based studies is the small sample size, high dropout rate, no follow-up data, and selection of motivated families.	▪ BMI percentile ▪ BMI z-score ▪ % overweight ▪ Waist circumference ▪ Diet	Most programs were successful in decreasing BMI z-score and some health consequences of overweight. At the end of treatment, children consumed more fiber and were less sedentary. A significant decrease in fat mass was reported in some studies.	Authors claimed that if parents recognize the importance of weight control, they will be motivated to persuade their children for weight control. Evidence shown that low parental confidence predicts dropout rate from family-based behavioral treatment.	• A multidisciplinary approach in schools in which children's family are involved, can be the most feasible and effective approach. • Future studies are needed to determine the long-term effects and sustainability of different programs.
Kitzman-Ulrich (2010)	Instruments: NR Authors reported small sample size in most studies has limited power to detect significant differences.	▪ BMI percentile ▪ BMI z-score ▪ % overweight ▪ Waist circumference ▪ Skinfold ▪ Diet ▪ Parenting	Results were consistent with the literature where targeting parent seems to promote sustained behavior change in youth. Parents demonstrated positive parenting skills (praise, create healthier home environment) resulted in significant weight reduction at 6-months and 12-months which was maintained at 24-months in intervention group but no longer significant.	Targeting parents as conduit for family level change through authoritative parenting styles (set boundaries, provide nurturing environment), positive parenting skills (monitor, reinforcement, role modelling), child management strategies to encourage positive behaviors in weight loss program for overweight youth, with some demonstrating moderate to large effect sizes.	• Weight loss program integrated components on parenting style, parenting skills, child management principles, or family functioning variables had a positive effect on youth weight loss. However, more studies are needed. • Only few studies specifically evaluated parenting styles or family functioning variables as mediators of youth weight loss.
Knowlden (2012)	Instruments: NR	▪ BMI percentile ▪ BMI z-score ▪ % overweight	It was suggested that targeting parents alone was more effective than targeting	Most interventions (n=7) targeted parents as the exclusive agents of change	• Additional research is needed to explore the efficacy of the home and

Author (Year)	Appraisal instruments and rating	Outcomes assessed	Main results and findings of systematic reviews	Strategies of effective interventions and recommendations	Conclusion and implications for research and practice
		▪ Waist circumference ▪ Diet ▪ PAL ▪ Parenting	both parents and children. Studies have continued to support the parents-only paradigm as the most effective mediator of childhood obesity for this intervention prototype.	with educational sessions incorporated as the primary modality for delivering the intervention to the parents. Authors suggested interventions to target behaviors such as child engagement in 60 minutes of moderate to vigorously intense physical activity on most days of the week, consumption of five cups of fruits and vegetables each day, replacement of sugar sweetened beverages with sugar-free beverages, and limitation of screen time (leisure television and computer use) to no more than 2 hours per day.	family milieu for treating childhood obesity. • Future research should explore more convenient educational outlets for parents or alternatives such as online learning and social media platforms. • Future research may include long-term outcome evaluation (at least 24 months from baseline) and implementation process evaluation. • Evaluation can be enhanced through operationalization of behavioral and social theories including social cognitive theory and the theory of planned behavior which are commonly applied in childhood obesity interventions.
Kothandan (2014)	Instruments: Critical Appraisal Skills Program (CASP) tool adapted from the public health research unit. All studies included in the review met the NICE Grading of evidence and recommendation level of Ib and A and scored	▪ Weight ▪ BMI ▪ BMI z-score ▪ % overweight ▪ Diet ▪ PAL ▪ Sedentary behavior ▪ Parenting	Parent-involved family-based interventions had significant beneficial effects on the child weight and BMI. Interventions lasting more than 6 months showed a significant change in BMI when compared to a duration of less than 6 months.	The importance of a combined diet, physical activity and behavior components were highlighted in many studies. Involving the parents directly in the treatment could yield a more effective outcome as family-based behavioral intervention showed a long-term positive outcome for	• The evidence shows that family- and school-based interventions have a considerable effect on treating childhood obesity. • However, the effectiveness of the interventional frameworks depends on factors such as age, short- or long-term outcome, and methodological quality of the trials. • Further research studies with longer intervention duration (>3 months) are

Author (Year)	Appraisal instruments and rating	Outcomes assessed	Main results and findings of systematic reviews	Strategies of effective interventions and recommendations	Conclusion and implications for research and practice
	between 8 and 10 (max), except for 1 study which reported low methodological quality due to a lack of participants and follow up data.		Parental involvement is more effective for children aged 6 to 12 than those over 12 years. Parent-only group is significantly effective compared to other groups in 2 of 3 studies. Poor compliance rate was reported in both groups in family-based intervention trials.	overweight and obese children.	required to allow behavior change and to conduct long-term follow up measurements. • Intervention effectiveness can be measured using basic primary outcomes such as weight, BMI, percentage overweight and waist circumference to avoid heterogeneity of outcome measures among the studies.
Loveman (2015)	Instruments: Risk of bias tool of the Cochrane Collaboration Trial quality was generally low due to insufficient information to assess the risk of bias. Trials were at high risk of bias on at least one domain (n=14), and at least 3 domains (n=6), respectively. Results need to be interpreted cautiously.	▪ Weight ▪ BMI ▪ BMI z-score ▪ % body fat ▪ Diet ▪ PAL ▪ Parenting	Results suggested that parent-only interventions are similar to parent-child interventions, and minimal contact interventions, but that they are better than a waiting list control. There was moderate heterogeneity (I^2 = 37%), and similar results occurred with a fixed-effect meta-analysis. All included trials had a high risk of attrition bias, many with high drop-out/loss to follow up rates (40-79%).	The interventions in the included trials predominantly focused on nutritional, physical activity and behavioral components. Few trials had similar intervention characteristics and, together with the mixture of outcomes assessed and results seen, it was difficult to establish whether there is any intervention type that is more likely to lead to a successful outcome.	• Parent-only interventions may be an effective treatment option for overweight or obese children aged 5 to 11 years when compared with waiting list controls. However, the evidence for parent-only interventions is at present limited. • There is a need to conduct and report cost-effectiveness analyses in future research to establish whether parent-only interventions are more cost-effective than parent-child interventions.
Sung Chan (2013)	Instruments: adapted Methodological Quality Rating Scales (MQRS)	▪ Weight ▪ BMI ▪ BMI z-score	Family-based model of intervention produced positive effects regarding weight loss in overweight	Family-based lifestyle interventions on healthy eating and exercising which involved primarily one parent (or whole	• Findings strongly suggest that a behavioral approach to family-based intervention consistently achieved better outcomes.

Author (Year)	Appraisal instruments and rating	Outcomes assessed	Main results and findings of systematic reviews	Strategies of effective interventions and recommendations	Conclusion and implications for research and practice
	The overall methodological rigor was satisfactory with an average score of 8 (ranged from 6 to 12 MQRS points). Ten studies (67%) scored 8 or above (out of 14). The remaining 5 studies (33%) scored an average of 6.		children. 80% of the studies indicated that weight reduction of treatment groups was significantly better than control group at the end of treatment. All 15 RCTs showed that family played an important role in lifestyle changes of overweight children. Weight-related measures used in the studies were heterogeneous, making it difficult to compare across the studies.	family) were more effective than family-based healthy lifestyle interventions that incorporated additional training in parenting style and child management. Family-based interventions rooted in behavior theory achieved better results than those theoretically connected to family systems theory in terms of treatment effectiveness.	• Future research should improve the methodological design and continue to explore the potential of the family systems approach. • There is a need to further identify the family components that can potentially mediate treatment effects. Current studies have not adequately addressed how family mediates treatment effects. • Greater attention should be given to age, gender, and culture when designing family-based interventions.
Upton (2014)	Instruments: Effective Public Health Practice Project Quality Assessment Tool for Quantitative studies None of the studies fulfilled all the quality criteria and 4 studies received moderate global ratings. Data collection methods received moderate or strong ratings, except 1 study, which used non-validated measures. All except 2 studies	▪ BMI ▪ BMI z-score	All family-based weight management programs included in the review, either targeted the parent and child only or the whole family, were effective on weight outcomes. Five studies showed short term effectiveness, except 1 study reported no change in BMI z-score post intervention although it was found that BMI z-score was maintained following the intervention. Five studies showed longer-term weight-	Most studies (70%) aimed to change behavior of both the index child and family members while the remaining 3 studies aimed to change behavior of the index child only. Most frequently used techniques in intervention components were education (n=5) and goal setting (n=5). Activity sessions were included in 4 studies, and 3 studies included parenting sessions.	• Family-based weight management programs implemented in community settings can be effective on several weight-related outcomes. • However, there is insufficient evidence to suggest how the inclusion of parents and the wider family may impact on the effectiveness of community-based weight management program for children and young people. • Programs need to be piloted before they can be further tested on a larger scale, but study design needs to be strengthened. • Future research may include longer follow-up periods and clearly address

Author (Year)	Appraisal instruments and rating	Outcomes assessed	Main results and findings of systematic reviews	Strategies of effective interventions and recommendations	Conclusion and implications for research and practice
	reported withdrawals and drop-outs.		related outcomes ranging from 12 to 24 months.		the link between parental involvement and improved weight-related outcomes.
Young (2007)	Instruments: NR	▪ Weight ▪ BMI ▪ BMI z-score ▪ % overweight	This meta-analysis indicated that interventions containing a family-behavioral component showed a greater and significant mean effect size compared to alternative treatment and control groups that also appear to be maintained across follow-up over several months.	A high level of parental involvement and multiple treatment components such as intense dietary monitoring, physical activity, and behavioral techniques, may contribute to the effectiveness of these interventions. While the present meta-analysis suggests that including parents in weight-loss intervention enhances outcomes, it does not provide clear insights into which of the many possible aspects of parental influence were modified in the intervention to produce the desired weight-loss.	• This meta-analysis illustrates that family-behavioral weight-loss treatments for children can be an effective intervention. • Remaining questions include the long-term outcomes associated with these interventions, as well as the specific components of these programs that produce effective results. • Future research should continue to examine the nature of effective family-behavioral weight loss interventions for children.

BMI: Body Mass Index; PAL: physical activity level; NR: not reported; SES: socioeconomic status; I^2: (statistics) percentage of variation across studies that is due to heterogeneity rather than chance; NICE: The National Institute for Health and Care Excellence; RCT: randomized controlled trials.

The majority of SRs evaluated family-based studies which targeted parents and children in the interventions and compared with a waitlist or no intervention control group[39, 45, 46, 50, 52, 91, 144, 155, 157, 158] and/or usual care.[39, 46, 91, 144] Six SRs evaluated parent-only interventions in comparison with a waitlist or no intervention control group[39, 41, 52, 157, 158] and/or usual care.[41] Seven SRs[41, 50, 52, 91, 144, 156, 157] examined intervention studies which compared parent-only conditions with parent-child conditions. Six SRs assessed child-only interventions and compared them with parent-only intervention arms[49, 52, 91, 157] and/or parent-child intervention arms.[49, 52, 155, 157] Two SRs[46, 144] provided a summary of the effectiveness of parent-child interventions based on different settings: family-, school-, and clinic-based interventions, in the treatment of childhood obesity. Overall, interventions have aimed to change behavior of both the index child and their parents and/or family members through targeted intervention components including dietary change, physical activity and behavior modification or cognitive behavioral therapy;[41, 45, 52] and through intervention techniques, such as nutrition and physical activity education, and goal setting.[45, 91] Dietary interventions focused on increasing healthy food consumption through the use of traffic light dietary approaches (e.g. The Stoplight Diet) or similar strategies.[50, 91, 156] Physical activity interventions aimed to increase physical activity and reduce sedentary behaviors, either through specified targets, or through individualized goal setting.[91, 156] Detailed characteristics of included SRs were summarized in Appendix 8.

2.6.4 Findings of the review

All reviews, except one,[155] found that family-based lifestyle interventions were effective, as indicated by a decrease in weight or weight-related outcomes (e.g. zBMI, percentage overweight) from baseline. The one review[155] which targeted African-American girls only was unable to draw clear conclusions due to most included studies being pilot trials with small sample sizes (n participants<50) and short duration (12 weeks or less). Overall, no studies reported adverse events. Detailed findings and interventions included in each SRs are presented in Table 2-2. Key findings for each pre-defined intervention of interest are described below. Detailed results and GRADE quality of evidence (QOE) are presented in the Summary of Findings (GRADE tables) 1 to 7 for each intervention of interest respectively.

2.6.4.1 Parent-child interventions vs Waitlist/no intervention control

Detailed results and quality of evidence were presented in the Summary of Finding 1. Eight SRs[45, 46, 52, 91, 144, 155, 157, 158] (eight trials; 581 children) and one meta-analysis[50] (three trials; 274 children) provided evidence supporting the effectiveness of parent-child interventions in reducing zBMI compared to waitlist controls after interventions ranged between three and 12 months (moderate QOE). Results from systematic reviews[45, 46, 52, 91, 144, 155, 157, 158] found greater

zBMI reduction in the active intervention groups for all but one trial and was consistent with the findings of the meta-analysis[50] of three trials. At post-intervention follow-up (ten months to two years; four trials; 288 children; low QOE) the zBMI reduction was maintained.[39, 45, 46, 52, 91, 157] Therefore, the strength of overall intervention effectiveness was awarded the color 'green'; indicating beneficial/positive intervention effects (Table 2-3). The overall QOE were rated as low to moderate quality.

BMI percentile was reported in a SR[158] (one trial; 105 children; moderate QOE) and a meta-analysis[50] (four trials; 230 children; moderate QOE). There was a greater reduction of BMI percentile by -0.5% in intervention groups (three trials), while one trial found no significant difference between groups.[50, 158] At post-intervention follow-up (three to six months; five trials; 328 children; low QOE) the BMI percentile reduction was maintained.[39, 50] The outcome overall was beneficial and consistent in SR and meta-analysis, hence, resulting in award of the color 'green'. The overall QOE were rated as low to moderate quality.

Percentage overweight was reported in a SR[158] (one trial; 40 children; moderate QOE) and a meta-analysis[50] (three trials; 167 children; moderate QOE). All four trials observed a greater reduction of percentage overweight by -0.3% in intervention groups.[50, 158] The strength of overall intervention effectiveness was awarded the color 'green'. The overall QOE were rated as moderate quality. Waist circumference was reported in four SRs[45, 46, 91, 155] (three trials; 324 children; moderate QOE), Two trials found intervention group had lower waist circumference at 6 months, and 12 months, respectively, while another trial found no difference between groups at 1 month.[45, 46, 91, 155] At post-intervention follow up (12 months; one trial; 116 children; low QOE) the waist circumference remained significantly lower.[45, 46] The strength of overall intervention effectiveness was awarded the color 'green'. The overall QOE were rated as low to moderate quality.

There were no meta-analyses that evaluated dietary changes or physical activity levels as a result of an intervention. Three SRs[46, 91, 155] (four trials; 210 children; low QOE) found interventions improve diet quality, however meta-analysis were not conducted due to the heterogeneity of the study methods as well as the dietary outcome measures used in reporting results (e.g. energy intake, nutrient intake, food groups servings). Two SRs[91, 155] (four trials; 253 children; low QOE) found physical activity levels and screen time were not different between groups (three trials) while one trial found the intervention increased physical activity levels. The overall QOE were rated as low quality.

Summary of Findings 1

1. Parent-child intervention compared to Waitlist control in childhood obesity treatment program

Patient or population: Children with overweight or obesity
Setting: Family-based (outpatients; community; schools)
Intervention: Parent-child intervention
Comparison: Waitlist or no intervention control

Outcomes (timeframe)	Review citation	Effect sizes within and between groups			№ of participants (primary studies)	Quality of the evidence (GRADE)	Comments
		Waitlist control	Parent-child	Between groups			
1.1 End of intervention results from meta-analyses							
BMI z-score (6m to 12m)	50	-	-	Parent-child interventions had lower BMI z-score by -0.36	274 (3 NRCTs) *	⊕⊕⊕◯ MODERATE [a]	Results were significant for 3 trials
BMI percentile (3m to 2y)	50	-	-	Parent-child interventions had lower BMI percentile by -0.502%	230 (4 NRCTs) *	⊕⊕⊕◯ MODERATE [a]	Significant reduction in BMI percentile for 2 trials (effect size: -1.911 and -0.835). Results were not significant for 1 trial and significance was not reported for 1 trial.
Percentage overweight (6m to 12m)	50	-	-	Parent-child interventions had lower %overweight by -0.343	167 (3 NRCTs) *	⊕⊕⊕◯ MODERATE [a]	Reduced %overweight were significant in 2 out of 3 trials.
1.2 End of intervention results from systematic reviews							
BMI z-score (3m to 12m)	45, 46, 52, 91, 144, 155, 157, 158	-0.01	-0.08 to -0.18	Parent-child interventions had lower BMI z-score by a range of -0.07 to -0.24. Control group in 1 trial had lower BMI z-score.	581 (6 RCTs, 2 NRCTs)	⊕⊕⊕◯ MODERATE [a]	2 trials reported all effect sizes, 3 reported either within or between group effect sizes, and 3 did not report any effect size. N participants were not reported for 2 trials.
BMI (1m to 12m)	39, 46, 91, 144, 155, 158	Increased (1 study)	Decreased (1 study)	Parent-child interventions had lower BMI at 1-6 months (6 trials). Control group had lower BMI at 10 weeks (1 trial). No difference between groups at 12 months (1 trial).	269 (8 RCTs)	⊕⊕◯◯ LOW [a,b]	None quantified effect sizes and all indicated direction of effects (increased or decreased BMI). N participants were not reported for 3 trials.
BMI percentile (13 wks)	158	-0.47%	-0.65%	Parent-child interventions had lower BMI percentile by -0.18%	105 (1 RCT)	⊕⊕⊕◯ MODERATE [a]	Results from only 1 trial.
Percentage overweight (7m)	158	-	-	Parent-child interventions had lower %overweight	40 (1 RCT)	⊕⊕⊕◯ MODERATE [a]	Results from only 1 trial.

1. Parent-child intervention compared to Waitlist control in childhood obesity treatment program

Patient or population: Children with overweight or obesity
Setting: Family-based (outpatients; community; schools)
Intervention: Parent-child intervention
Comparison: Waitlist or no intervention control

Outcomes (timeframe)	Review citation	Effect sizes within and between groups			№ of participants (primary studies)	Quality of the evidence (GRADE)	Comments
		Waitlist control	Parent-child	Between groups			
Weight (6m to 2yrs)	155	-	-	Parent-child interventions had lower weight at 1-2 years (2 trials). No difference between groups at 6 months (1 trial).	345 (3 RCTs)	⊕⊕⊕◯ MODERATE [a]	Results from a small number of studies.
Waist circumference (1m to 12m)	45, 46, 91, 155	-	-	Parent-child interventions had lower waist circumference at 6 months (1 trial) and at 12 months (1 trial; ES: -0.37, p<0.0001). No difference between groups at 1 month (1 trial).	324 (3 RCTs)	⊕⊕⊕◯ MODERATE [a]	Results from a small number of studies.
Body composition (6m to 2 years)	46, 155	-	-	Parent-child interventions had lower fat mass in 1 trial at 6 months. Control group had lower %body fat in 1 year (1 trial), and at 2 years (1 trial).	222 (2 RCTs, 1 NRCT)	⊕⊕◯◯ LOW [a,b]	N participants were not reported for 1 trial.
Dietary changes (1m to 12m)	46, 91, 155	-	See comment	Parent-child interventions had better diet outcome 1-12 months (3 trials). No difference between groups at 6 months (1 trial).	210 (4 RCTs)	⊕⊕◯◯ LOW [a,b]	3 trials found interventions improved diet, while 1 trial found no difference. Reduction in child's energy intake in 1 month (1 trial), increment in child's fiber intake at 12 months (1 trial). Fast food and soft drinks intakes reduced significantly and vegetables intakes increased at 10 weeks (1 trial).
Physical activity level (1m to 6m)	91, 155	-	-	No difference between groups at 1-6 months (2 trials for physical activity, 1 trial for screen time). Parent-child interventions had significantly higher physical activity at 10 weeks (1 trial).	253 (4 RCTs)	⊕⊕◯◯ LOW [a,b]	3 trials found no difference, while 1 trial found intervention is effective.
Parental outcomes (1m)	91	-	-	No difference between groups in parental BMI and waist circumference at 1 month.	43 (1 RCT)	⊕⊕◯◯ LOW [a,b]	Results from only 1 trial.

1. Parent-child intervention compared to Waitlist control in childhood obesity treatment program

Patient or population: Children with overweight or obesity
Setting: Family-based (outpatients; community; schools)
Intervention: Parent-child intervention
Comparison: Waitlist or no intervention control

Outcomes (timeframe)	Review citation	Effect sizes within and between groups			№ of participants (primary studies)	Quality of the evidence (GRADE)	Comments
		Waitlist control	Parent-child	Between groups			
1.3 Longest follow up results from systematic reviews							
BMI z-score (10m to 2y)	39, 45, 46, 52, 91, 157	+0.02	-0.08 to -0.09	Parent-child interventions had lower BMI z-score by a range of -0.11 to -0.23.	288 (4 RCTs)	⊕⊕◯◯ LOW [a,b]	2 trials reported all effect sizes, 1 reported within group effect sizes, and 1 did not report any effect size. N participants were not reported for 1 trial.
BMI (1y to 2y)	45, 46	Reduced 0.5 zBMI (target) in 12% children	Reduced 0.5 zBMI (target) in 33% children	Parent-child interventions had significant lower BMI at 1 year (1 trial) and 2 years (1 trial). 1 trial had lower BMI by 0.3 (95%CI -0.62 to 0.02; p>0.05) at 24 months.	65 (2 RCTs, 1 NRCT)	⊕⊕◯◯ LOW [a,b]	1 trial reported effect sizes. N participants were not reported for 2 trials.
BMI percentile (3m to 6m)	39, 50	-	-2.40%	Parent-child interventions had lower BMI percentile at 3 months follow up (p<0.01), and 6 months post intervention.	328 (1 RCT, 4 NRCTs)	⊕⊕◯◯ LOW [a,b]	1 trial reported effect sizes.
Waist circumference (12m)	45, 46	-	-	Parent-child interventions had significantly lower waist circumference by -0.47cm (p<0.0001).	116 (1 RCT)	⊕⊕◯◯ LOW [a,b]	-
Body composition (2y)	46	-	-	Parent-child interventions had lower %body fat .	NR (1 RCT)	⊕⊕◯◯ LOW [a,b]	-

*__The risk in the intervention group__ (and its 95% confidence interval) is based on the assumed risk in the comparison group and the **relative effect** of the intervention (and its 95% CI). **CI:** Confidence interval

GRADE Working Group grades of evidence
High quality: We are very confident that the true effect lies close to that of the estimate of the effect
Moderate quality: We are moderately confident in the effect estimate: The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different
Low quality: Our confidence in the effect estimate is limited: The true effect may be substantially different from the estimate of the effect
Very low quality: We have very little confidence in the effect estimate: The true effect is likely to be substantially different from the estimate of effect

Explanations

a. Downgraded by one level due to small sample size and small number of studies.
b. Downgraded by one level due to serious limitations in risk of bias.

2.6.4.2 Parent-child interventions vs. Usual care

Additionally, when compared to a usual care control group (six trials from four SRs; 308 children (two trials did not report sample size); low QOE), which were usually mailed

information or a workbook or minimal sessions, the parent-child interventions achieved a greater reduction in child's BMI, BMI percentile, percentage overweight, and/or weight.[39, 46, 91, 144] However, the overall QOE was rated as being of low quality, as each outcome was informed by only one trial with a small sample size (n=16 to 192). Mixed effects on zBMI were found between intervention and usual care control groups where one trial indicated intervention was effective, while another trial found no difference between the groups.[46, 91] Detailed results and quality of evidence were presented in the Summary of Findings 2.

2.6.4.3 Parent-only interventions vs Waitlist/no intervention control

Detailed results and quality of evidence were presented in Summary of Findings 3. Four SRs (seven trials; 393 children) and one meta-analysis[41] (two trials; 153 children) provided evidence supporting the effectiveness of parent-only interventions in improving child weight outcomes. Overall, when compared to a waitlist control group, parent-only interventions reduced zBMI (three trials; 224 children; moderate QOE),[41, 52, 157] BMI (three trials; 55 children; low QOE)[41, 157] and BMI percentile (one trial; 98 children; low QOE),[39, 41] while mixed results were reported for parental BMI (two trials; 169 parents; low QOE).[41] Apart from zBMI (moderate QOE), evidence on these listed outcomes were rated as low quality due to small sample sizes, the small number of studies and/or inconsistent results.

Meta-analysis[41] (two trials; 153 children; moderate QOE) which reported outcome of parent-only interventions presented results for zBMI only, and indicated that parent-only interventions had significantly lower zBMI by -0.12 following interventions that ranged between three and four months, and the changes remained significant at six to 12 months post intervention. Results from two SRs[52, 157] (one trial; 71 children; low QOE) supported the meta-analysis of two trials where zBMI reduced by -0.13 in intervention group after four months intervention, and remained lower by -0.14 than control groups at 10 months. The outcome overall is beneficial and consistent in SRs and meta-analysis, hence, resulting in award of the color 'green'. The overall QOE were rated as low to moderate quality.

Summary of Findings 2

2. Parent-child intervention compared to Usual care control in childhood obesity treatment program

Patient or population: Children with overweight or obesity
Setting: Family-based (outpatients; community; schools)
Intervention: Parent-child intervention
Comparison: Usual care control

Outcomes	Review citation	Effect sizes within and between groups			№ of participants (primary studies)	Quality of the evidence (GRADE)	Comments
		Usual care control	Parent-child	Between groups			
2.1 End of intervention results from systematic reviews							
BMI z-score (6m)	46, 91	-	-	Mixed effects ranged from no difference between groups (1 trial) to Parent-child interventions had lower BMI z-score (1 trial).	16 (2 RCTs)	⊕⊕◯◯ LOW [a,b]	Mixed effects. N participants were not reported for 1 trial that found no difference.
BMI (6m)	46	-	-	Parent-child interventions had lower BMI.	NR (1 RCT)	⊕⊕◯◯ LOW [a,b]	Results from only 1 trial.
BMI percentile (12w)	39	No change	Decreased; p<0.01	Parent-child interventions had significant lower BMI percentile.	84 (1 RCT)	⊕⊕◯◯ LOW [a,b]	Results from only 1 trial.
Percentage overweight (6m)	144	-0.66%	-7.58%	Parent-child interventions had lower %overweight by -0.0758 at 6 months.	192 (1 RCT)	⊕⊕⊕◯ MODERATE [a]	Results from only 1 trial.
Weight (6m)	46, 91	-	-	Parent-child interventions had significant lower weight.	16 (1 RCT)	⊕⊕◯◯ LOW [a,b]	Results from only 1 trial.
2.2 Longest follow up results from systematic reviews							
BMI z-score (12m)	46, 91	-	-	Parent-child interventions had significant reduction in BMI z-score at 12 months.	16 (1 RCT)	⊕⊕◯◯ LOW [a,b]	Results from only 1 trial.
Percentage overweight (12m & 18m)	144	-	-	No difference between groups in percentage overweight at 12- and 18-months follow up.	192 (1 RCT)	⊕⊕⊕◯ MODERATE [a]	Results from only 1 trial.

***The risk in the intervention group** (and its 95% confidence interval) is based on the assumed risk in the comparison group and the **relative effect** of the intervention (and its 95% CI). **CI:** Confidence interval

GRADE Working Group grades of evidence
High quality: We are very confident that the true effect lies close to that of the estimate of the effect
Moderate quality: We are moderately confident in the effect estimate: The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different
Low quality: Our confidence in the effect estimate is limited: The true effect may be substantially different from the estimate of the effect
Very low quality: We have very little confidence in the effect estimate: The true effect is likely to be substantially different from the estimate of effect

Explanations

a. Downgraded by one level due to small sample size and small number of studies.
b. Downgraded by one level due to serious limitations in risk of bias.

Summary of Findings 3

3. Parent-only intervention compared to Waitlist control in childhood obesity treatment program

Patient or population: Children with overweight or obesity
Setting: Family-based (outpatients; community; schools)
Intervention: Parent-only intervention
Comparison: Waitlist or no intervention control

Outcomes	Review citation	Effect sizes within and between groups			№ of participants (primary studies)	Quality of the evidence (GRADE)	Comments
		Waitlist control	Parent-only	Between groups			
3.1 End of intervention results from meta-analyses							
BMI z-score (3m to 4m)	41	-0.01 (0.46) to -0.01 (0.15)	-0.11 (0.44) to -0.14 (0.19)	Parent-only interventions had significantly lower BMI z-score by -0.12 [95%CI -0.21,-0.04; p=<0.005; I^2=0].	153 (2 RCTs)	⊕⊕⊕◯ MODERATE [a]	Results from a small number of studies.
3.2 End of intervention results from systematic reviews							
BMI z-score (4m)	52, 157	-0.01 (0.15)	-0.14 (0.19)	Parent-only interventions had significantly lower BMI z-score by -0.13 [95%CI 0.027,0.226; p=<0.05].	71 (1 RCT)	⊕⊕◯◯ LOW [a,b]	Results from only 1 trial.
BMI (3m to 6m)	41, 157	-0.1 to -0.15	-1.6 to -2.43	Parent-only interventions had significantly lower BMI by a range of -1.6 to -2.28.	55 (3 RCTs)	⊕⊕◯◯ LOW [a,b]	Results from a small number of studies.
BMI percentile (10w)	39, 41	0.1 (3.52)	-2.3 (5.66)	Parent-only interventions had lower BMI percentile by -2.4 [95%CI -4.22,-0.58].	98 (1 RCT)	⊕⊕◯◯ LOW [a,b]	Results from only 1 trial.
Parental outcomes (10w to 5m)	41	-0.7 to +0.1	-0.3 to -0.9	Parent-only interventions had lower Parental BMI by -0.4 at 10 weeks (1 trial). No difference between groups at 5 months (1 trial).	169 (2 RCTs)	⊕⊕◯◯ LOW [a,c]	Mixed effects. Results from a small number of studies.
3.3 Longest follow up results from meta-analyses							
BMI z-score (6m to 12m)	41	-	-	Parent-only interventions had significantly lower BMI z-score by -0.1 [95%CI -0.19,-0.01; p=<0.05; I^2=0].	136 (2 RCTs)	⊕⊕⊕◯ MODERATE [a]	Results from a small number of studies.
3.4 Longest follow up results from systematic reviews							
BMI z-score (10m)	52, 157	0.02 (0.17)	-0.12 (0.22)	Parent-only interventions had lower BMI z-score by -0.14.	71 (1 RCT)	⊕⊕◯◯ LOW [a,b]	Results from only 1 trial.
BMI (3m & 10m post intervention)	41, 158	0.68	-0.3 to -1.18	Parent-only interventions had lower BMI by a range of -0.98 to -1.86.	52 (3 RCTs)	⊕⊕⊕◯ MODERATE [a]	Results from a small number of studies.
BMI percentile (6m post intervention)	41	-0.2 (3.67)	-2.1 (5.71)	Parent-only interventions had lower BMI percentile by -1.9 [95%CI -3.76,-0.04]..	98 (1 RCT)	⊕⊕⊕◯ MODERATE [a]	Results from only 1 trial.

3. Parent-only intervention compared to Waitlist control in childhood obesity treatment program

Patient or population: Children with overweight or obesity
Setting: Family-based (outpatients; community; schools)
Intervention: Parent-only intervention
Comparison: Waitlist or no intervention control

Outcomes	Review citation	Effect sizes within and between groups			№ of participants (primary studies)	Quality of the evidence (GRADE)	Comments
		Waitlist control	Parent-only	Between groups			
Parental outcomes (6m & 10m)	[41]	-0.6 to +0.1	-0.2 to -0.6	Parent-only interventions had lower Parental BMI by -0.3 at 6 months (1 trial). No difference between groups at 10 months (1 trial).	169 (2 RCTs)	⊕⊕◯◯ LOW [a,b]	Mixed effects. Results from a small number of studies.

*__The risk in the intervention group__ (and its 95% confidence interval) is based on the assumed risk in the comparison group and the **relative effect** of the intervention (and its 95% CI). **CI:** Confidence interval

GRADE Working Group grades of evidence
High quality: We are very confident that the true effect lies close to that of the estimate of the effect
Moderate quality: We are moderately confident in the effect estimate: The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different
Low quality: Our confidence in the effect estimate is limited: The true effect may be substantially different from the estimate of the effect
Very low quality: We have very little confidence in the effect estimate: The true effect is likely to be substantially different from the estimate of effect

Explanations

a. Downgraded by one level due to small sample size and small number of studies.
b. Downgraded by one level due to serious limitations in risk of bias.
c. Downgraded by one level due to serious limitations in inconsistency.

2.6.4.4 Parent-only interventions vs. Usual care

Detailed results and quality of evidence were presented in Summary of Findings 4. There was a smaller number of SRs that compared parent-only interventions with a usual care control group (seven trials from one SR; 925 children; moderate QOE) which were usually mailed information or a workbook or minimal sessions. Only one trial (170 children) reported zBMI and found no significant difference between groups after a three to six-month intervention (low QOE).[41] Five trials from one SR (648 children; moderate QOE) assessed BMI percentile while only one trial (107 children; low QOE) assessed BMI, and all reported a greater reduction in intervention groups.[41] Overall, no trial has reported negative effects (ineffective) on weight-related outcomes for parent-only interventions. At post-intervention follow up (six to 24 months), parent-only interventions had greater reduction in BMI (two trials; 614 children; moderate QOE) and BMI percentile (one trial; 60 children; moderate QOE); and no differences in zBMI (one trial; 165 children; low QOE) compared to usual care control groups.[41, 52, 157] The overall QOE were rated as low to moderate quality.

Summary of Findings 4

4. Parent-only intervention compared to Usual care control in childhood obesity treatment program

Patient or population: Children with overweight or obesity
Setting: Family-based (outpatients; community; schools)
Intervention: Parent-only intervention
Comparison: Usual care control

Outcomes	Review citation	Effect sizes within and between groups			№ of participants (primary studies)	Quality of the evidence (GRADE)	Comments
		Usual care control	Parent-only	Between groups			
4.1 End of intervention results from meta-analyses							
BMI z-score (3m to 6m)	[41]	-0.05 (0.16)	-0.03 (0.35) to -0.07 (0.35)	No difference between groups [95%CI -0.08, 0.08; p=0.99; I^2=0].	170 (1 RCT)	⊕⊕◯◯ LOW [a,b]	Results from only 1 trial, comparing two Parent-only intervention conditions with one control conditions.
4.2 End of intervention results from systematic reviews							
BMI (6m)	[41]	0.5 (1.85)	0.1 (2.25)	Both groups had increased BMI at follow up, however, Parent-only interventions had lower BMI by -0.42 [95%CI -1.18, 0.38].	107 (1 RCT)	⊕⊕◯◯ LOW [a,b]	Results from only 1 trial.
BMI percentile (12w to 2y)	[41]	0 to -1.8	-0.28 to -4.9	Parent-only interventions had lower BMI percentile by a range of -0.28 to -3.1.	648 (5 RCTs)	⊕⊕⊕◯ MODERATE [a]	None of the studies demonstrated treatment effects. These could not be pooled because of lack of standardisation. Sample sizes ranged from 43 to 237 participants.
4.3 Longest follow up results from meta-analyses							
BMI z-score (9m to 12m)	[41, 52, 157]	-0.06 (0.16)	-0.02 (0.34) to -0.08 (0.35)	No significant difference between groups. Mean difference was 0.01 [95%CI -0.07, 0.09; p=0.81; I^2=0].	165 (1 RCT)	⊕⊕◯◯ LOW [a,b]	Results from only 1 trial, comparing two Parent-only intervention conditions with one control conditions.
BMI (up to 2y)	[41]	1.3 (1.98) to 1.44 (1.71)	0.8 (2.25) to 1.37 (1.53)	Both groups had increased BMI at follow up, however, Parent-only interventions had lower BMI by -0.12 [95%CI -0.39, 0.15; p=0.39; I^2=0].	614 (2 RCTs)	⊕⊕⊕◯ MODERATE [a]	Results from a small number of studies. One study did not report the duration of follow-up after the six month intervention; in the other study, follow-up was at 24 months
4.4 Longest follow up results from systematic reviews							
BMI percentile (6m post intervention)	[41]	-0.66 (5.41)	-1.59 (4.53)	Parent-only interventions had lower BMI percentile by -0.93 [95%CI -3.49, 1.63; p=NR; I^2=nil] at 6 months post intervention. PO: -1.59 (4.53); WC: -0.66 (5.41)	60 (1 RCT)	⊕⊕⊕◯ MODERATE [a]	Results from only 1 trial.

4. Parent-only intervention compared to Usual care control in childhood obesity treatment program

Patient or population: Children with overweight or obesity
Setting: Family-based (outpatients; community; schools)
Intervention: Parent-only intervention
Comparison: Usual care control

Outcomes	Review citation	Effect sizes within and between groups			№ of participants (primary studies)	Quality of the evidence (GRADE)	Comments
		Usual care control	Parent-only	Between groups			

*__The risk in the intervention group__ (and its 95% confidence interval) is based on the assumed risk in the comparison group and the **relative effect** of the intervention (and its 95% CI). **CI:** Confidence interval

GRADE Working Group grades of evidence
High quality: We are very confident that the true effect lies close to that of the estimate of the effect
Moderate quality: We are moderately confident in the effect estimate: The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different
Low quality: Our confidence in the effect estimate is limited: The true effect may be substantially different from the estimate of the effect
Very low quality: We have very little confidence in the effect estimate: The true effect is likely to be substantially different from the estimate of effect

Explanations

a. Downgraded by one level due to small sample size and small number of studies.
b. Downgraded by one level due to serious limitations in risk of bias.

2.6.4.5 Parent-only vs Parent-child interventions

Detailed results and quality of evidence were presented in the Summary of Findings 5. Three SRs[41, 52, 144] (three trials; 164 children) and three meta-analyses[41, 50, 156] (five trials; 402 children) reported zBMI at the end of the interventions (10 weeks to six months). Results from meta-analyses[41, 50, 156] showed no significant difference in zBMI (moderate QOE) between the two interventions. Systematic reviews[41, 52, 144] also reported consistent zBMI reduction in both groups (low QOE). Given there was no significant difference between parent-only interventions and parent-child interventions, the color 'amber' was awarded suggesting that both interventions are equally beneficial. The overall QOE were rated as low to moderate quality.

BMI percentile was reported in a SR,[52] parental BMI was reported in a SR,[41] and percentage of children who were overweight was reported in four SRs.[41, 52, 91, 157] Overall, there was no significant difference in child BMI percentile (one trial from one SR; 80 children; low QOE)[52] and parental BMI (three trials from one SR; 207 parents; low QOE)[41] between parent-only interventions and parent-child interventions. Mixed findings were reported for the percentage of children who were overweight (two trials from four SRs; 88 children; low QOE);[41, 52, 91, 157] with one trial reporting a greater reduction in parent-only intervention groups while the other trial found no difference between groups (percentage of children who were overweight reduced in both groups). No trial reported that parent-only interventions were less effective in comparison to parent-child interventions on the above outcomes.

Summary of Findings 5

5. Parent-only intervention compared to Parent-child intervention in childhood obesity treatment program

Patient or population: Children with overweight or obesity
Setting: Family-based (outpatients; community; schools)
Intervention: Parent-only intervention
Comparison: Parent-child intervention

Outcomes	Review citation	Effect sizes within and between groups			№ of participants (primary studies)	Quality of the evidence (GRADE)	Comments
		Parent-child	Parent-only	Between groups			
5.1 End of intervention results from meta-analyses							
BMI z-score (4m to 6m)	[50]	-0.423	-0.73	Parent-only interventions had lower BMI z-score by 0.152.	125 (2 NRCTs)	⊕⊕⊕◯ MODERATE [a]	Results from a small number of non-randomised controlled studies.
BMI z-score (4m to 6m)	[156]	0.08(0.72) to -0.17(0.82)	-14(0.78) to -0.4(0.96)	Parent-only interventions had lower BMI z-score by -0.16 [95%CI -0.44,0.11; p=NS; I^2=0], however, difference was not insignificant.	210 (3 RCTs)*	⊕⊕⊕◯ MODERATE [a]	Results from a small number of studies. All 3 studies in Jull 2015 also included in Loveman 2015.
BMI z-score (10w to 6m)	[41]	-	-	Parent-only interventions had lower BMI z-score by -0.06 [95%CI -0.13,0.02; p=NS; I^2=0.37], however, difference was not insignificant.	277 (3 RCTs)*	⊕⊕⊕◯ MODERATE [a]	Results from a small number of studies. All 3 studies in Jull 2015 also included in Loveman 2015.
5.2 End of intervention results from systematic reviews							
BMI z-score (10w to 6m)	[41, 52, 144]	-0.08 to -0.1	-0.14 to -0.4	Parent-only interventions had lower BMI z-score by a range of -0.06 to -0.3. Difference between groups was significant for 1 trial, insignificant for 1 trial, and p-value not reported for 1 trial.	164 (3 RCTs)	⊕⊕◯◯ LOW [a,b]	Results from a small sample sizes and small number of studies.
BMI percentile (5m)	[52]	-1.13	-1.55	Parent-only interventions had lower BMI percentile by -0.42, however difference was insignificant.	80 (1 RCT)	⊕⊕◯◯ LOW [a,b]	Results from only 1 trial.
Percentage overweight (10w to 6m)	[41, 52, 91, 157]	-1.91% to -2.5%	-4.52% to -9.5%	Parent-only interventions had significantly lower %overweight by a range of -2.61% (p>0.05; 1 trial) to -7% (p<0.05; 1 trial).	88 (2 RCTs)	⊕⊕◯◯ LOW [a,b]	Results from a small sample sizes and small number of studies.
Parental outcomes (10w to 5m)	[41]	-0.04 to -0.7	0.1 to -0.9	No significant difference between groups in Parental BMI.	207 (3 RCTs)	⊕⊕◯◯ LOW [a,b]	Mixed effects. Results from a small number of studies.
5.3 Longest follow up results from meta-analyses							
BMI z-score (10m to 11m)	[156]	-0.12 (0.15 to 0.22)	-0.09(0.2) to -0.18(0.34)	No significant difference between groups.	102 (2 RCTs)	⊕⊕⊕◯ MODERATE [a]	Results from a small sample sizes and small number of studies.

5. Parent-only intervention compared to Parent-child intervention in childhood obesity treatment program

Patient or population: Children with overweight or obesity
Setting: Family-based (outpatients; community; schools)
Intervention: Parent-only intervention
Comparison: Parent-child intervention

Outcomes	Review citation	Effect sizes within and between groups			№ of participants (primary studies)	Quality of the evidence (GRADE)	Comments
		Parent-child	Parent-only	Between groups			
BMI z-score (6m to 18m)	[41]	-0.09 to -0.35	-0.16 to -0.24	Parent-only interventions had lower BMI z-score by -0.04 [95%CI 0.15,0.08; p=NS; I^2=0.38], however, difference was not insignificant.	267 (3 RCTs)	⊕⊕⊕◯ MODERATE [a]	Results from a small sample sizes and small number of studies.
5.4 Longest follow up results from systematic reviews							
BMI z-score (10m to 2y)	[41, 52]	0.1 to -0.32	-0.09 to -0.5	Parent-only interventions had significantly lower BMI z-score by -0.6 (p<0.01) in 1 trial, and no significant differences between groups in 3 other trials.	329 (4 RCTs)	⊕⊕◯◯ LOW [a,b]	Results from a small sample sizes and small number of studies.
BMI percentile (11m)	[52]	0.02	-1.74	No difference between groups in BMI percentile.	80 (1 RCT)	⊕⊕◯◯ LOW [a,b]	Results from only 1 trial.
Percentage overweight (6m to 12m)	[41, 52, 91, 157]	4 to -1.91	-4.52 to -12	Parent-only interventions had significantly lower percentage overweight by -12.4% (p=<0.05) in 1 trial, and no significant differences between groups in 1 other trial.	88 (2 RCTs)	⊕⊕◯◯ LOW [a,b]	Results from a small sample sizes and small number of studies.
Parental outcomes (6m to 11m)	[41]	+0.3 to -0.2	+0.1 to -0.6	No significant difference between groups in Parental BMI.	207 (3 RCTs)	⊕⊕⊕◯ MODERATE [a]	Results from a small sample sizes and small number of studies.

***The risk in the intervention group** (and its 95% confidence interval) is based on the assumed risk in the comparison group and the **relative effect** of the intervention (and its 95% CI). **CI:** Confidence interval. **NS**: Not significant.

GRADE Working Group grades of evidence
High quality: We are very confident that the true effect lies close to that of the estimate of the effect
Moderate quality: We are moderately confident in the effect estimate: The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different
Low quality: Our confidence in the effect estimate is limited: The true effect may be substantially different from the estimate of the effect
Very low quality: We have very little confidence in the effect estimate: The true effect is likely to be substantially different from the estimate of effect

Explanations

a. Downgraded by one level due to small sample size and small number of studies.
b. Downgraded by one level due to serious limitations in risk of bias.

2.6.4.6 Child-only vs parent-only or parent-child interventions

For the purpose of comparing interventions with parental involvement to those without parental involvement, this section presented results of the two remaining intervention categories specified in the data summary section: 'Parent-only interventions vs. Child-only interventions', and 'Parent-child interventions vs. Child-only interventions'. Detailed results and quality of evidence were presented in the Summary of Findings 6 and Summary of Findings 7. There was limited evidence that compared parent-child and child-only interventions (10 trials from five SRs; 546 children; moderate to low QOE),[49, 52, 155, 157, 158] and even fewer studies that compared parent-only and child-only interventions (three trials from four SRs; 181 children; low QOE).[49, 52, 91, 157] Overall, no trial reported that child-only interventions were more effective than interventions with parental involvements. Parent-only and/or parent-child interventions have demonstrated positive improvement on weight (three trials from one SR; 91 children; low QOE),[49] zBMI (two trials from one SR; 236 children; low QOE),[52] BMI (one trial from one SR; 36 children; moderate QOE),[155] percentage overweight (six trials from five SRs; 288 children; moderate QOE), [49, 52, 91, 157, 158] parental weight (one trial from one SR; 76 parents; low QOE)[49] during follow up at one to seven year/s. The overall QOE were rated as low quality.

Summary of Findings 6

6. Parent-only intervention compared to Child-only intervention in childhood obesity treatment program

Patient or population: Children with overweight or obesity
Setting: Family-based (outpatients; community; schools)
Intervention: Parent-only intervention
Comparison: Child-only control

Outcomes	Review citation	Effect sizes within and between groups			№ of participants (primary studies)	Quality of the evidence (GRADE)	Comments
		Child-only	Parent-only	Between groups			
6.1 End of intervention results from systematic reviews							
Percentage overweight (1y)	[49, 52, 91, 157]	-8.10%	-14.60%	Parent-only interventions had significantly lower percentage overweight by -0.065 [p=<0.05].	60 (1 RCT)	⊕⊕◯◯ LOW [a,b]	Results from only 1 trial.
6.2 Longest follow up results from systematic reviews							
BMI z-score (12m & 24m)	[52]	-0.17 to -0.19	-0.35 to -0.39	Parent-only interventions (diet focused) had greater BMI z-score reduction than Child-only interventions (physical activity focused) by -0.22 [95%CI -0.38,-0.06] at 12 months and by -0.17 [95%CI -0.34,0.01] at 24 months.	71 (1 RCT)	⊕⊕◯◯ LOW [a,b]	Results from only 1 trial.
Percentage overweight (1y, 2y & 7y)	[91]	-20%	-29%	Parent-only interventions had significantly lower %overweight (p=<0.005) at 2 years and remained lower at 7 years from baseline.	50 (1 RCT)	⊕⊕◯◯ LOW [a,b]	Results from only 1 trial.

***The risk in the intervention group** (and its 95% confidence interval) is based on the assumed risk in the comparison group and the **relative effect** of the intervention (and its 95% CI). **CI:** Confidence interval

GRADE Working Group grades of evidence
High quality: We are very confident that the true effect lies close to that of the estimate of the effect
Moderate quality: We are moderately confident in the effect estimate: The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different
Low quality: Our confidence in the effect estimate is limited: The true effect may be substantially different from the estimate of the effect
Very low quality: We have very little confidence in the effect estimate: The true effect is likely to be substantially different from the estimate of effect

Explanations

a. Downgraded by one level due to small sample size and small number of studies.
b. Downgraded by one level due to serious limitations in risk of bias.

Summary of Findings 7

7. Parent-child intervention compared to Child-only intervention in childhood obesity treatment program

Patient or population: Children with overweight or obesity
Setting: Family-based (outpatients; community; schools)
Intervention: Parent-child intervention
Comparison: Child-only control

Outcomes	Review citation	Effect sizes within and between groups			№ of participants (primary studies)	Quality of the evidence (GRADE)	Comments
		Child-only	Parent-child	Between groups			
7.1 End of intervention results from systematic reviews							
BMI (16w)	[155]	-	Decreased (p<0.05)	Parent-child interventions had lower BMI.	36 (1 RCT)	⊕⊕⊕◯ MODERATE [a]	Results from only 1 trial.
Percentage overweight (18w)	[157]	-5.10%	-8.60%	Parent-child interventions had lower %overweight by -0.035	31 (1 RCT)	⊕⊕◯◯ LOW [a,b]	Results from only 1 trial.
Weight (16w)	[49]	-3.3 kg	-5.3 to -8.4 kg	Parent-child interventions had lower weight in all 3 trials, by a range of -2 to -5.1 kg (from 2 trials), with significant p<0.05 in 2 trials, while p-value not reported in 1 trial.	91 (3 RCTs)	⊕⊕◯◯ LOW [a,b]	Results from a small sample sizes and small number of studies.
Parental outcomes (8m)	[49]	-	Decreased (p<0.01)	Parent-child interventions had significantly lower parental weight by -2.0 (p=<0.01)	76 (1 RCT)	⊕⊕◯◯ LOW [a,b]	Results from only 1 trial.
7.2 Longest follow up results from systematic reviews							
BMI z-score (12m & 24m)	[52]	-	-	Parent-child interventions had significantly lower BMI z-score by -0.13 [95%CI 0.027,0.226; p=<0.05].	165 (1 RCT)	⊕⊕◯◯ LOW [a,b]	Results from only 1 trial.
Percentage overweight (9m to 5y)	[49, 157, 158]	4.3 to -8.2	-7.1 to -14	Parent-child interventions had lower %overweight by a range of -0.2% to -18.3%	147 (3 RCTs)	⊕⊕◯◯ LOW [a,b]	Results from a small sample sizes and small number of studies.

***The risk in the intervention group** (and its 95% confidence interval) is based on the assumed risk in the comparison group and the **relative effect** of the intervention (and its 95% CI). **CI:** Confidence interval

GRADE Working Group grades of evidence
High quality: We are very confident that the true effect lies close to that of the estimate of the effect
Moderate quality: We are moderately confident in the effect estimate: The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different
Low quality: Our confidence in the effect estimate is limited: The true effect may be substantially different from the estimate of the effect
Very low quality: We have very little confidence in the effect estimate: The true effect is likely to be substantially different from the estimate of effect

Explanations

a. Downgraded by one level due to small sample size and small number of studies.
b. Downgraded by one level due to serious limitations in risk of bias.

2.7 Summary of Evidence

The strength of overall intervention effectiveness immediately post intervention is presented in the Summary of Evidence (Table 2-3) using a traffic-light visual indicator. Parent-child and parent-only interventions were awarded the color 'green' on most outcomes indicating interventions were effective or beneficial in improving weight-related outcomes. No intervention receives a 'red' indicator, meaning no intervention had a detrimental or less-effective impact when compared to the comparator group.

Table 2-3 Summary of evidence

	N	zBMI	BMI	BMI percentile	Percentage overweight	Weight	Waist circumference	Body composition	Diet	PAL/ SB	Parental outcomes
PC vs WC	46	11 [39, 46, 49, 50, 52, 91, 155-157]	8 [46, 50, 52, 144, 155-157]	5 [157]	4 [155, 157]	3 [50]	3 [50, 52, 91, 156]	3 [50, 52]	4 [50, 52, 156]	4 [50, 156]	1 [156]
PC vs UC	6	2 [52, 156]	1 [52]	1 [144]	1 [46]	1 [52, 156]	-	-	-	-	-
PO vs WC	9	3 [39, 41, 49]	3 [39, 41]	1 [41, 144]	-	-	-	-	-	-	2 [41]
PO vs UC	7	1 [41]	1 [41]	5 [41]	-	-	-	-	-	-	-
PO vs PC	11	5 [41, 46, 49, 155, 158]	-	1 [49]	2 [39, 41, 49, 156]	-	-	-	-	-	3 [41]
PO vs CO	2	-	-	-	2 [39, 45, 49, 156]	-	-	-	-	-	-
PC vs CO	6	-	1 [50]	-	1 [39]	3 [45]	-	-	-	-	1 [45]

N: number of primary trials; zBMI: BMI z-scores; BMI: Body Mass Index; PAL: physical activity level; SB: sedentary behaviour; PC: parent-child interventions; WC: waitlist control; UC: usual care control; PO: parent-only interventions; CO: child-only interventions; numbers in superscript are citations of included systematic reviews; traffic-light visual indicator for effectiveness immediately end of intervention: Green indicates an effective or beneficial intervention; Amber indicates no intervention effect or no difference when compared to the comparator, or unclear effect due to insufficient information; and Red indicates a detrimental or less-effective intervention when compared to the comparator.

In summary, family-based behavioral lifestyle interventions targeting parents, with or without child involvement can be effective in achieving successful weight change outcomes in children aged two to 18 years. When compared to a waitlist control group, parent-child interventions[39, 46, 49, 50, 52, 91, 144, 155-157] (one month to two years follow up) and parent-only interventions[39, 41, 49, 144] (10 weeks to 10 months follow up) were both effective in improving weight-related outcomes, such as a reduction in zBMI, BMI and BMI percentile. However, these interventions did not result in an impact on parent outcomes, including parents' BMI, waist circumference, and/or weight.[41, 156] A smaller number of studies compared parent-child interventions[52, 144, 156] or parent-only interventions[41] to a usual care control group (mailed information or a workbook or minimal sessions) and the outcomes indicated that multi-component and more intensive interventions, defined as a high level of parental involvement and multiple treatment components such as intense dietary monitoring, physical activity, and behavioral techniques,

with a focus on nutrition, physical activity and behavior modification had greater overall effectiveness.[41, 52, 144, 156] Both parent-child interventions and parent-only interventions showed greater effectiveness when compared to child-only interventions, despite the limited number of studies reporting such comparisons.[39, 45, 49, 50, 156] These overall findings are supported by evidence showing multi-component interventions with higher intensity or greater parental involvement were usually more effective in improving child weight outcomes.[40, 50]

While interventions for children often require parents to be involved, SRs and meta-analyses suggest that interventions with parents only are equally effective when compared to interventions with parents and children.[41, 52, 91, 144, 156] Five SRs indicated that parent-only interventions had similar (four SRs);[41, 52, 144, 156] or greater (one SR)[91] effectiveness compared to parent-child interventions. However, all 14 SRs have included interventions with parental involvement, but did not specify clearly whether mothers, fathers or both parents participated in the interventions. This has prevented the umbrella review from further synthesizing the results by sub-categories to compare intervention effectiveness by different parental roles (e.g. mother-child vs father-child interventions). There was an insufficient number of SRs reporting behavioral outcomes (secondary outcomes) such as dietary intake and physical activity to draw any conclusions regarding such parameters. Hence, intervention effectiveness in the present review mainly refers to improvement in weight, body composition, and weight-related anthropometric indicators.

2.8 Discussion

The current umbrella review has systematically identified, synthesized, and graded a wide range of evidence on the effectiveness of targeting parents within individual-level treatment interventions for relative weight loss or weight maintenance in children aged 18 years and under who were overweight or obese. Results indicate that family-based behavioral interventions appear to be an effective strategy for weight management in children aged between two and 18 years, as indicated by a reduction in weight or weight-related outcomes (e.g. zBMI, percentage overweight) from baseline. The findings of the current umbrella review are similar to a previous umbrella review which assessed only RCTs with longer term intervention duration (≥6 months) in child weight management.[56] The SRs found that a comprehensive multi-component intervention is effective in improving child metabolic and anthropometric measures, and appears to have the best overall outcomes when compared to single component interventions focused on physical activity, diet, education, pharmacological, or surgical approach.[56] The effectiveness of a multi-component intervention combining dietary advice, physical activity, and behavior modification was also frequently mentioned in the SRs included in the current umbrella review.[40, 144] Evidence consistently supports the effectiveness of childhood obesity interventions that set goals for behavior change, such as consuming five

servings of fruits and vegetables each day and replacing sugar sweetened beverages with sugar-free beverages.[91] Studies to date have recommended interventions that engage children in 60 minutes of moderate to vigorously intense physical activity on most days of the week, and limit screen time (leisure television and computer use) to no more than two hours per day.[91] These findings are consistent with the Australia's Physical Activity and Sedentary Behavior Guidelines for Children (five to 12 years).[90] The recent Australian 24-Hour Movement Guidelines for the Early Years recommend that preschoolers aged two to five years spend at least 60 minutes throughout the day in energetic play including; running, jumping, kicking, and throwing, and to limit screen time to no more than one hour per day.[90] However, within the included SRs, there was a lack of reporting on behavioral change such as dietary intake and physical activity as a result of the interventions.

Parents, as the gate keeper of the family food supply and as nutrition role models for their children, have a major influence on their children's eating habits.[35, 36, 159, 160] It is acknowledged that parents may play different roles as children age, however, the involvement of parents in intervention is essential and this is supported by evidence showing that parent's weight and lifestyle behavior are related to that of their children.[38, 161, 162] Family-based interventions included in the current umbrella review have directly involved one or both parents,[144, 158] and/or included family members or siblings[49, 50] in the treatment, and these interventions demonstrated greater effectiveness compared to control groups without parental or family involvement. Although the existing SRs suggest that including parents in weight management interventions enhances outcomes, they do not provide clear insights into which of the many possible aspects of parental influence were modified in the interventions and were key to achieving the desired weight outcomes (e.g. feeding practices, food parenting).[40] An SR of nine trials reported that no clear pattern emerged in terms of physical activity intervention effectiveness related to family member involvement (whole family, parents and the index child, or child only), goal of the family member, format of the intervention delivery (parents and child together or in separate groups) or age of child.[155]

Few weight management intervention trials had similar intervention characteristics and, together with the mixed outcomes assessed and reported results, it was difficult to establish whether there is any particular intervention type (parent-only vs parent-child) that is more likely to lead to a successful outcome in terms of change in child weight outcomes.[41] Nevertheless, the current umbrella review found that no intervention had a detrimental or not effective impact on child weight-related outcomes when compared to the comparator control group. Studies suggest that if parents recognize the importance of their child's weight, they will be motivated to influence their children in terms of lifestyle behaviors related to weight control.[46] Encouraging participating family members to change their own behaviors and reduce their

own body weight may be an effective strategy for overweight children in terms of reducing excess weight or preventing further weight gain.[155]

Evidence also indicates that low parental self-confidence predicts dropout rates in family-based behavioral treatment,[46] with one SR[39] of seven trials indicating potential predictors of program success (greater reduction in child BMI) included higher parental motivation, lower baseline BMI percentile in children, higher parental attendance, younger children, and lower socioeconomic status. Future interventions could include strategies targeting parents' self-confidence to actively engage them in interventions and to motivate and encourage them to be good role models for their children by improving their lifestyle behaviors.

There was emerging evidence indicating that parent-only interventions are as effective, if not more effective, in improving child weight and/or weight-related behavior as parent-child interventions.[41, 52, 91, 144, 156] The primary modality of intervention delivered to parents was through face-to-face educational sessions.[91] Key strategies targeting parents included providing education on healthy eating and physical activity, fostering the development of parenting skills to promote positive health behaviors in children, and coping with difficult situations.[39, 156] Interventions targeted nutrition and/or physical activity education along with parenting skills showed larger and more significant changes compared to interventions with education plus behavioral control components.[50] Effectiveness has been demonstrated in child weight management interventions that target parents as the agent of change through education sessions on nutrition and/or physical activity, authoritative parenting styles (setting boundaries, provide nurturing environment), positive parenting skills (self-monitoring, reinforcement, role modelling), and child behavior management strategies to encourage positive behaviors in weight management programs for overweight children.[157] Interventions targeting parents to improve self-efficacy and confidence in managing health behavior also assist in forming positive lifestyle habits within the family.[161, 163, 164] It is therefore important to note that interventions that involve parents only are likely to be less costly than interventions that involve the whole family, especially when parents and children are in separate groups.[45] However, the most commonly involved populations within the included SRs were children aged between six to 13 years when parents were usually the gate keeper of the family food supply. Parents' roles usually evolve as their children grow into adolescence and begin to gain more control and independence in making decisions including food preferences, such as lunchbox meals and snack choices, when eating at home or eating out with peers. Therefore, parent-only approaches for families with adolescents may be need to be different from those with younger children. Nevertheless, there are numerous issues to consider due to the lack of high quality evidence and high attrition rates in parent-only interventions. Further investigations are warranted to explore whether parent-only interventions are more cost-

effective and sustainable,[41, 52] and to examine the barriers to participation and other complexities behind higher attrition rates in parent-only interventions through qualitative research.[52]

While previous research supports effective interventions that involve greater parental involvement as a whole, the majority of interventions targeting parents did not clearly specify whether mothers or fathers were involved.[39] Whenever mentioned, studies commonly refer only to maternal involvement, with the paternal role generally overlooked.[60-63] A recent systematic review seeking to assess father involvement in pediatric obesity prevention trials found that only 6% of parents in studies limited to one parent participation were fathers (N=123).[64] While only 2% of included studies identified a lack of paternal participation as a potential limitation, 99% included studies did not explicitly attempt to engage with fathers.[64] However, evidence shows that fathers are involved in child feeding, cooking, shopping and food choices,[65] as well as other aspects of child health and wellbeing.[62] Paternal BMI has been reported to be more strongly linked to childhood obesity than maternal BMI.[66] This suggests that the beliefs and behaviors of fathers need to be taken into account when implementing weight related lifestyle intervention within the family.[165] Future research should consider actively engaging both mothers and fathers in parent-targeted interventions for child weight management.

The current umbrella review had a number of limitations, as with any SR, including that potentially relevant studies may have been omitted as the review only included published SRs in English. The JBI manual recommends to include grey literature searches, however, this approach is often included in standard SRs. Therefore, unpublished grey literature would have been reported in the included SRs in the current umbrella review. There is the possibility that inherent bias existed in the reporting of this review where errors may have arisen in the initial appraisal and data extraction of the included SR or meta-analysis and they have been carried though in the current umbrella review.[152] In some of the included SRs, it was unclear whether there was more than one independent reviewer for study selection (n=7 SRs) and/or data extraction (n=4 SRs), unclear which quality appraisal or risk of bias instrument used (n=6 SRs), and unclear assessment of the presence of publication bias (n=12 SRs). There were a few occasions where results reported within SRs (narrative synthesis and results tables) were ambiguous. To address this, the original primary studies included in the SRs were referred to obtain information to enhance the accuracy of umbrella review synthesis. The umbrella review was also dependent on the reporting of the included research syntheses which may limit reporting of desirable details of interventions in the present report. For example, a limited number of SRs have reported dietary and physical activity outcomes which has impeded further synthesis of the intervention effectiveness on these behavioral outcomes of interests

in the current umbrella review. Positive behavior change outcomes as a result of an intervention will provide an indication that an intervention is effective in modifying health behavior, which is likely to lead to weight loss in the longer term. Better reporting of behavior outcomes as a result of interventions would help to evaluate intervention effectiveness through preliminary impact on health behavior when weight change is usually not observed or is not significant within a short intervention duration generally between three and six months for most studies. As the majority of the included SRs did not adequately report on statistical significance (p-values) of the intervention trials, the umbrella review has not been able to synthesize a precise summary of intervention types which were significantly more effective than the other intervention types on various outcomes of interest. However, using a systematic approach, the umbrella review is able to provide recommendations after grading the quality of evidence on a range of interventions and the strength of intervention effectiveness against numerous weight-related outcomes in children aged 18 years and under who were overweight or obese.

2.9 Conclusions

Lifestyle behavior interventions targeting parents only, or parents with their child, are effective in achieving successful weight management outcomes in children aged two to 18 years. Multi-component family-based interventions combining dietary, physical activity, and behavior modification have consistently demonstrated effectiveness. Effective interventions employed parent-targeted strategies, including nutrition and physical activity education sessions, positive parenting skills, role modelling, and child behavior management.

2.9.1 Implications for practice

Health professionals can work with parents, as the key agents of change for their children, to encourage healthy eating and lifestyle behavior change across the family. It was not possible to recommend that one intervention component is more effective than the other. Therefore, the implications for practice includes a summary of strategies and interventions related to parental involvement within interventions. Parents can be provided with education on healthy eating and physical activity, not only to increase knowledge but to enhance self-efficacy and confidence in managing health behaviors within the home. Parent-targeted consultations can focus on fostering positive parenting skills in order to promote positive health behaviors in children and to cope with difficult situations related to health behavior change (e.g. family mealtime's challenges). Positive parenting skills, such as monitoring, reinforcement, role modelling, and provide nurturing environment, are relevant to support parents in facilitating healthy lifestyle change in family.

2.9.2 Implications for research

Future interventions need to examine whether engaging both parents within the parental component of interventions, especially fathers, can further enhance intervention effects. It is recommended for researchers to explicitly describe role of parents (e.g. mothers, fathers) involved in the interventions as opposed to using the term ‘parents’ when referring to the participants; who are often predominantly mothers. Future research should include larger and more diverse population groups, and examine the impact of interventions of longer duration and follow-up. There is a need for more comprehensive reporting of health behavior outcomes (e.g. dietary intake, physical activity levels) in order to assess which intervention components contribute to effectiveness and their relationship with change in health risk factors that are also associated with overweight and obesity.

Chapter 3: Development of text messages targeting healthy eating for children in the context of parenting partnerships

This chapter aligns with Thesis Aim 3 and presents the development of a set of text messages, targeted to mothers and fathers that is complementary to a family-focused nutrition intervention and guided by behaviour change frameworks.

Aim 3. To develop a set of evidence-based text messages, targeted to mothers and fathers, that is complementary to a family-focused nutrition intervention to improve child weight status and dietary intake.

The content of this chapter has been published in the journal Nutrition and Dietetics.

The work presented in this chapter was completed in collaboration with the co-authors (Appendix 9).

Suggested citation:

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3.1 Abstract

Aim: There has been an increase in the use of text messaging to deliver and support health interventions. The aim was to develop a bank of text messages targeting healthy eating for children in the context of parenting partnerships that could be used in a family intervention.

Methods: Text messages were developed using the Theoretical Domains Framework and Behaviour Change Wheel COM-B model by study investigators using a three phase approach; i) initial development of a message bank, ii) messages were reviewed and evaluated by experts and parents on their clarity, usefulness, and relevance using a 5-point Likert scale and open text spaces for additional feedback, and iii) refinement of messages content and finalised the message bank.

Results: Messages were reviewed for 'clarity', 'usefulness', and 'relevance' by 20 parents and 28 health experts, who were predominantly female (92%), parents of primary school age children (33%), of low to middle socioeconomic status (78%), with a mean age of 39 years (SD±9.87). From an initial set of 97 messages developed, 48 messages were retained through consultation. Messages were designed to complement the intervention, while engaging both parents.

Conclusions: The three-phase development created a set of text messages acceptable to experts and parents that aim to support improvement in child eating behaviours. The process provides a template and practical guide for researchers and health providers looking to apply a systematic approach to text messages development. Future research should investigate acceptability and impact of these messages as a component of family-based nutrition intervention.

Key words: Children; Healthy Diet; Parenting; Text Messaging

3.2 Introduction

Parents serve as the gate keepers and role models for a family's food intake and have a major influence on child eating habits.[36] Family-based behavioral lifestyle interventions that include parental involvement lead to better child health outcomes, including weight, Body Mass Index (BMI) and other measures of adiposity.[37, 41, 48, 51] However, in family-based interventions mothers and fathers are not usually represented equally.[63, 64] A systematic review on family-based childhood obesity studies (n=667 studies) found that only 51% included both mothers and fathers.[63] The evidence supporting the efficacy of mothers and fathers within dietary interventions on child health outcomes supports the rationale for increasing parental participation, as well as targeting both parents in childhood obesity interventions.[68]

Parenting partnership or 'co-parenting' is the term used to describe the relationship that both parents share in raising children.[70] The quality of the parenting partnership has been shown to positively impact a child's social and emotional development, including impulse control,[72-74] which suggests that it might influence a child's lifestyle behaviour and weight status. However, a systematic review of 213 studies on childhood obesity interventions found no interventions that focused on the parenting partnership in relation to dietary intake or childhood obesity.[64] Despite the importance and evidence for positive co-parenting the knowledge gap indicates that research targeting the parenting partnership for optimising child and family outcomes in lifestyle interventions is warranted.

Existing research suggests the use of text messages in combination with additional behavioural interventions (e.g. in-person weekly group sessions) are effective in supporting parents with preschool children,[120] as well as adolescents,[122] who were overweight and obese in improving weight related behaviours. Evidence indicates that mothers and fathers engage with interventions delivered via text messages when they provide relationship focused information, encouragement, support, and links to supplementary resources.[123] Text message technology has the potential to engage both parents by communicating corresponding health messages in family interventions and especially addresses barriers to paternal participation by taking intervention to fathers or the parent who may not be able to attend the intervention in a non-intrusive, temporal manner.[121] Currently, there is a lack of reporting within intervention studies as to how text messages were developed and whether the development process was informed by theoretical behaviour change frameworks or included any formal evaluation with the intended recipients.[127]

Health behaviour change theories generally comprise social cognitive theories which primarily focus on intra-individual factors (i.e. reflective cognitive processes) as opposed to wider social and environmental factors (i.e. interpersonal influence between parent-child dyad, and interactions within family systems).[98] The Theoretical Domains Framework (TDF) is an overarching holistic theoretical framework comprises of 14 key theoretical domains, such as 'Knowledge', 'Skills' and 'Emotion', constructed based on 33 behaviour change theories.[102-104] The TDF domains can be further condensed and integrated into a behaviour change model which characterises individual behaviour occurrences as the results of interactions between Capability, Opportunity and Motivation (the COM-B model).[99, 104] The TDF and COM-B model have been used in existing research to develop a parent-targeted smartphone application (App) for childhood weight management.[166] However, the study focused on designing the App and not development of text messages. Moreover, the App content was underpinned with behaviour change techniques at intra-individual level (i.e. food portion sizes) as opposed to inter-individual variables (i.e. parenting partnership, family system). Therefore, the current

study aimed to develop a bank of text messages targeting healthy eating within families that were specific to each parental context using the TDF and COM-B model.

3.3 Methods

The study was approved by the Hunter New England Human Research Ethics Committee (16/07/20/4.04) and the University of Newcastle Human Research Ethics Committee (H-2016-0329). The text messages development schema (Figure 3-1) was adapted from previous studies,[119, 167] with adaptations made to incorporate behaviour change theories (i.e. TDF and COM-B model) in messages development, and a 5-point Likert scale in the reviewer evaluation survey, as detailed below.

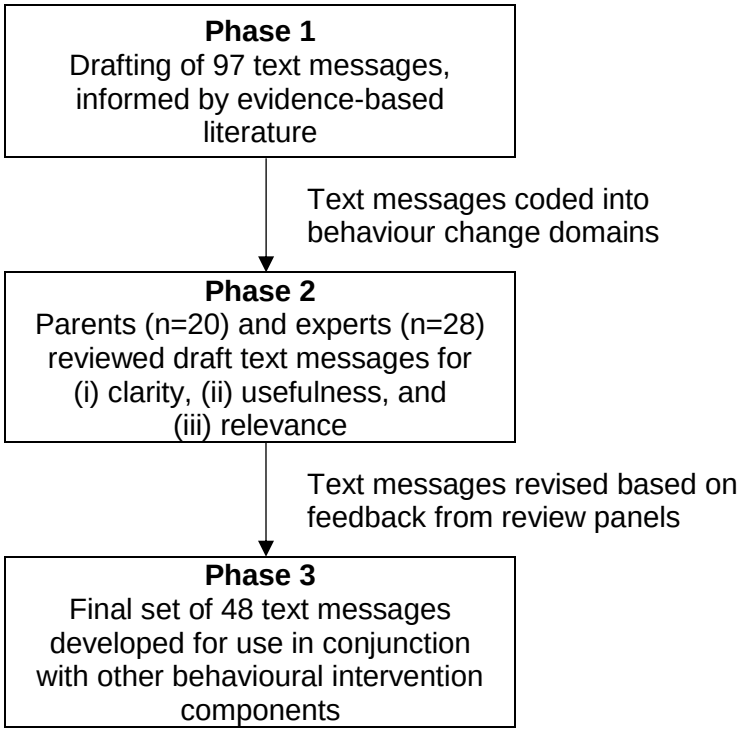

Figure 3-1 Text message development schema

Phase 1 involved design and development of messages. Text messages were designed to be delivered to both the father and mother, or caregiver where relevant. The intention was to engage both parenting partners in activities related to healthy eating in families, while encouraging them to be supportive of each other and to work together in resolving conflicts. Three of 14 TDF domains (i) knowledge, (ii) goals, and (iii) social influences, and four of nine intervention functions[99] (i) education (provide information), (ii) persuasion (prompt reflections/discussions), (iii) modelling (prompt actions), and (iv) enablement (prompt discussions/actions), were selected by two researchers experienced in family-based lifestyle intervention (LKC and CM) to underpin the messages development.

The content of each message corresponded to one or more intervention functions (i.e. to provide information; prompt reflections; prompt discussions; and/or prompt actions) which dictated the message tone and language style. The specific message content was based on a previous survey of Australian parents of school aged children (n=75) which asked them about the program content they would like to receive if participating in a family lifestyle program.[115] Existing research studies in focus groups and interviews with parents[168] and adolescents[169] about text messages to address lifestyle behaviours, as well as other health behaviour studies in children[115, 120] have suggested relevant topics for messages development within the current study. The most desired program content areas were "Knowledge about healthy food portion sizes for different ages", "Healthy recipes", "Specific information on nutrition topics" and "Education for my child about healthy eating".[115] Messages were drafted to address this content, and some messages were added links to online evidence-based resources. These included factors related to eating habits, diet quality, food preparation, family mealtimes, and healthy snack ideas. By including links for additional resources, the messages also increase opportunity for parents to facilitate behaviour change. This pool of draft text messages (n=97) were developed by the research team and independently mapped to one of the three TDF domains and one of the four intervention functions by two researchers (LKC and CM). Conflicts were resolved between the two researchers through a consensus discussion which acknowledged that some messages were crossing multiple domains and a final decision was made on the most appropriate single domain and/or function to be mapped to the draft messages. The messages were limited to 160 characters as the maximum length to be sent as a single text message. Messages were designed as passive one-way interaction so that there was no need for the recipient to reply. However, they can choose to act in response to the message prompts and click on the links to view resources.

In phase 2, the messages were reviewed by experts and parents for construct and content validation. Identified stakeholders from two distinct groups (i) parent, stepparent, or care giver of a child aged 18 and below; and (ii) experts in the field of family-based research, health behavioural research, or nutrition and dietetics were invited to review the content of draft messages. Experts were family health researchers, health researchers, dietitians, or nutrition academics. The expert reviewers were invited through mailing lists from academic and health institutions in the Hunter region, New South Wales, Australia, including universities, hospitals, and health services where staff would have knowledge and experience in developing and implementing family-based intervention, and/or clinical services related to healthy eating and weight management. A convenience sample of parents were recruited through the School of Health Sciences staff email of the University of Newcastle which comprises both academic and professional staff, and by snowballing and word of mouth within the local research network

at the Priority Research Centre in Physical Activity and Nutrition, which has over 100 members.

Both groups were asked to provide feedback via an online reviewer evaluation survey administered using an online survey platform (www.qualtrics.com). At the start of the survey, reviewers were asked to indicate one or more of the following roles that may apply to them: family-based researcher, health behaviour researcher, dietitian, parent or caregiver of a child. Researchers and/or dietitians who were also parents were classified as experts. Participants were then asked demographic information (8 items: gender, age, aboriginal status, education, occupation, postcode, number and age of children). Postcodes were matched to Socio-Economic Indexes for Areas (SEIFA) Index of Relative Socio-Economic Advantage and Disadvantage (IRSAD) for Postal Areas ranking to ascertain socioeconomic statuses (SES; i.e. low, middle, high). Each reviewer of the same role (i.e. expert or parent) was randomly assigned to review either 50 messages (set A) or 47 messages (set B). For the purposes of construct and content validation, reviewers were asked to evaluate each message on three feedback categories: (i) clarity, (ii) usefulness, and (iii) relevance to parents of overweight children and respond on a 5-point Likert scale ranging from "1" (strongly disagree) to "5" (strongly agree). Open text spaces were provided for additional feedback or suggestions to improve message content. As an incentive for participation, all parent reviewers were offered the option to enter a prize draw to win one of two $50 gift vouchers upon survey completion.

Phase 3 involved refinement of messages content and final selection of messages. For each message in Phase 2, a mean score was created for each feedback category (i.e. *clarity*, *usefulness*, *relevance*), with a total combined score for each message ranging from three (minimum) to 15 (maximum). Messages were discarded if they scored below three for *usefulness*, and retained without change if scored four or above for all individual categories. The remaining messages were refined based on reviewers' feedback.

Once the key messages were identified, the qualitative comments from the reviewers were checked by two researchers (LKC and CM), in addition to rewording and grammar, to ensure that the message content and structure were optimal. The research team then reassessed all remaining messages to create an even distribution across TDF domains, complementary message content, and intervention functions. A final set of text messages was selected for distribution over 12-weeks to targeted end users (i.e. mothers and fathers), across 4-weekly rotations of decreasing frequency (i.e. 5, 4, 3, then 2 text messages per week), based on previous evidence on the importance of varying the frequency of message delivery.[127] The condensed set of messages was re-circulated to the research team for consideration in terms of overall appropriateness. Readability was checked on the final set of messages using an

online tool (https://www.webpagefx.com/tools/read-able/) to ensure the messages are comprehensible for parents with low literacy. All reviewers were then asked to review the final messages and provide feedback which was used to derive the final message set. A list of the final text messages are presented in Appendix 10.

All analyses were undertaken using Stata version 12 software (StataCorp, College Station, TX, U.S.). Results were considered statistically significant with p-values <0.05. Descriptive statistics were conducted to describe demographic characteristics by reviewer roles. Messages scores were expressed in mean and standard deviation (SD) by reviewer roles and message sets (i.e. set A or B).

3.4 Results

A total of 51 reviewers completed the survey and all reviewed the final message set. Of these, 20 were parents and 28 were health experts. Three identified themselves as neither parents nor experts, thus, were excluded from the analysis. The demographic characteristics of parents and expert reviewers were presented in Table 3-1. Overall, the parent and expert reviewers (n=48) were predominantly female (92%), non-indigenous (100%), parents of primary school age children (33%), between low and middle SES class (73%), reporting having a university degree (48%), and the group mean age were 39 years (SD±10). The 20 parent reviewers were predominantly mothers (n=19; 95%). The parents reported having one or more children who were aged below five years (n=9; 45%), and/or primary school age 5-12 years (n=10; 50%), and/or secondary school age 12-18 years (n=4; 20%). Of the 28 experts who completed the survey in phase 2, seven were researchers of family-based studies, 12 were health researchers, and nine were dietitians. There were 12 experts who had expertise in two or more areas: family research, health research, nutrition. Of the experts, 50% were also parents and 39% had young children aged below 12 years at the time of participation.

Table 3-1 Demographics of participants by reviewer roles

Demographics	Parents	Family	Health	Dietitian	Combined
Participants, n (%)	20 (100)	7 (100)	12 (100)	9 (100)	48 (100)
Age (years), mean (SD)	41 (9)	45 (12)	36 (10)	37 (9)	39 (10)
Gender, n (%)					
Female	19 (95)	5 (71)	12 (100)	8 (89)	44 (92)
Male	1 (5)	2 (29)	0 (0)	1 (11)	4 (8)
Education, n (%)					
Certificate/Diploma	2 (10)	0 (0)	0 (0)	0 (0)	2 (4)
University Degree	10 (50)	2 (29)	7 (58)	4 (44)	23 (48)
Higher University Degree	8 (40)	5 (71)	5 (42)	5 (56)	23 (48)
SEIFA, n (%)					
Low (IRSAD 1-3)	7 (35)	3 (43)	1 (8)	1 (11)	12 (25)
Mid (IRSAD 4-6)	6 (30)	7 (100)	6 (50)	4 (44)	23 (48)
High (IRSAD 7-10)	7 (35)	2 (29)	1 (8)	0 (0)	10 (21)
Invalid postcode	0 (0)	0 (0)	1 (8)	2 (22)	3 (6)

Demographics	Parents	Family	Health	Dietitian	Combined
Number of children, n (%)					
None	0 (0)	2 (29)	8 (67)	4 (44)	14 (29)
1	4 (20)	1 (14)	0 (0)	0 (0)	5 (10)
2	5 (25)	1 (14)	1 (8)	4 (44)	11 (23)
3	5 (25)	2 (29)	2 (17)	1 (11)	10 (21)
4	4 (20)	1 (14)	1 (8)	0 (0)	6 (13)
5	1 (5)	0 (0)	0 (0)	0 (0)	1 (2)
6	1 (5)	0 (0)	0 (0)	0 (0)	1 (2)
Age of children, n (%)					
0-5 years	9 (45)	2 (29)	0 (0)	3 (33)	14 (29)
5-12 years	10 (50)	1 (14)	1 (8)	4 (44)	16 (33)
12-18 years	4 (20)	1 (14)	1 (8)	0 (0)	6 (13)
Above 18 years	6 (30)	2 (29)	3 (25)	1 (11)	12 (25)

SD: standard deviation; SEIFA: Socio-Economic Indexes for Areas; IRSAD: Index of Relative Socio-Economic Advantage and Disadvantage

Median scores by category can be found in Table 3-2. Overall, the 97 messages had a median [interquartile range] group score (max=15) of 13 [1.5], with sub scores (max=5) of 4 [1] for each individual category: clarity, usefulness, and relevance. The overall total scores were not significantly different between parents and experts in ether message set. While family and health researchers did not differ significantly in their message scores, dietitians rated the messages significantly lower for all categories compared to family ($p<0.001$) and health researchers ($p<0.001$).

Table 3-2 *Median score and interquartile range by text messages (n=97) feedback category*

	Parents	Experts	Combined
Number of reviewers, n	20	28	48
Total score (3-15), median (IQR)	12.5 (1.5)	13 (2)	13 (1.5)
Clarity (score 1-5), median (IQR)	4 (0.5)	4 (1)	4 (1)
Usefulness (score 1-5), median (IQR)	4 (0.5)	4 (1)	4 (1)
Relevance (score 1-5), median (IQR)	4 (0.5)	5 (1)	4 (1)

IQR: interquartile range; calculated by Q3 (75^{th}) minus Q1 (25^{th}).

Based on the message review protocol adapted from previous studies,[119, 167] 65 messages were retained without changes (score ≥4 for all three categories); 14 messages were retained and reworded to improve clarity; 18 messages were reassessed for potential inclusion, resulting in agreement (LKC and CM) to discard 12 messages. The revisions involved minimal corrections including spelling, grammar, and minor wordings. A final set of 48 messages was selected as a set for use within an intervention targeting parents to improve dietary behaviours of their children. The set consisted 36 messages targeting both parents, six messages targeting fathers and six messages targeting mothers. The set contained a combination of messages which aim to provide information about healthy eating, prompt reflections and discussions related to healthy eating goals, and promote healthy eating behaviour. Messages with a focus to improve knowledge (n=14; 29%) were mainly giving information to impart

knowledge. Messages that focused on goals (n=15; 31%) were designed to prompt actions related to goal settings and action planning. Messages to address social influences (n=19; 40%) prompted reflection to inform discussion and subsequent actions. The overarching form of action was to achieve discussions between parents about child health behaviours. The literacy level of the final set of messages was on average grade 6 level for readability (i.e. readily understood by most 11 to 12-year olds).

3.5 Discussion

The aim of the current study was to develop a set of text messages that targeted healthy eating behaviours within families and to leverage the important role that parents and the parenting partnership plays in determining child and family health outcomes. The current study employed a review process involving a range of experts and researchers in family and health behaviour research, nutrition academics, dietitian, and parents as message recipients who reviewed and provided suggestions to improve message content and clarity. The three phases of the message development provide a practical guide for researchers and health providers looking to apply a systematic approach to text messages development in the future.

Evidence suggests that children can achieve improved behavioural outcomes (e.g. stronger impulse control) when their parents report stronger parenting partnerships.[72-74] However, there are limited studies utilising parenting partnerships to address child eating behaviours, hence the current approach is novel. The messages were designed to be implemented in combination with additional behavioural interventions (e.g. website, face-to-face group sessions) to prompt parents on healthy eating within the family while simultaneously leveraging the influence of parenting partnerships to support lifestyle change. The inclusion of maternal and paternal specific text messages was to help engage both parents in the behaviour change, and to potentially overcome only one parent being responsible for change.[63, 64]

Reporting of methods used to develop text message content is currently lacking in the literature. It is commonly unclear whether the text messages were developed in an ad hoc way, informed by behaviour change theoretical frameworks, reviewed by health experts, or co-developed with feedback from the intended recipients. The current paper outlines details of the application of the TDF[104] and COM-B model[99] for development of text messages underpinned by relevant theory and informed by the evidence on efficacious child weight management strategies within the context of the parenting partnership. The current study contributes to the literature gap by presenting a systematic process for the development of text messages.[103, 104] The text messages developed in the current study were also grounded

in theory and evidence concerning the importance of the relationship that parents share in the raising of children, the parenting partnership.

Limitations of the current study include the relatively small sample of reviewers evaluating the messages who were predominantly female (92%). Despite open recruitment strategies were used to be inclusive of both mothers and fathers, parent participants who responded to invitation to participate were primarily mothers and well-educated. A systematic review on 667 family-based childhood obesity studies found that only 17% of the total parent participants were fathers.[63] Future research involving usability testing with parents and evaluation of the effects of the text messages on child eating behaviour should actively recruit both parents/caregivers especially fathers. Lastly, the final set of text messages was developed specifically for a parent population with school aged children in the context of improving children's eating habits. Further research is warranted to apply the methodology developed for testing in other population groups and health contexts, to expand the research on text messages in specific areas of family interventions.

3.6 Conclusion

The text messages development process, which incorporated messages underpinned with the TDF and COM-B models of behaviour change, created a set of text messages acceptable to experts and parents (primarily mothers) that aim to support improvement in child eating behaviours. The consultation process provided assurance that the text messages were likely to be comprehensible, useful, and relevant to parents seeking to improve their children's dietary intake.

Chapter 4: Feasibility and preliminary efficacy of a technology-based nutrition intervention for families of children with overweight or obesity

This chapter aligns with Thesis Aim 4 and presents a pilot study that used a novel family-focused telehealth nutrition intervention to support families in improving child weight status and dietary intake. The study also evaluated the impact of additional SMS targeted to mothers and fathers (presented in Chapter 3) when delivered in conjunction with telehealth intervention.

Aim 4. To develop and test the feasibility, acceptability, and efficacy of a novel family-focused online telehealth nutrition intervention in improving child weight status and dietary intake, and the impact of the addition of evidence-based text messages targeted to mothers and fathers.

The content of this chapter has been published in the Journal of Telemedicine and Telecare.

The work presented in this chapter was completed in collaboration with the co-authors (Appendix 11).

Suggested citation:

Chai LK, Collins CE, May C, Ashman A, Holder C, Brown LJ, Burrows TL. Feasibility and efficacy of a web-based family telehealth nutrition intervention to improve child weight status and dietary intake: a pilot randomised controlled trial. *J Telemed Telecare*. 2019 Jul 31:1357633X19865855. doi: 10.1177/1357633X19865855

4.1 Abstract

Introduction: Innovative eHealth solutions that improve access to child weight management interventions are crucial to address the rising prevalence of childhood obesity globally. The study aimed to evaluate feasibility and preliminary efficacy of a 12-week online telehealth nutrition intervention to improve child weight and dietary outcomes, and the impact of additional text messages (SMS) targeted to mothers and fathers.

Methods: Families with children aged four to 11 years were randomised across three groups: Telehealth, Telehealth+SMS, or Waitlist-control. Both Telehealth and Telehealth+SMS groups received two telehealth consultations delivered by a dietitian, 12 weeks access to a nutrition website and a private Facebook group. The Telehealth+SMS group received additional SMS. Feasibility was assessed through recruitment, retention, and intervention utilisation. Efficacy was assessed through changes in measured child body mass index (BMI), waist circumference and diet.

Results: Forty-four (96%) and 36 (78%) families attended initial and second telehealth consultations, respectively. Thirty-six families (78%) completed week 12 assessments. Child BMI and waist circumference changes from baseline to week 12 were not statistically different within or between groups. Children in Telehealth+SMS had significantly reduced percentage energy from energy-dense nutrient-poor food (95% CI -21.99 to -0.03%E; P=.038) and increased percentage energy from healthy core food (95% CI -0.21 to 21.89%E; P=.045) compared to Waitlist-controls.

Discussion: A family-focused online telehealth nutrition intervention is feasible with high 12-week retention. While the modest sample size reduced power to detect between group changes in weight status, some improvements in child dietary intakes were identified in those receiving telehealth and SMS.

4.2 Introduction

Childhood obesity has been recognised as a global health problem. The World Health Organisation Commission on Ending Childhood Obesity 2016 report highlighted that progress in combating childhood obesity has been slow and inconsistent worldwide.[21] The report indicated that more effort is required to address childhood obesity and contained six recommended strategies including the “provision of family-based, multicomponent, lifestyle weight management services for children and young people” with obesity.[21] Existing reviews also suggested that family-focused behavioral lifestyle interventions with direct parental involvement lead to improved indicators of child weight status (e.g. body mass index (BMI), percentage overweight).[39, 41, 45, 144] A review of systematic reviews suggests that family-

focused intervention strategies should include both parents (i.e. mothers and fathers) as the agents of change, foster positive parenting skills, and provide parental resources to encourage lifestyle changes within the home.[87] Despite the development of evidence-based strategies for family-focused childhood obesity treatment, personalised (i.e. individual-tailored) child weight management services for families of children with overweight or obesity remain scarce within Australian public health services.[107-109] The current lack of public health services for managing childhood obesity in relation to the scale of the issue means that capacity to address the extent of childhood obesity across the geographically diverse Australian population is not adequate.[108]

A worldwide increase in access to internet and smart devices has facilitated research into the use of web-based electronic health (eHealth) interventions that include family-focused healthy lifestyle programs.[42, 170] In the US and UK, approximately 90% of adults use the internet and 91% of millennials own a smartphone.[171] In Australia, more than 97% of households with children under age 15 years have access to the internet via computer, smartphone or tablet.[172] Australian data shows that technology use is increasing and not limited by socioeconomic status (SES) or geographic location.[172] This is important for intervention development in families of low SES where children are more likely to be affected by overweight or obesity.[173] The use of an eHealth intervention has potential to overcome traditional barriers to participation, offers flexibility for busy families to engage in treatment, improve access, extend reach of nutrition services to rural regions and reduce cost, travel time and leave of absence from work/school that is often associated with attendance at face-to-face clinical appointments.[115]

The application of eHealth in childhood obesity intervention is an emerging area of practice.[42] A review of eHealth interventions for childhood obesity identified only five studies that involved children aged five to 10 years and the remaining 13 studies involved adolescents aged 12 to 18 years, with intervention strategies including text messages (SMS), websites and smartphone apps.[58] Telehealth intervention (defined by the International Organisation for Standardisation as the 'use of telecommunication techniques for the purpose of providing telemedicine, medical education, and health education over a distance')[128] for childhood obesity is scarce.[129] A review of telehealth use in childhood obesity treatment found only four studies (one pilot trial, three observational studies); all published since 2008.[129] The pilot trial comprised a group-based telehealth intervention delivered by a psychologist externally to parents who connected via videoconferencing in a school setting, while children participated in an activity-based group intervention.[130] There remains a knowledge gap, in terms of feasibility, of an online childhood obesity intervention with family-based telehealth connection using household electronic devices. Therefore, the current study aimed to investigate the

feasibility and preliminary efficacy of a novel 12-week family-focused online telehealth nutrition intervention in improving child weight status and dietary intake. The secondary aim was to investigate whether additional evidence-based SMS messages targeted to mothers and fathers enhanced the intervention.

4.3 Methods

4.3.1 Study Design

The study was a pilot randomised controlled trial (RCT) with participants randomised to three study arms: i) Telehealth; ii) Telehealth+SMS; iii) Waitlist control. Both intervention groups (Telehealth, Telehealth+SMS) received intervention access immediately following randomisation after completing baseline assessments. Telehealth+SMS received additional SMS plus all intervention components of Telehealth group. The control group received no intervention for three months and was given access to all intervention components (same as Telehealth+SMS) after week 12 assessments. The study adhered to the checklist adapted from the Consolidated Standard of Reporting Trials (CONSORT) guidelines for pilot and/or feasibility studies.[174] The overall study design is illustrated in CONSORT diagram (Figure 4-1).

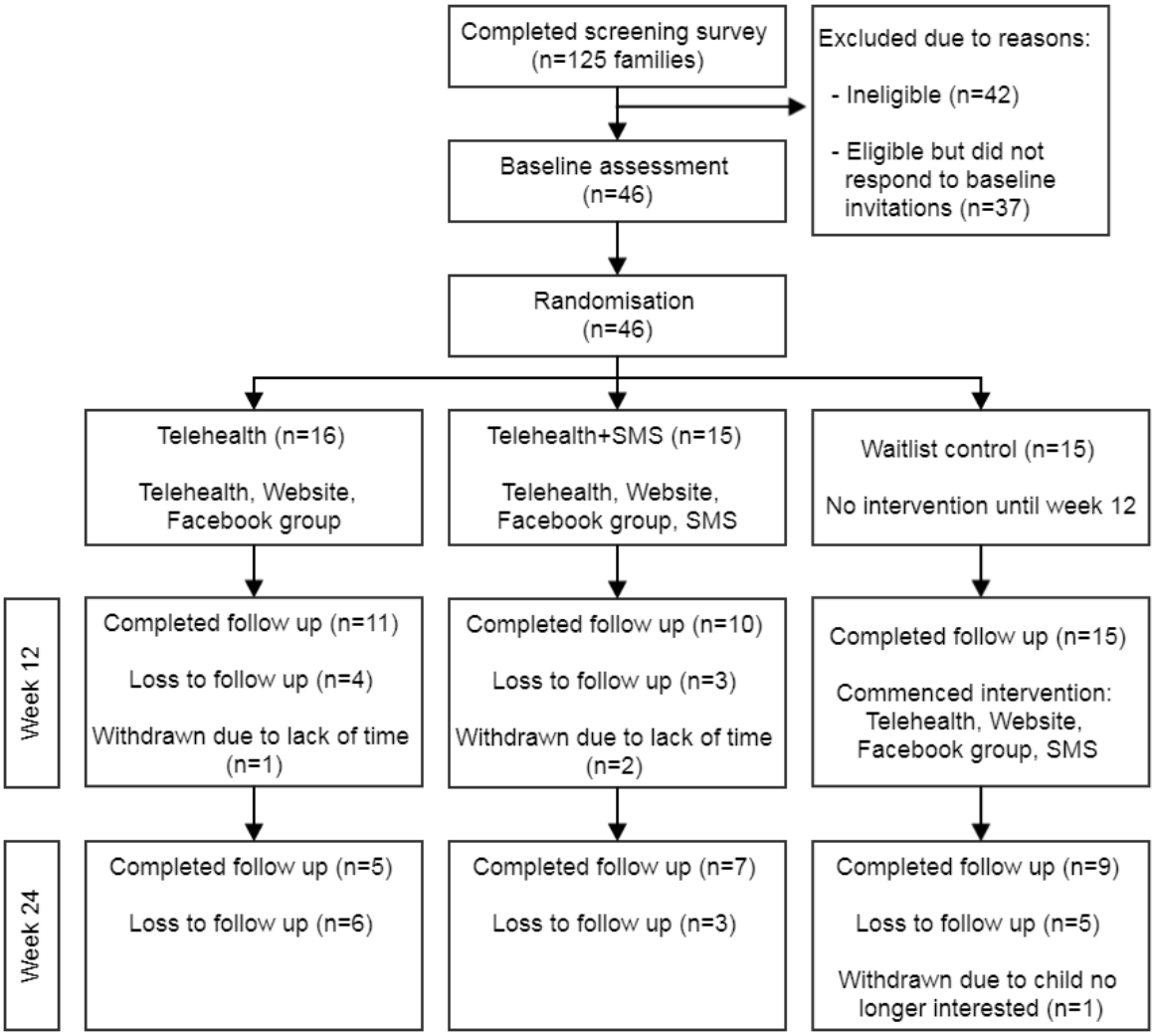

Figure 4-1 *CONSORT 2010 Flow Diagram*

The study was approved by the Hunter New England Local Health Districts Human Research Ethics Committee (16/07/20/4.04) and University of Newcastle Human Research Ethics Committee (H-2016-0329).

4.3.2 Recruitment and participants

Participants were children aged four to 11 years with BMI ≥21.5kg/m^2 (International Obesity Task Force (IOTF) children cut-offs)[19] and their parent/s who consented to attend assessments at one of the three study sites in New South Wales, Australia, and access the online intervention using their own electronic devices. The eligible child BMI was kept broad for recruitment as previous studies showed that parents of children with overweight or obesity often fail to recognize their child's weight status as being overweight[175] and tend to under-report their child's weight, especially for children with overweight or obesity.[176, 177] Therefore, the eligible child BMI was set to be above the mid-point of the healthy weight category (≥21.5kg/m^2) in order to be inclusive in recruiting children with overweight or obesity.

Families were recruited to one metropolitan (i.e. Newcastle) and two rural sites (i.e. Tamworth, Armidale) between July 2017 and May 2018. Extensive recruitment strategies were used to distribute study information (including a direct link to the online screening survey) through networks surrounding Hunter New England region: John Hunter Children Hospital dietetics clinic – a regional tertiary weight management service and only one of three centres in New South Wales, Australia offering such service, health professional networks (including flyers mailed out to 136 general practitioners), 92 primary schools, family-friendly community venues (e.g. libraries, gyms, cafes), contemporary media (television news, newspaper and radio), and social media networks targeted to Newcastle, Tamworth, and Armidale regions.

Families were excluded if the index child was participating in another weight management intervention during the study period; had a secondary cause for obesity or significant learning difficulties; required medication (except insulin) that influence growth, weight or appetite; or required a therapeutic (i.e. texture modified) diet. Parent written consent and child assent were obtained prior to baseline data collection. To reduce waiting time for families who enrolled early, families commenced the program in six different cohorts at various time frames ranging from July 2017 to April 2018 and attended their respective data collection sessions for each time-point. Families received AU$10 gift vouchers at each data collection session (total $30 for three sessions) to subsidize travel costs.

4.3.3 Sample size and randomisation

Existing research recommended a sample size of at least 12 per group for pilot studies when there is no prior information as a reference.[178] A researcher not involved in data collection and analysis generated computer-based block randomisation sequences and prepared concealed

envelopes, which were revealed following baseline assessments by a researcher not involved in data collection. Researchers performing lab measurements were blinded to participant's group. Dietitians delivering interventions were blinded to the intervention groups (i.e. Telehealth or Telehealth+SMS) but not to control group.

4.3.4 Back2basics Family intervention

4.3.4.1 Telehealth dietitian consultation

Semi-structured telehealth consultations (approximately 20 minutes each) were delivered in weeks 1 and 4 by an Accredited Practising Dietitian (APD) using Hunter New England Health Local Health District's Clinical Telehealth online videoconferencing software (Scopia)[179] during scheduled clinic appointments. Families received instructions to download and install Scopia through a website link.[179] Families initiated telehealth connections from their device during the consultation where at least one parent and the index child were present, while other family members were also welcome to participate. Telehealth consultations were guided by the CALO-RE taxonomy of behaviour change techniques related to healthy eating (Table 4-1).[99] Discussion topics included Australian Dietary Guidelines (ADG) recommendations for children,[82] Australia Eating Survey (AES) dietary report (further details see 'Outcome measures'), family goals settings (e.g. first goal focused on increasing servings of nutrient-rich core food; second goal focused on reducing energy-dense, nutrient-poor (EDNP) food or excessive EDNP portion sizes) aligned with the ADG[82] and previous effective interventions,[89, 180] and rewards. The AES dietary report and behavioural goals discussed were emailed to parents following the initial consultation. The second consultation in week 4 addressed progress towards goals and to problem-solving in relation to barriers to change.

4.3.4.2 Website

The Back2Basics Family (B2BF) website contained information on various nutrition topics (Table 4-2) adapted from the efficacious HIKCUPS child obesity treatment program,[89, 181] purpose-built healthy cooking videos[182] previously designed for families with low literacy and budget, and additional topics based on a previous survey with 75 parents.[115] Families were free to access the website at their preferred time and frequency. New topics were introduced each week throughout the program to maintain participants' engagement, which has been shown to be effective in previous research.[183]

4.3.4.3 Facebook group

The B2BF Facebook group was a closed online medium (membership upon invitation only) for parents to exchange ideas and information related to the B2BF website. The Facebook group included weekly announcements posted by the researchers when new topics were

released on the B2BF website (Table 4-2). The Facebook groups for the three study arms were kept separate to reduce cross-group contamination.

4.3.4.4 Text messages

A series of SMS targeting healthy eating for children was delivered to both parents (e.g. mother and father) of the child in 4-weekly rotations of decreasing frequency[127] (i.e. 5, 4, 3, then 2 messages per week). For sole parent families, SMS were delivered to the sole parent only, except for where another co-parent (e.g. grandparent) was regularly involved in shared child care. In total, 42 SMS were delivered over the 12 weeks intervention to each consenting parent. The SMS were grounded in behaviour change theory and informed by evidence-based child weight management strategies.[125] Detailed process of the SMS development and content validation has been published elsewhere.[125]

Table 4-1 *Back2basics Family telehealth consultations guided by CALO-RE taxonomy of behaviour change techniques*

Behaviour change technique	Telehealth session content and objectives
Initial consultation	
2. Provide information on consequences of behaviour to the individual.	Discuss implications of current dietary habits on future health of individual, and benefits of healthy eating (energy balance, improve diet quality) and healthy weight.
5. Goal setting (behaviour)	Set two behavioural goals to decrease energy intake (decrease EDNP food) and increase diet quality (increase core food)
7. Action Planning	Make a detailed plan describing exactly how a family will achieve behaviour and outcome goals including frequency.
8. Barrier identification/ problem solving	Investigate potential barriers to action plan for healthy eating and identify ways to overcome.
9. Set graded tasks	Break down eating behaviours in action plan to smaller easier tasks. Goals may be incremental to build on success.
12. Prompt rewards contingent on effort or progress towards behaviour	Encourage parent/s to offer praise or positive comments for attempts or progress at achieving a behavioural goal.
16. Prompt self-monitoring of behaviour.	Ask families to keep a food diary record (e.g. food serves/times per day) and/or regularly assess food intake using Healthy Eating Quiz online.
20. Provide information on where and when to perform the behaviour.	Discuss when and where to perform healthy eating (including times and places whether healthy food option is available, i.e. schools, weekend, birthday parties).
23. Teach to use prompts/cues.	Discuss identifying environmental prompts to remind them about healthy eating (e.g. phone alerts, time of day, fruit bowl on table).
24. Environmental restructuring	Alter environment to be more supporting of healthy eating (e.g. fruit bowl on table, smart groceries shopping).
25. Agree behavioural contract	Prepare a written agreement on the performance of an explicitly specified behaviour so that there is a written record of the parent and child's resolution witnessed by another.

29. Plan social support/social change.	Plan how to elicit social support to help them achieve target behaviour/outcome (e.g. friend, buddy, group, spouse, family).
30. Prompt identification as role model/position advocate	Plan how to involve whole family for the healthy change. Parents can be the role models for the kids, supportive siblings are great.
38. Time management	Discuss how to manage their time in order to make time for the behaviour (i.e. groceries, cooking, serving, eating)
Second consultation	
10. Prompt review of behavioural goals	Review extent to which previously set behavioural goals were achieved. This will follow previous goal setting and an attempt to act on those goals, followed by a revision/readjustment of goals.
13. Provide rewards contingent on successful behaviour	Discuss a reward for when they achieve goals and perform behaviour at week 12 (no reward provided if goal not achieved).
19. Provide feedback on performance	Provide data about recorded behaviour (e.g. AES report, food diary) or commenting on a family's behavioural performance against a set goal.
18. Prompting focus on past success	Involves instructing a family to think about or list previous successes in performing the behaviour (or parts of it)
35. Relapse prevention/coping planning	Planning how to maintain the behaviour that has been changed (e.g. eating vegetables 3 times per week). Identify in advance situations in which the changed behaviour may not be maintained (school holidays, festive events) and develop strategies to avoid or manage those situations.
15. Prompting generalisation of a target behaviour	Once behaviour is performed in a particular situation, the family is encouraged to try it in another situation. The idea is to ensure that the behaviour is not tied to one situation but becomes a more integrated part of the person's life that can be performed at a variety of different times and in a variety of contexts.
16. Prompt self-monitoring of behaviour	Ask families to keep a food diary record (e.g. food serves/times per day) and/or regularly assess food intake using Healthy Eating Quiz online.

ENDP: energy-dense nutrient-poor food/drinks

Table 4-2 *Examples of Back2basics Family Website content and schedule*

Released in week	Topics	Targeted participants
Baseline week	About Healthy Eating	Parents
Baseline week	Easy recipes	Parents and children
Week 1	Australian Dietary Guidelines	Parents and children
Week 1	How much is enough?	Parents and children
Week 2	Here's how to do it	Parents and children
Week 3	Rewards and Role Modelling	Parents
Week 4	Mealtimes champs	Parents and children
Week 4	Praise and Motivation	Parents
Week 5	Lunchbox ideas	Parents and children
Week 6	Cooking with Kids	Parents and children
Week 7	Snack attack	Parents and children
Week 8	Tackle Takeaways	Parents and children
Week 9	Label reading ABC	Parents and children
Week 10	Smart groceries shopping	Parents and children
Week 11	Stop Bullying	Parents

4.3.5 Outcome measures

4.3.5.1 Feasibility

Feasibility was measured through recruitment, retention, and intervention utilisation using process measures documented by researchers, telehealth attendance recorded by dietitian, and demographic and process evaluation surveys completed by parents. Demographic data were collected via baseline surveys and including: parents and child age, sex, and BMI, parents' education level, postcode, and family context (i.e. single or both biological/step-parents living with the child). Postcodes were matched to the Modified Monash (MM) Model, which categorises metropolitan, regional, rural and remote areas into seven MM categories for geographic classifications,[184, 185] and Socio-Economic Indexes for Areas, Index of Relative Socio-Economic Advantage and Disadvantage for Postal Areas ranking, which determines SES (i.e. low, middle and high).[186] Additional data on intervention fidelity and acceptability (participants' satisfaction) were also collected and were reported elsewhere.[187]

4.3.5.2 Efficacy

Preliminary efficacy of the interventions was indicated by differences between group changes in measured child BMI, zBMI (BMI z-scores), waist circumference, and dietary intake from baseline to week 12. Child height, weight, and waist circumference were measured by trained research assistants using standard protocols. Height was measured to the nearest 0.1cm using a Biospace BSM370 Automatic Stadiometer with children barefoot and their head positioned in the Frankfort horizontal plane.[188] Weight was measured to the nearest 0.1kg without shoes and in light clothing using an InBody 720™ body composition analyser (Newcastle and Tamworth sites) or SECA 803 electronic weighing scale (Armidale site). Waist circumference was measured around the umbilicus to the nearest 0.1cm using a KDS Steel Measurement Tape, on bare skin, with children standing with legs shoulder-width apart and arms at resting position. All measures were conducted twice, and a third measure was obtained if the first and second measures were not within 0.3cm for height, 0.4kg for weight, or 0.5cm for waist circumference. Child BMI were calculated and zBMI were computed using the Cole's LMS statistical method.[19]

The child version of the online AES semi-quantitative food frequency questionnaire (FFQ) was used to evaluate child dietary intake, with a personalised dietary report generated and used as the basis of the telehealth consultations. The child version of the AES is a 120-item semi-quantitative FFQ to capture parent-reported child dietary intake,[136] and has previously been validated for fruit,[189] vegetable,[189] dietary fats[190] and energy intake[191] in Australian children using plasma carotenoids concentration or red blood cell membrane fatty acids as a biomarker. An individual response is required for each food item in the AES, with options ranging from 'never' to 'four or more times per day'; and for some beverages up to 'seven or more glasses

per day'. Parents were asked to report the child dietary intake over the past three to six months as this reporting period is designed to capture usual eating habits. At follow up visits, parents reported child dietary intake for the previous three months. The AES uses child-specific serving sizes and the following nutrient databases: Australian AusNut 1999 database (All Foods) Revision 14, and AusFoods (Brands) Revision 5 (Xyris Software (Australia) Pty Ltd, 2004: Brisbane Australia).[137] A personalised dietary report was generated and sent to the dietitian once a parent completed the online AES. The report includes evaluation of total energy intake (kJ) and the percentage energy (%E) derived from nutrient-rich food groups (core food) compared to EDNP food, and overall diet quality assessed by the Australian Recommended Food Score (ARFS) which has a maximum score of 73; with subgroup scores of 21 for vegetables, 12 for fruits, 13 for meat and alternatives (i.e. legumes, nuts), 13 for grains, 11 for dairy products, 2 for condiments, and 1 for water.[138, 139]

Child physical activity level (PAL) was assessed as a confounding factor, due to its effects on weight change, using the Physical Activity Questionnaire for Children.[192] The questionnaire is a nine-item seven-day recall instrument which has been validated and has demonstrated high accuracy in estimating energy expenditure with moderate reliability.[193, 194]

4.3.6 Statistical analysis

All data manipulation and statistical analyses were undertaken using STATA, version 12 (Stata Corp LP, College Station, TX, USA) by a researcher not involved in data collection. Results were considered statistically significant where $P<0.05$. Descriptive analysis were used to assess feasibility outcomes: recruitment, retention, and intervention utilisation collected from intervention families at week 12 and control families at week 24 (i.e. at the conclusion of intervention). Differences between groups at baseline were assessed using analysis of variance. The primary analyses for intervention outcomes were intention-to-treat, defined as using available data from all randomised participants and multiple imputation by chained equations for missing data, and were performed using linear mixed models to examine changes of child anthropometry and dietary intake, expressed as differences of means and 95% confidence intervals between baseline and week 12. The P-value associated with the interaction effect between group and time was used to determine the statistical significance of any difference between groups over time.

4.4 Results

4.4.1 Feasibility

Recruitment: Of the 125 families who completed the screening survey, 83 eligible families were invited to participate in the study, and 46 families (n=28 Newcastle, n=18 Tamworth/Armidale) completed baseline assessments and were randomised to one of three

study arms: Telehealth group (n=16), Telehealth+SMS group (n=15), and Control group (n=15). The most successful recruitment avenue was through Facebook posts (35%; n=16), followed by emails to corporate mailing lists (33%; n=15), school newsletter (15%, n=7), word of mouth from family or friends (9%; n=4), general practitioners (4%, n=2), magazine (2%, n=1) and flyer from a local café (2%, n=1). Baseline characteristics between groups were not significantly different (P>0.05). Children (mean age 9±2.3 years) were predominantly male (59%), living with both biological parents (65%), and had overweight/obesity (70%). Baseline percentage energy intakes from core food and EDNP food were 62%E and 39%E, respectively. Parents (mean age 41±7.2 years) were predominantly female (96%), of middle SES (65%), living in major cities (61%), and had overweight/obesity (79%), a certificate/diploma (30%) followed by postgraduate degree (26%). Detailed baseline characteristics of children and their parents are presented in Table 4-3.

Table 4-3 *Baseline characteristics of children and their parents*

Characteristics	Telehealth (n=16)	Telehealth+SMS (n=15)	Control (n=15)	Total (n=46)
Children				
Age (years), mean ± SD	8 ± 2.6	8 ± 1.8	9 ± 2.5	9 ± 2.3
Gender, n male (%)	6 (38)	11 (73)	10 (67)	27 (59)
Anthropometry, mean ± SD				
BMI (kg/m^2)	22.5 ± 5.1	21.3 ± 4.4	23.6 ± 5.7	22.5 ± 5.1
Waist circumference (cm)	75 ± 15	73 ± 14	77 ± 16	75 ± 15
Weight category, n (%)				
Healthy weight	6 (13)	4 (9)	4 (9)	14 (30)
Overweight	3 (7)	5 (11)	2 (4)	10 (22)
Obesity	7 (15)	6 (13)	9 (20)	22 (48)
Usual dietary intake, mean ± SD				
Energy intake (kJ/day)	10032 ± 3266.7	10232 ± 2768.7	9149 ± 3010.5	9810 ± 2997.3
Core food (%E)	62 ± 14.2	62 ± 12.0	62 ± 11.2	62 ± 12.2
EDNP food (%E)	38 ± 14.2	38 ± 12.0	39 ± 10.8	39 ± 12.2
ARFS score	35 ± 8.0	31 ± 6.6	30 ± 7.4	32 ± 7.5
Living arrangements, n (%)				
With both biological parents	9 (56)	12 (80)	9 (60)	30 (65)
With a biological parent and a stepparent	3 (19)	1 (7)	1 (7)	5 (11)
Live in more than one house regularly	2 (13)	1 (7)	2 (13)	5 (11)
With a single parent only	2 (13)	1 (7)	3 (20)	6 (13)
Parents				
Age (years), mean (SD)	40 ± 5.9	43 ± 8	40 ± 7.9	41 ± 7.2
Gender, n female (%)	15 (94)	14 (93)	15 (100)	44 (96)
BMI (reported), mean (SD)	29.5 ± 6.2	28.9 ± 4.9	31.8 ± 7.6	30.1 ± 6.3
Education level, n (%)				
School certificate	1 (6)	0 (0)	2 (13)	3 (7)

Characteristics	Telehealth (n=16)	Telehealth+SMS (n=15)	Control (n=15)	Total (n=46)
Higher school certificate	1 (6)	3 (20)	2 (13)	6 (13)
Certificate/Diploma	5 (31)	7 (47)	2 (13)	14 (30)
Undergraduate degree	5 (31)	2 (13)	4 (27)	11 (24)
Postgraduate degree	4 (25)	3 (20)	5 (33)	12 (26)
Geographic classifications, n (%)				
Major City (MM 1)	13 (82)	9 (60)	6 (40)	28 (61)
Medium Regional (MM 4)	0 (0)	0 (0)	1 (7)	1 (3)
Small Regional (MM 5)	3 (19)	6 (40)	8 (54)	17 (37)
Socioeconomic status, n (%)				
Low (IRSAD 1-3)	2 (13)	3 (20)	2 (13)	7 (15)
Mid (IRSAD 4-7)	10 (63)	8 (53)	12 (80)	30 (65)
High (IRSAD 8-10)	4 (25)	4 (27)	1 (7)	9 (20)

BMI: Body Mass Index; zBMI: BMI z-scores; EDNP: Energy-dense, nutrient-poor food/drinks; ARFS: Australian Recommended Food Scores; MM: Modified Monash Category (MM 1: Major City, MM 4: Medium Regional, MM 5: Small Regional); IRSAD: Index of Relative Socio-Economic Advantage and Disadvantage; Weight categories as per International Obesity Task Force age-appropriate cut-offs - Healthy weight: BMI 18.5-24.9 kg/m^2, Overweight: BMI 25-29.9 kg/m^2, Obesity: BMI ≥30 kg/m^2. Usual dietary intake was measured using child version of online Australia Eating Survey.

Retention: The overall retention rate at week 12 was 78% (n=36 families). Three intervention families, reported as having lack of time, withdrew within first month of participation, and seven intervention families were lost to follow up (defined as not responding after three reminders about assessments) at week 12. All control families (n=15) completed week 12 assessments, however, one family withdrew as the child was no longer interested and nine (60%) completed process evaluation survey at week 24. Baseline characteristics of children (e.g. age, sex, BMI, energy intake, proportion of healthy food groups compared to less healthy foods) and parents (e.g. age, sex, BMI) who were and were not followed up at week 12 and week 24 were not significantly different.

Intervention utilisation: Telehealth consultation attendance showed that 96% (n=44 of 46 families; Telehealth n=16, Telehealth+SMS n=14, Control n=14) attended the initial consultation and 78% (n=36 of 46 families; Telehealth n=12, Telehealth+SMS n=12, Control n=12) attended the second consultation. Additional SMS's were delivered to 29 families (sole-parent n=4, co-parents n=25) who received the SMS intervention component (Telehealth+SMS n=15, Control n=14). The SMS intervention engaged 14 out of 25 fathers (56%) who were a co-parent. Further intervention utilisation data were reported by 30 parents (n=21 intervention families at week 12 and n=9 control families at week 24) who completed process evaluation survey. Utilisation of other web-based intervention components were reported by the majority of families and included logging in to the B2BF website at least once (77%; n=23), visited the B2BF Facebook group at least once (80%; n=24), and 100% received the SMS (n=19 families; seven mother-father dyads and 12 mothers-only). The frequency and pattern of website and Facebook group usage were also objectively tracked and results were

reported in detailed elsewhere.[187] Of all 46 families, only two (4%) required additional support for installing Scopia telehealth software, while none required extra support in assessing the B2BF website and Facebook group.

4.4.2 Efficacy

Child outcomes at week 12 are summarised in Table 4-4. Overall, child BMI, zBMI, waist circumference and physical activity level changes were not significantly different within-groups or between-groups. Interaction effects between group and time demonstrated that total daily energy intake was significantly reduced in the Telehealth group, when compared to Control group (-2835kJ; P=.026), but not statistically significantly different when compared to the Telehealth+SMS (-2291kJ; P=.078). Child dietary intake improved in both intervention groups, with changes statistically significant for the Telehealth+SMS, in terms of reduced percentage energy from EDNP food (-11%E; P=.038) and increased percentage energy from nutrient-rich core food (+11%E; P=.045) compared to Controls, who demonstrated a reverse trend (i.e. increased total energy intake, increased percentage energy from EDNP food and decreased percentage energy from core food).

4.5 Discussion

The current study evaluated feasibility and preliminary efficacy of a novel 12-week family-focused online telehealth nutrition intervention to support families of children aged 4 to 11 years who were or at risk of overweight and obesity in improving child weight status and dietary intake. Findings demonstrate that a tailored family-focused online nutrition intervention delivered by APDs using telehealth consultations is feasible, with no major technological problems encountered and very few participants requiring additional support to download and install the telehealth platform (Scopia). Consistent with existing research, there were no significant technological problems noted in using telehealth.[130, 195, 196] It is affirming that parents were able to set up and initiate telehealth connection independently based on written instructions provided on the website; telehealth can be offered as an alternative modality for family-based childhood obesity nutrition intervention. A previous systematic review[129] reported that telehealth showed promise for addressing childhood obesity and could be a reasonable approach for reaching a wider population, especially geographically isolated families.[129] The current study was able to provide telehealth intervention to families living in medium to small regional areas (40% participants in MM 4 and 5) and has demonstrated that dietitian-led individualised telehealth consultations with family-initiated telehealth connection using household electronic devices were feasible.

Preliminary results highlight that children in intervention groups had improved dietary intake at week 12. This supports findings reported in previous group-based telehealth childhood

Table 4-4 *Intention-to-treat analysis of changes in child outcomes at week 12 (n=46)*

	Telehealth group (T) (n=16)			**Telehealth+SMS group (TS) (n=15)**			**Control group (C) (n=15)**			**Between-group difference (Week 12 - Baseline)**		
Mean (95% CI)	Baseline	Week 12	Week 12 (minus) Baseline	Baseline	Week 12	Week 12 (minus) Baseline	Baseline	Week 12	Week 12 (minus) Baseline	T vs C	TS vs C	T vs TS
BMI, kg/m^2	22.5 (19.94 to 25.01)	22.5 (19.27 to 25.72)	0 (-3.43 to 3.47); P=0.991	21.3 (19.09 to 23.54)	21.9 (18.75 to 25.1)	0.6 (-2.38 to 3.6); P=0.688	23.6 (20.7 to 26.56)	23.8 (20.66 to 26.9)	0.2 (-1.66 to 1.97); P=0.868	-0.1 (-3.63 to 3.37); P=0.938; GxT P=0.947	0.5 (-2.93 to 3.84); P=0.785; GxT P=0.818	-0.6 (-4.42 to 3.24); P=0.752; GxT P=0.782
zBMI	1.9 (1.41 to 2.39)	1.8 (1.15 to 2.52)	-0.1 (-0.82 to 0.69); P=0.859	1.8 (1.23 to 2.3)	1.9 (1.15 to 2.55)	0.1 (-0.56 to 0.73); P=0.79	2.1 (1.46 to 2.83)	2.1 (1.36 to 2.89)	0 (-0.47 to 0.43); P=0.931	0 (-0.81 to 0.71); P=0.898; GxT P=0.915	0.1 (-0.63 to 0.84); P=0.766; GxT P=0.808	-0.2 (-1.01 to 0.7); P=0.708; GxT P=0.747
Height, cm	136 (127.48 to 144.42)	138.4 (128.48 to 148.34)	2.5 (-7.32 to 12.24); P=0.621	137.6 (129.95 to 145.2)	138.6 (128.07 to 149.12)	1 (-8.2 to 10.25); P=0.827	136.2 (128.01 to 144.47)	137.7 (129.49 to 145.87)	1.4 (-4.04 to 6.92); P=0.607	1 (-8.63 to 10.67); P=0.83; GxT P=0.859	-0.4 (-10.75 to 9.92); P=0.935; GxT P=0.945	1.4 (-10.23 to 13.1); P=0.799; GxT P=0.825
Weight, kg	43.9 (34.68 to 53.19)	45.2 (34.16 to 56.31)	1.3 (-9.96 to 12.57); P=0.82	41.8 (34.46 to 49.19)	43.8 (32.81 to 54.7)	1.9 (-8.3 to 12.16); P=0.71	45.6 (36.3 to 54.92)	46.9 (37.21 to 56.65)	1.3 (-4.63 to 7.27); P=0.663	0 (-11.28 to 11.25); P=0.998; GxT P=0.998	0.6 (-10.91 to 12.13); P=0.914; GxT P=0.927	-0.6 (-13.84 to 12.58); P=0.922; GxT P=0.931
Waist circumference, cm	75.5 (67.82 to 83.1)	75.2 (66.06 to 84.32)	-0.3 (-9.89 to 9.35); P=0.956	73.3 (66.38 to 80.26)	74.3 (65.68 to 82.94)	1 (-8 to 9.98); P=0.829	77.2 (68.94 to 85.44)	79.5 (71.91 to 87.01)	2.3 (-3.18 to 7.72); P=0.415	-2.5 (-12.72 to 7.64); P=0.614; GxT P=0.661	-1.3 (-11.37 to 8.82); P=0.798; GxT P=0.826	-1.3 (-12.77 to 10.25); P=0.822; GxT P=0.841

	Telehealth group (T) (n=16)			Telehealth+SMS group (TS) (n=15)			Control group (C) (n=15)			Between-group difference (Week 12 - Baseline)		
Mean (95% CI)	Baseline	Week 12	Week 12 (minus) Baseline	Baseline	Week 12	Week 12 (minus) Baseline	Baseline	Week 12	Week 12 (minus) Baseline	T vs C	TS vs C	T vs TS
Energy intake, kJ	10032.5 (8417.39 to 11647.61)	8094.2 (6641.05 to 9547.35)	-1938.3 (-3948.25 to 71.65); P=0.059	10232.1 (8818.29 to 11645.84)	8837.5 (7085.58 to 10589.39)	-1394.6 (-3311.63 to 522.47); P=0.154	9149.3 (7612.04 to 10686.62)	10046 (8775.95 to 11316.05)	896.7 (-529.2 to 2322.54); P=0.218	-2835 (-5332.16 to -337.78); P=0.027; GxT P=0.026	-2291.2 (-4850.34 to 267.85); P=0.078; GxT P=0.078	-543.7 (-3329 to 2241.56); P=0.692; GxT P=0.696
EDNP food, %E	38.3 (31.21 to 45.29)	30.1 (23.74 to 36.51)	-8.1 (-16.31 to 0.06); P=0.052	38.2 (32.06 to 44.34)	28.5 (22.04 to 35)	-9.7 (-17.33 to -2.02); P=0.013	39.3 (33.77 to 44.76)	40.6 (35.38 to 45.82)	1.3 (-4.93 to 7.6); P=0.677	-9.5 (-20.4 to 1.49); P=0.088; GxT P=0.073	-11 (-21.99 to -0.03); P=0.049; GxT P=0.038	1.6 (-10.11 to 13.21); P=0.788; GxT P=0.782
Core food, %E	61.8 (54.81 to 68.82)	69.5 (62.96 to 76.08)	7.7 (-0.83 to 16.24); P=0.077	61.8 (55.7 to 67.9)	71.4 (64.82 to 77.93)	9.6 (1.86 to 17.29); P=0.015	60.9 (55.16 to 66.57)	59.6 (54.26 to 64.94)	-1.3 (-7.62 to 5.09); P=0.696	9 (-2.06 to 20); P=0.108; GxT P=0.098	10.8 (-0.21 to 21.89); P=0.054; GxT P=0.045	-1.9 (-13.65 to 9.91); P=0.748; GxT P=0.745
ARFS score	34.6 (30.67 to 38.58)	33.9 (30.17 to 37.56)	-0.8 (-5.48 to 3.97); P=0.753	30.7 (27.35 to 34.12)	35.6 (30.37 to 40.87)	4.9 (-0.15 to 9.93); P=0.057	30.1 (26.34 to 33.93)	30.3 (26.12 to 34.55)	0.2 (-3.64 to 4.04); P=0.919	-1 (-6.93 to 5.01); P=0.746; GxT P=0.769	4.7 (-1.18 to 10.56); P=0.114; GxT P=0.147	-5.6 (-11.93 to 0.63); P=0.076; GxT P=0.095
PAL score	2.3 (2.04 to 2.5)	2.4 (2.07 to 2.66)	0.1 (-0.26 to 0.45); P=0.597	2.3 (2.08 to 2.6)	2.5 (2.08 to 2.82)	0.1 (-0.23 to 0.45); P=0.523	2.3 (2.09 to 2.55)	2.4 (2.13 to 2.58)	0 (-0.19 to 0.26); P=0.774	0.1 (-0.38 to 0.5); P=0.775; GxT P=0.778	0.1 (-0.37 to 0.53); P=0.73; GxT P=0.734	0 (-0.48 to 0.46); P=0.95; GxT P=0.951

T: Telehealth group; TS: Telehealth+SMS group; C: Control group; BMI: Body Mass Index; zBMI: BMI z-scores; PAL: physical activity level measured using Physical Activity Questionnaire for Children; EDNP: Energy-dense, nutrient-poor food/drinks measured using child version of online Australia Eating Survey; ARFS: Australian Recommended Food Scores measured using child version of online Australia Eating Survey; GxT: interaction effect between group and time where a significant interaction effect means that there are significant differences between groups and over time; the change in outcomes over time is different depending on group allocation.

obesity interventions where children decreased energy intakes,[195, 196] increased fruit and vegetables servings,[195] and decreased consumption of sugar-sweetened beverages [195] and EDNP food.[195, 196] The lack of statistically significant changes in child weight status have also been consistently reported in these studies.[195, 196] It is likely that the current study being a feasibility and pilot trial which was not sufficiently powered to evaluate efficacy for primary outcomes had insufficient sensitivity to detect statistically significant between group differences in child weight status. Therefore, we conducted a post hoc sample size calculation using standard deviation of child BMI (i.e. 5.1) and recommend a sample size of 104 per group to be able to detect two units of difference in BMI at 80% power.

Evidence showed the use of SMS in combination with additional behavioural interventions is effective in supporting parents to improve child weight-related behaviour.[120, 122] This is a potential strategy to engage more than one parent in interventions by giving information complementary to telehealth consultation to both parents; therefore, including parents who are not able to attend consultations. The current study also aimed to investigate whether additional SMS's targeted to parents, when delivered as part of an online telehealth nutrition intervention would enhance intervention efficacy in improving child outcomes. The lack of statistically significant difference between Telehealth and Telehealth+SMS groups led to the hypothesis that both intervention groups may be just as effective. However, results need to be interpreted with caution given the relatively small sample size overall and a smaller group of mother-father dyads (n=14 pairs) who received the SMS. This small sample size has limited statistical power to detect significant differences in child outcomes both within and between groups. Thus, potential benefits of additional SMS should be explored in a future larger trial.

The overall retention rate for the current study was 78% at week 12 which is slightly higher compared to existing childhood obesity intervention studies which reported retention rates ranging from 27% to 73%.[197] Research has reported that program enrolment is enhanced by a parent's awareness of and desire to improve their child's overweight status,[198] while program attendance is improved by child involvement in attendance decisions.[117] The current study targeted both parents and children through telehealth and the web-based intervention components and hence was more inclusive in engaging the entire family in the intervention. This may be a potential reason for the comparatively higher retention rate in the current study. Interestingly, all drop-outs at week 12 in the current study were from intervention groups, with 100% week-12 retention in control group. This suggests that families remained motivated to improve child weight status and dietary intake once they signed up for the program even though three months had elapsed since enrolment.

A previous survey[115] (n=75 parents) indicated that they would be interested in participating in an online family lifestyle program, with a preference for an online program that was easy to use, practical, engaging, endorsed by qualified health professionals, and was able to involve

their children while providing individual tailored feedback for the children. However, it remains uncertain whether the in-person data collection appointments of the current study were a barrier to families' participation, as transportation and scheduling conflicts were some of the identified barriers to program engagement in childhood obesity interventions.[199] Future studies should explore whether a solely online program could attract a greater number of families enrol into the program, thereby increasing participation rates. A solely online program offers the potential to combine telehealth and use of the personalised nutrition and dietary intake report generated from the validated parent-reported child AES, which can be completed online and at home.[137] Existing validation studies identified that parents are relatively accurate reporters of their child height and weight.[176, 200] Hence, using web-based approaches clinicians can collect child anthropometrics and dietary intake data remotely without having families to travel and schedule for in-person appointment at clinics.

The preliminary efficacy results warrant caution in their interpretation and generalisability given the study limitations. The AES has been associated with an over-reporting bias, consistent with previous studies reporting validation results for FFQs relative to other reference methods.[201] While the AES may not be suitable for estimating absolute dietary intake for children, it has been demonstrated to provide a relative validation of parent-reported child fruit and vegetable intake using plasma carotenoids concentration: beta-carotene ($r=0.56$, $P<0.05$), alpha-carotene ($r= 0.51$, $P<0.001$), cryptoxanthin ($r=0.32$, $P<0.001$).[189] The short time frame and small sample size of the current study are likely to have contributed to insufficient power to detect a statistically significance in child anthropometry outcomes. However, the purpose of feasibility studies is to determine whether the intervention warrants further testing and identify areas for refinement. The current study showed that a personalized family-focused online telehealth nutrition intervention is feasible for families facing the issue of childhood obesity and likely to improve child weight-related and dietary outcomes. Using technology-based dietary assessment, this intervention offers families easy access to personalised, credible and timely dietetics consultations using telehealth in the comfort of their own home. The intervention modalities are highly scalable, and the novel approach may increase access of a large number of families to health services without the inconveniences of transportation, travel time or cost, an important clinical implication.

In conclusion, a 12-week family-focused online nutrition intervention delivered using telehealth technology to support parents in improving child weight status and dietary intake is feasible. The feasibility of the intervention and modest improvements in child outcomes warrant further investigation in a fully-powered randomised controlled trial assessing intervention efficacy and whether a solely online program will increase participation, retention and reach.

Chapter 5: Fidelity and acceptability of a technology-based nutrition intervention for families of children with overweight or obesity

This chapter aligns with Thesis Aim 4 and presents the process evaluation of the pilot study (presented in Chapter 4) with a focus on intervention fidelity and acceptability.

Aim 4. To develop and test the feasibility, acceptability, and efficacy of a novel family-focused online telehealth nutrition intervention in improving child weight status and dietary intake, and the impact of the addition of evidence-based text messages targeted to mothers and fathers.

The content of this chapter has been published in the Journal of Telemedicine and Telecare.

The work presented in this chapter was completed in collaboration with the co-authors (Appendix 12).

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5.1 Abstract

Introduction: Previous reviews of family-based interventions for childhood obesity treatment found that studies were of low methodological quality with inadequate details reported, especially related to intervention fidelity. The evaluation of fidelity is crucial to inform interpretation of the intervention outcomes. This study aimed to summarise intervention fidelity, participants' acceptability and satisfaction with a 12-week family-focused technology-based child nutrition and weight management intervention.

Methods: Families with children aged four to 11 years participated in a telehealth intervention with complementary components: website, Facebook group, and text messages. Intervention fidelity was reported using National Institutes of Health Treatment Fidelity Framework. Delivery was measured using a dietitian-reported evaluation survey. Google Analytics and Bitly platform were used to objectively track data on frequency and pattern of intervention use. Participants' acceptability and satisfaction were measured using a process evaluation survey.

Results: Telehealth consultations delivered by trained dietitians had good adherence (⩾83%) to the structured content. Process evaluation results indicated that parents (n=30; mean age 41 years, 97% were female, body mass index 30kg/m^2) found the intervention components easy to use/understand (87%-100%), the program had improved their family/child eating habits (93%), and they wanted to continue using telehealth and the website, as well as recommending it to other parents (90%-91%).

Discussion: In summary, a family-focused technology-based child nutrition and weight management intervention using telehealth, website, Facebook and SMS can be delivered by trained dietitians with good fidelity and attain high acceptability and satisfaction among families with primary school aged children in New South Wales, Australia.

5.2 Introduction

Systematic reviews in both obesity prevention and treatment for children and adolescents suggest that family-based behavioural interventions improve child outcomes in weight, BMI and other measures of body fat composition.[37, 41, 47-52] However, evidence for intervention effectiveness on child weight and weight-related behavior remains inconsistent due to the wide variety of intervention designs and strategies used (i.e. single vs multicomponent, low vs high intensity)[40, 50, 148] and lack of high quality studies.[37, 147] A recent umbrella review of randomised controlled trials in family-based behavioural interventions for obesity treatment in children identified that a large proportion of studies were of low methodological quality due to unclear or inadequate reporting of methods and behavioural outcomes.[87] Another review found few studies reported any evaluation of intervention fidelity – important measures to help gain a

better understanding of factors associated with desirable or undesirable outcomes and inform future development and/or refinement of efficacious interventions.[202]

Intervention fidelity refers to the extent to which the intervention is delivered as it was intended.[203] The National Institutes of Health Treatment Fidelity Framework[204] includes five fidelity domains of : Design, Training, Delivery, Receipt, and Enactment.[205] The evaluation and reporting of intervention fidelity is important, especially for multicomponent intervention designs that are commonly applied in childhood obesity research. This can provide clarity on what was actually taught (intervention delivery), what was learnt (intervention receipt), what was used (enactment), and whether one/some or all of the intervention components contributed to the reported intervention outcomes. It is also important to assess participants' acceptability and satisfaction with an intervention in order to identify areas for revision and/or refinement in future interventions.

A previous study of an eight weekly family-based psychoeducational group intervention about behaviour, activity and nutrition was delivered using telehealth and led by trained psychologists.[195] The study is one of the few studies which reported intervention fidelity outcomes.[195] However, consistent with what is reported in the literature, intervention fidelity was not fully reported in the study.[195] A systematic review highlighted that existing studies usually have adequate reporting of intervention design, including the description of behaviour change theories underpinning the intervention development.[202] However, studies commonly only report briefly on intervention delivery (i.e. number of sessions, participant satisfaction) and have been reported to be lacking in other aspects of intervention delivery, such as session length/duration and content of the intervention as delivered.[202] Therefore, the current study aimed to report intervention fidelity and participants' acceptability and satisfaction with a novel family-focused technology-based child nutrition and weight management intervention.

5.3 Methods

The Back2Basics Family program aimed to improve dietary intakes and weight outcomes of children using a 12-week technology-based nutrition program tailored for families with primary school aged children. Eligible participants were parent/s or legal guardians (referred to hereafter as 'parents') and their children aged four to 11 years with a BMI ≥21.5kg/m^2 (International Obesity Task Force (IOTF) children cut-offs).[19] Children who had a secondary cause for obesity or required medication (except insulin) that influence growth, weight or appetite; or required a therapeutic (i.e. texture modified) diet were excluded. The intervention protocol, recruitment, and primary outcomes with intent-to-treat analysis were described in a separate paper.[206] Ethics approvals were received from the Hunter New England Local Health

Districts Human Research Ethics Committee (16/07/20/4.04) and University of Newcastle Human Research Ethics Committee (H-2016-0329).

5.3.1 Intervention design

Briefly, the intervention was delivered as a three-armed pilot randomised controlled trial (RCT). Forty six families were randomised at baseline and 35 families completed week 12 data collection. The intervention arm 1 (Telehealth) received two semi-structured telehealth consultations (online video-consultations, attended by at least one parent and the index child), access to the program website and a Facebook group for parents. The intervention arm 2 (Telehealth+SMS) received the same components as intervention arm 1 plus additional evidence-based text messages (SMS)[125] targeted to both parents (e.g. mother and father) of the child where possible, except for single parent or when only one parent consented to receive the SMS. The waitlist control group received all the intervention components at week 12 follow-up from baseline.

Telehealth consultations were delivered using Avaya Scopia Desktop Client (version 8.2.1; California, United States) by an APD via scheduled appointments with individual families. A telehealth dietetic consultation was scheduled in week 1 as well as a second consultation in week 4. The website nutrition and health topics were released weekly, from weeks 1 to 12 on an automated schedule through WordPress (version 4.6.10), an online publishing platform which was used to build the program website. For each website topic released, a short summary and link to the webpage was posted on the same day to the Facebook group, prompting participants to access the website content via a new notification through Facebook. Furthermore, some SMS texts contained a shortened link to a relevant topic on the program website to nudge participants to access the website content.

5.3.2 Training of providers

A standard protocol containing telehealth consultation structure and content, guided by the CALO-RE taxonomy of behaviour change techniques[99] related to healthy eating was developed by experienced dietitians (TB, CC, LKC) to guide the telehealth consultation. Three Accredited Practising Dietitians (APDs) who were experienced in working with children and families were responsible for delivering the telehealth consultations. In this study, the APDs received training on providing family-focused child weight management consultations using a non-weight focused approach. The training was delivered through a one-hour face-to-face workshop and included information about the standard protocol for the telehealth consultations, structure and content of the consultations, behaviour change techniques mapped to consultation content, telehealth session evaluation, supplementary materials and checklist to guide the consultations, and functions and features of telehealth platform – Scopia Desktop

Client, developed by Avaya. After completing the training, each APD delivered a mock telehealth consultation using Scopia. Senior dietitians (TB and CC) provided support and supervision when required throughout the intervention period.

5.3.3 Intervention delivery

Treatment delivery was measured using a self-reported session evaluation survey completed by APDs after delivering each telehealth consultation. The session evaluation mainly focused on adherence to the structured content of the telehealth consultations. The session evaluation also included three open-ended questions relating to the timing, duration and participants of the consultation. In addition, a 5-point Likert scale was used for the APD to indicate their perception of the participants' understanding of the content, and whether the consultation appeared to hold participants' interest and attention (based on participants' responses throughout the interactive telehealth consultation, and involvement in goal setting and strategies discussion). Adherence to the publication schedule of website topics and Facebook posts were documented by the research team using a checklist to confirm weekly posts were published as planned. Delivery of the SMS was monitored and confirmed through weekly delivery status reports from Connection Software (Nottingham, UK), an online platform which was used to deliver the intervention SMS.

5.3.4 Intervention receipt and enactment

Intervention receipt and enactment were measured using a self-reported process evaluation survey by parents who completed the intervention program (both intervention groups at week 12 and control group at week 24). The process evaluation mainly focused on parent-reported usage and perceived usability, acceptability, satisfaction and intent to continue use of the intervention components, including telehealth, website, Facebook group and SMS, where applicable. Parents were asked to rank the usefulness of, and their satisfaction with the individual intervention components on a 5-point Likert scale from strongly agree (=5) to strongly disagree (=1), as well as to record qualitative responses with further comments about usefulness and satisfaction of the intervention, and suggestions for future interventions. The process evaluation also included questions relating to the parent's perception on whether the program had made a difference to their family's and child's eating habits, an optional section about parents' perceived self-competency. Furthermore, the actual frequency and pattern of intervention usage were objectively tracked using Google Analytics (Google LLC, CA, USA), Sociograph Analytics (https://sociograph.io), and Bitly link management platform (Bitly, NY, USA) which identified the mean number of website visits, the most popular webpages, and resources downloads.

5.3.5 Statistical analysis

All data manipulation and statistical analyses were undertaken using STATA, version 12 (Stata Corp LP, College Station, TX, USA). Descriptive statistics were used to assess demographic characteristics of participants, outcomes of intervention fidelity: provider delivered intervention content as intended (*delivery*); participants' usage and comprehension of intervention (*receipt*); and parents' perceived changes in eating habits and related skills (*enactment*), and participants' acceptability and satisfaction of the intervention. A small number of open responses (i.e. parents' feedback and suggestions) were received, these responses were deidentified and described narratively in the main text.

5.4 Results

Process evaluation survey was completed by 30 families (65% of n=46 total participants) during the follow up assessments at the conclusion of intervention and their demographic characteristics at the time of completing the survey are presented in Table 5-1. Baseline characteristics of children and parents who completed the survey were not significantly different to those who did not complete the survey.[206]

Table 5-1 *Characteristics of parents and children who completed process evaluation survey*

Characteristics of participants	**n=30**
Child's age (years), mean±SD	9±2.5
Child's measured BMI, mean±SD	23±5.7
Child sex, n female (%)	14 (47)
Parent's age (years), mean±SD	41±7.9
Parent's reported BMI, mean±SD	30±6.5
Parent's sex, n female (%)	29 (97)
Education, n (%)	
School certificate (Years 10 or equivalent)	3 (10)
Higher school certificate (Years 12 or equivalent)	3 (10)
Certificate/Diploma (e.g. childcare, technician)	9 (30)
University Degree	9 (30)
Higher University Degree (e.g. Grad Dip, Masters, PhD)	6 (20)
Socioeconomic status, n (%)	
Low (IRSAD 1-3)	6 (20)
Mid (IRSAD 4-7)	18 (60)
High (IRSAD 8-10)	6 (20)
Modified Monash Model, n (%)	
Major City (MM 1)	18 (60)
Small Regional (MM 5)	12 (40)
Family context, n (%)	
Child living with both biological parents	18 (60)
Child living with a biological parent and a stepparent	2 (7)
Child living in more than one house regularly	4 (13)

Characteristics of participants	n=30
Child living with a single parent only	6 (20)

BMI: Body Mass Index; MM: Modified Monash Category (MM 1: Major City, MM 5: Small Regional); IRSAD: Index of Relative Socio-Economic Advantage and Disadvantage. Modified Monash Model is a seven-category classification system used to categorise locations based on geographical remoteness. Reference: Department of Health. Modified Monash Model [Internet]. 2018 [updated 2018 Jun 12; cited 2019 Jan 20]. Available from: http://www.health.gov.au/internet/main/publishing.nsf/Content/modified-monash-model

5.4.1 Intervention delivery

Telehealth session evaluation data, recorded by APDs, were available from 44 families who attended initial appointment (96% of 46 families who completed baseline) and 36 families who attended second appointment (78% of 46 families who completed baseline). Table 5-2 presented the overall duration, timing and participants of the telehealth appointments. Mean duration for the initial appointments (n=44) was 35 minutes and 20 minutes for the second appointments (n=36). The majority of the initial and second appointments (82%; n=82) were between 3pm and 6pm (Figure 5-1) attended by mothers and their child (86%; n=66), followed by both fathers and mothers with their child (13%; n=10). Child absence from appointments were due to tiredness (n=2; reported by the mother) and the parent forgetting the child was expected to participate (n=1).

Table 5-2 *Dietitian records of duration, timing and participants of telehealth appointments*

Telehealth appointments	Initial (n=44)	Second (n=36)	Total (n=80)
Duration (minutes), mean±SD	35±7.3	20±4.5	28±9.9
Participants, n (%)			
Child present	41 (93)	33 (92)	74 (93)
Mother present (with/without father)	43 (98)	34 (94)	77 (97)
Father present (with/without mother)	7 (16)	4 (11)	11 (14)
Dietitian perceptions, n (%)			
Participants found the information in this session easy to understand	41 (93)	35 (97)	76 (95)
The session held participant's interest and attention	38 (86)	34 (94)	72 (90)

Note: Dietitian perceptions presented in this table were responses measured using a 5-point Likert scale representing that dietitians agree (=4) or strongly agree (=5) with each of the above items.

For 90% of the telehealth consultations, the APDs agreed or strongly agreed that the participants found the information provided in the consultations was easy to understand and that the consultations held participants' interest and attention (Table 5-2). The APDs were able to adhere to the structured content for the initial appointments; all six topics were discussed with 42 families in their initial appointment, while two families did not discuss one of the topics (i.e. energy balance on intake vs output) as the parents and children reported already knowing about the topic. For the second appointments, all 36 families reviewed their previously set goals and strategies and 92% (n=33) felt that they were on track to meeting their goals. All families had discussed at least one of the behaviour change strategies, including: motivation

to change (97%; n=35), barriers to change (81%; n=29), how to maintain change (67%; n=24), practice change in new situation (44%; n=16) and rewards for achieving goals (86%; n=31).

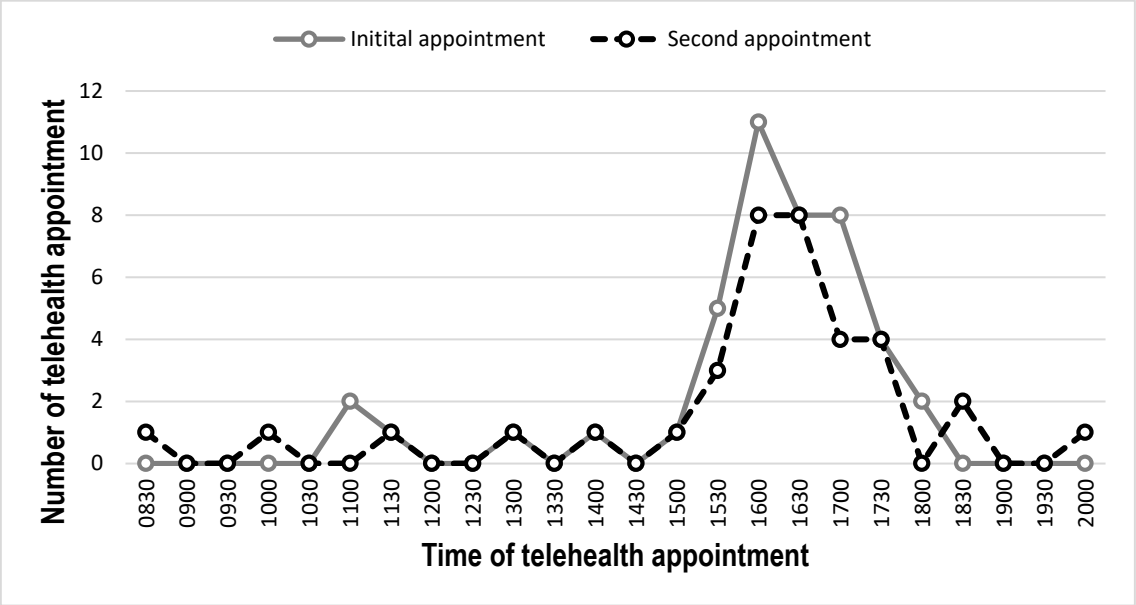

Figure 5-1 *Time of initial and second telehealth appointments*

5.4.2 Intervention receipt and usage

Website: One-third of the parents reported that they had accessed the website (Figure 5-2) once per month (n=10; 33%), followed by once per fortnight (n=7; 23%). Another 23% (n=7) of parents reported that they had never used the website, mainly due to lack of time:

"With a new baby I have little time to read things online, but I do want to use the website more in the near future."; *"I had problems logging on and I was quite slack (honestly) I liked the text messaging and Facebook."*,

or that they felt they already had a good level of knowledge about nutrition:

"I didn't access the website as I personally know quite a few things about nutrition, healthy lifestyle and exercise."

Overall, Google Analytics showed that participants visited the program website a total of 1566 times with the highest average number of visits on Tuesdays (Figure 5-3) and around 4pm (Figure 5-4). The most commonly used devices for accessing the website was desktop (66%), mobile phone (27%), and tablet (7%). The majority of website visits were through direct/shortened website links (64%), followed by links posted on Facebook (27%), search engines (e.g. Google; 8%), and links included in SMS (1%). The most and least accessed main website topics and all downloads of resources (total 214 downloads for nine files) are presented in Table 5-3.

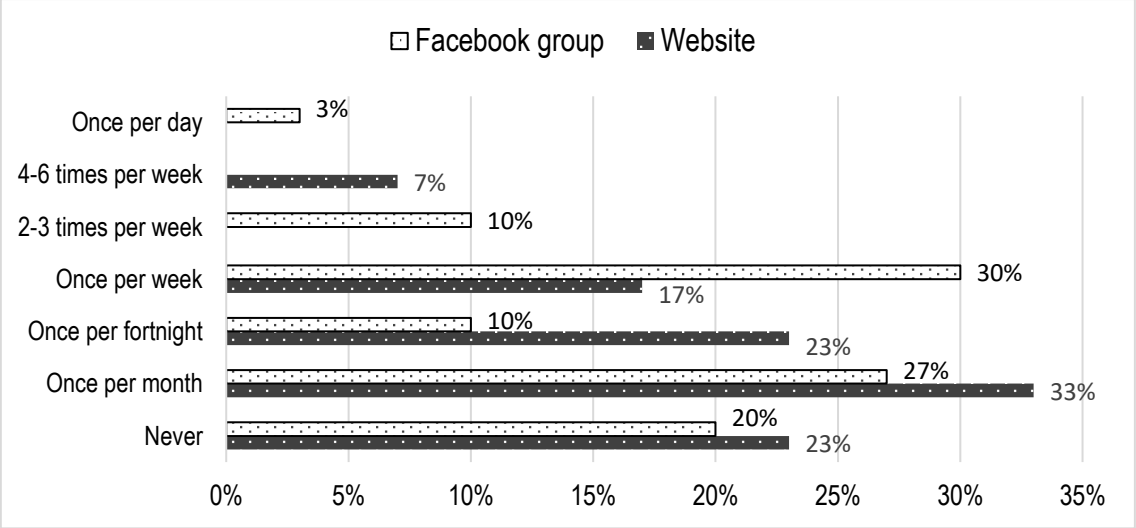

Figure 5-2 *Reported frequency of use of intervention components by parents (n=30) enrolled in a healthy lifestyle intervention for their children*

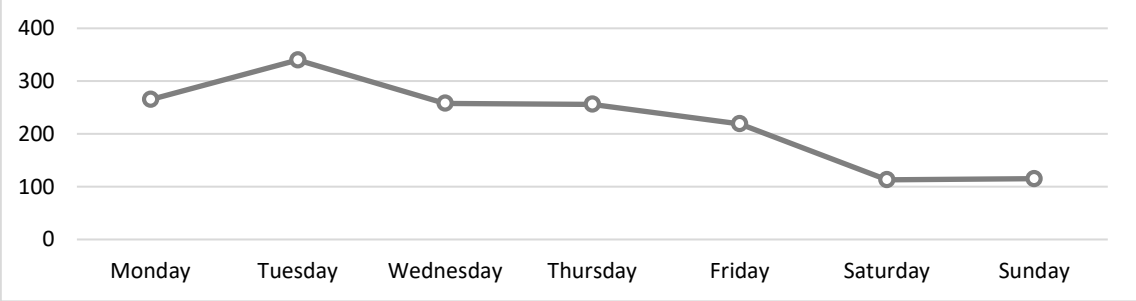

Figure 5-3 *Average number of website visits on each day of the week*

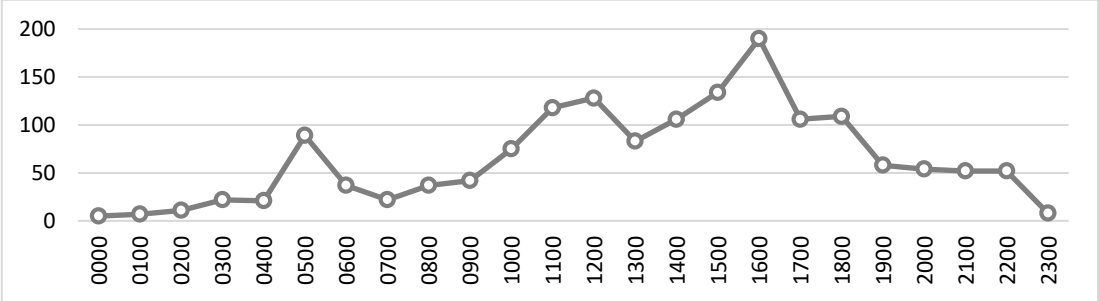

Figure 5-4 *Average number of website visits on each hour of the day*

Table 5-3 *Analytics of website visits and downloads*

Website content	**N (%)**
Webpage, number of visits	
Daily recommended serves of the five food groups	71 (5)
Introduction to the national dietary guidelines and food groups	56 (4)
Simple recipes and cooking videos (tailored for low literacy level)	50 (3)
Child healthy eating tips for parents*	24 (2)
Family meal times	22 (1)
Online tools and downloadable resources*	22 (1)
Tips for takeaways and eating out	20 (1)

Website content	N (%)
Lunchbox ideas	18 (1)
Tips to increase fruit and vegetables intake	16 (1)
Nutrition-themed online games	15 (1)
Praise and motivation*	12 (1)
Groceries shopping	11 (1)
Cooking with kids (children cooking tips for parents)	11 (1)
Label reading	11 (1)
Snack ideas	9 (1)
Rewards, rules and role modelling*	8 (1)
Stop bullying in school*	4 (0)
Further support (helplines)*	4 (0)
Physical activity	2 (0)
Downloadable resources, number of downloads	
Plan for Change (strategies)	55 (26)
Family menu planning of the week (sample)	38 (18)
Food diary (template)	35 (16)
Family menu planning of the week (template)	34 (16)
Shopping list (template)	21 (10)
Family food habits chart (checklist)	18 (8)
Goal setting chart (template)	9 (4)
Snack attack ideas (strategies)	4 (2)
Rewards ideas (strategies)	0 (0)

*These are parent-targeted website topics. Percentages may not sum up to 100% (total website visits of 1566 times) because only the main website topics are presented in the table.

Facebook: A similar number of parents reported that they accessed the Facebook group (Figure 5-2) once per week (n=9; 30%) or once per month (n=8; 27%). Four out of five parents who reported that they had never used the Facebook group had all mentioned that they either rarely or do not use Facebook. Overall, Facebook analytics showed a total of 44 members joined the Facebook group (both parents were invited to join), 31 posts in the group were written by the research team, 26 posts (including comments) in the group were written by parents and 88 reactions (all were Facebook 'like') recorded by the parents. Parents' written posts and comments were generally positive:

"My daughter ate 1/4 cup of mixed vegetables for the first time in such a long time. But no luck getting vegetables eaten at school yet. But it's a start."; *"This [Cooking with Kids website topic] is our favourite. [Child name] loves helping. Eats a lot better too."*; *"I have found some good recipes on this website. [link]"*,

except for a parent who was disappointed at the child's BMI:

"I have just looked at my 8yo daughter's BMI. I am feeling like I have failed her and set her up for a heap of misery."

SMS: Of the 30 families who completed the process evaluation survey, 19 families (n=12 two-parents, n=3 separated parents, n=4 single-parent) were allocated to receive the SMS intervention via randomisation at baseline. Although both mothers and fathers were invited to participate in the intervention, only seven mother-father dyads and 12 mothers-only consented to receive the SMS. Parents all reported that they received the SMS, which was also supported by the objective SMS delivery report. Some of the SMS (19%; n=8 of total 43 SMS) contained a shortened link to the program website to act as a prompt for participants to read more about a topic on the program website. Bitly analytics data (Table 5-4) showed that the most clicked/viewed link was for 'Recipes' (37 clicks), followed by 'Home page' (22 clicks). A common trait observed for the three least clicked links was the SMS content did not provide information about the topic of the link. For example, the SMS with the most clicked link said:

"Busy day? No time to prepare a healthy meal? Try one of these 20-minute recipes tonight! [link]";

however, the SMS with the least clicked link said:

"When families use a shopping list, they buy less junk food and save money. How can you help your family to make this happen? [link]".

Table 5-4 *Analytics (number of clicks) of the links included in SMS*

Target recipients	N recipients	N clicks (%)	Topic of the link, if mentioned in SMS
Both parents	26	37 (142)	Recipes
Mothers	19	22 (116)	Website (Home page)
Both parents	26	13 (50)	Recipes
Both parents	26	11 (42)	Cooking tips
Both parents	26	10 (38)	Snack ideas
Both parents	26	9 (35)	Weekend eat-out
Fathers	7	7 (100)	Website (Home page)
Both parents	26	3 (12)	Not mentioned in SMS
Mothers	19	2 (11)	Not mentioned in SMS
Fathers	7	0 (0)	Not mentioned in SMS

5.4.3 Participants perception and satisfaction

Telehealth: Process evaluation results indicated that parents were satisfied with the telehealth intervention, including the venue, timing and content, as well as the other intervention components: website, Facebook group and SMS, and there appear to be no substantial difference in responses for the majority of the variables between the intervention groups (Table

5-5). All parents (n=30) reported that the consultation was informative and helpful, especially the discussion about goal settings and strategies planning where all of them agreed that the topic was useful. Parents reported that the consultation was valuable as it was a personalised and face-to-face interaction with the dietitian:

"The Telehealth sessions with the dietitian were the most valuable part of the program since it was personalised and the face to face interaction improved motivation and accountability",

and one parent reported wanting more specific recommendations related to goals and strategies:

"Information from dietitian consults were quite general and we were hoping for more specific goals and strategies that are relevant to us. The lunchbox idea was great, and we resonate with that well but was looking for more specific recommendations."

Other content, such as dietary guidelines recommendations, child dietary feedback and discussion about the use of rewards were also well accepted. The majority of parents who completed the telehealth intervention found the dietitians approachable 97% (n=29), that telehealth was convenient (100%, n=30) and easy to use (87%, n=26), and 90% (n=27) would continue to use telehealth, as well as recommend it to other parents.

Table 5-5 *Parents satisfaction of the intervention components and perceived self-competency*

Process evaluation items	T n (%)	T+SMS n (%)	Control n (%)	Total n (%)
Number of participants	11 (100)	10 (100)	9 (100)	30 (100)
Telehealth				
Telehealth was easy to set up/install	9 (82)	10 (100)	8 (89)	27 (90)
Telehealth was easy to use	9 (82)	10 (100)	7 (78)	26 (87)
Telehealth was convenient	11 (100)	10 (100)	9 (100)	30 (100)
Telehealth consultation was informative	11 (100)	10 (100)	9 (100)	30 (100)
Telehealth consultation was helpful	11 (100)	10 (100)	9 (100)	30 (100)
I would like to continue to use Telehealth for future consultations	9 (82)	10 (100)	8 (89)	27 (90)
I would recommend Telehealth to other parents	9 (82)	10 (100)	8 (89)	27 (90)
Telehealth venue and timing				
The room where consultations were held was suitable	9 (82)	10 (100)	9 (100)	28 (93)
The consultation session duration (around 20 minutes) was appropriate	11 (100)	10 (100)	9 (100)	30 (100)
The time of the day for the consultations was convenient	11 (100)	10 (100)	9 (100)	30 (100)
Telehealth dietitian				
The dietitian was very knowledgeable.	10 (91)	10 (100)	9 (100)	29 (97)
The dietitian had good communication skills	10 (91)	10 (100)	9 (100)	29 (97)
The dietitian was approachable	10 (91)	10 (100)	9 (100)	29 (97)
Telehealth consultation content				

Process evaluation items	T n (%)	T+SMS n (%)	Control n (%)	Total n (%)
The information provided was easy to understand	11 (100)	10 (100)	9 (100)	30 (100)
The information provided was appropriate	10 (91)	10 (100)	9 (100)	29 (97)
The information provided was motivating	9 (82)	10 (100)	9 (100)	28 (93)
Telehealth: was the information covered in each topic useful?				
Introduction to Australian Dietary Guidelines recommendations was useful	11 (100)	10 (100)	8 (89)	29 (97)
Australian Eating Survey results and feedback were useful	10 (91)	9 (90)	9 (100)	28 (93)
Goals settings and strategies planning was useful	11 (100)	10 (100)	9 (100)	30 (100)
Discussion about the use of rewards was useful	10 (91)	10 (100)	9 (100)	29 (97)
Telehealth: was the information covered in each topic about right?				
Introduction to Australian Dietary Guidelines recommendations was about right	10 (91)	9 (90)	9 (100)	28 (93)
Australian Eating Survey results and feedback were about right	10 (91)	9 (90)	9 (100)	28 (93)
Goals settings and strategies planning was about right	9 (82)	9 (90)	9 (100)	27 (90)
Discussion about the use of rewards was useful	8 (73)	9 (90)	8 (89)	25 (83)
Website (n=23 who accessed the website at least once since baseline)	N=8	N=7	N=8	N=23
The website was easy to use.	7 (88)	7 (100)	7 (88)	21 (91)
I felt confident using the website.	8 (100)	7 (100)	7 (88)	22 (96)
Most people could learn to use the website very quickly.	8 (100)	7 (100)	8 (100)	23 (100)
I liked the presentation and layout of the website.	5 (63)	7 (100)	6 (75)	18 (78)
Resources on the website worked well together.	5 (63)	7 (100)	8 (100)	20 (87)
I would like to continue to use the website frequently in the future.	7 (88)	6 (86)	8 (100)	21 (91)
The website was useful in helping us to improve our child's eating behaviour	4 (50)	7 (100)	5 (63)	16 (70)
I needed to learn a lot of things before I could use the website comfortably.	0 (0)	2 (29)	2 (25)	4 (17)
I needed support to find my way about the website.	1 (13)	1 (14)	2 (25)	4 (17)
I found the website difficult to use or unnecessarily complex.	1 (13)	2 (29)	1 (13)	4 (17)
Facebook group (n=24 who accessed the Facebook group at least once since baseline)	N=8	N=8	N=8	N=24
The Facebook posts were easy to understand.	7 (88)	8 (100)	7 (88)	22 (92)
The Facebook posts arrived at a good time of day.	6 (75)	8 (100)	5 (63)	19 (79)
The frequency of Facebook posts was about right.	7 (88)	8 (100)	4 (50)	19 (79)
I use the website more frequently because of the Facebook posts.	3 (38)	7 (88)	6 (75)	16 (67)
I would like to continue using the Facebook group in the future.	3 (38)	5 (63)	3 (38)	11 (46)
Text messages (n=19 who received the SMS intervention)	NA	10	9	19
The text messages were easy to understand.	NA	10 (100)	9 (100)	19 (100)
The text messages arrived at a good time of day.	NA	10 (100)	7 (78)	17 (89)
The frequency of text messages was about right.	NA	9 (90)	8 (89)	17 (89)
I would like to continue receiving the text messages in the future.	NA	6 (60)	4 (44)	10 (53)
Text messages (n=15 who received the SMS and have a parenting partner)	NA	9	6	15

Process evaluation items	T n (%)	T+SMS n (%)	Control n (%)	Total n (%)
I worked more closely with my partner because of the text messages.	NA	3 (33)	4 (67)	7 (47)
The text messages have helped improve the way my partner and I work together.	NA	2 (22)	4 (67)	6 (40)
Parents self-competency (n=11 who completed this optional section)	N=5	N=4	N=2	N=11
I believe that I can help my child to lead a healthy life.	5 (100)	4 (100)	2 (100)	11 (100)
I believe that my family will help each other to reach our health goals.	5 (100)	4 (100)	1 (50)	10 (91)
I am able to talk to my family about healthy lifestyle.	5 (100)	4 (100)	1 (50)	10 (91)
I am sure that I can do what is best to keep my family healthy.	5 (100)	4 (100)	2 (100)	11 (100)
I know that I can make healthy snack choices regularly.	5 (100)	4 (100)	2 (100)	11 (100)
Overall intervention (n=30)	N=11	N=10	N=9	N=30
The program has made a difference to our family's eating habits?	10 (91)	10 (100)	8 (89)	28 (93)
The program has made a difference to our child's eating habits?	11 (100)	10 (100)	8 (89)	29 (97)

T: Telehealth intervention group; T+SMS: Telehealth+SMS intervention group; NA: not applicable. Note: Results presented in this table were responses measured using a 5-point Likert scale representing that parents agree (=4) or strongly agree (=5) with each of the above items.

Website: The majority of parents who used the program website reported that it was easy to use (91%, n=21), useful in supporting to improve their child's eating behaviour (70%, n=16) and would continue to use in the future (91%, n=21). Parents were asked if there is any topic they would like to be added to or removed from the website, only one parent responded to the question and suggested to add *"more goal setting ideas"* to the website and *"don't remove anything"* from the website. However, another parent mentioned: *"Prefer to use an app more than a website, as more convenient to access through phone."* A small number of parents (17%, n=4) found the website difficult to use and felt they needed support to use the website (Table 5-5).

Facebook: Overall, about two-third of the parents (67%; n=16) who used the Facebook group reported that the Facebook posts prompted them to use the program website more frequently. A smaller group of parents (38%, n=3 of 8) in Telehealth group reported they have used the website more frequently as prompted by the Facebook posts and would like to continue using the Facebook group in the future, compared to Telehealth+SMS group (88%, n=7 of 8). However, the majority of parents from both intervention groups were satisfied with the timing and frequency of the Facebook posts, and deemed the content were easy to understand. (Table 5-5) A common feedback for the Facebook group was the lack of interactions between group members:

"Facebook posts need to be more interactive. Small number of people on the site meant no conversation."; *"The Facebook group really didn't work as no one put any comments on it. This may be because it is a sensitive subject your child being overweight."*

SMS: Parents who received the SMS and had a parenting partner (n=15), felt that the SMS had prompted them to work more closely with their partner (47%; n=7) or had improved the way they work together (40%; n=6). Parents who had received the SMS intervention found the SMS helpful, relevant, motivating and reported that it kept them on track:

"I found these relevant and motivating."; *"The text messages came through at just the right time. Just as things started to slip, it helped us stay on track."*

A parent mentioned that having the SMS delivered to both parents was helpful in encouraging conversations/discussions:

"The text messages were actually the best part of the whole program. They were really helpful and handy reminders, when you've started to slip and forget goals. They had helpful hints for conversations and I really liked them."; *"I really liked the fact that both my partner and I received the same text message at the same time. This meant the information was first-hand for us both - we could individually process the information and then discuss it as equals. So, both of us receiving the text messages was really helpful!"*

Some parents preferred the SMS to be gender neutral:

"Just made a bit more general and not refer to Mum or Dad.",

or targeted to the child:

"Perhaps text messages aimed at the child so parents can show them."

Overall, the majority of parents (93%, n=26) felt that the program had improved their family and child eating habits. A smaller number of parents (n=11) also completed the optional questions about parents self-competency and all felt that they were able to help their child to lead a healthy life, make healthy snack choices regularly and do what is best to keep their family healthy (Table 5-5). There were no reports of unexpected adverse events as a result of the intervention.

Parents reported in the open-response questions (qualitative component) of the survey that they had had a positive experience in the program:

"The program gave us access to new and relevant information, endless support with the Facebook group, not to mention the live video calls with the dietitian, who was truly fantastic

and answered any questions we had. We are glad we participated and urge other families to do the same.",

and saw improvements in their child's eating behaviour and food choices, as well as the family's:

"I have enjoyed the program as we have talked more about healthy foods. My child has also stopped eating Muesli bars."; *"I think this is a great program. She will think more for herself when it comes to healthier options, e.g. put less butter on her sandwich. We have been making pizzas at home with healthier toppings rather than always buying takeaway."*; *"My daughter and husband started increasing the amount of greens in the evenings as one of our goals. I have personally reduced the sugar intake, chips intake and chocolate intake as well - which is great."*

Some parents also indicated that self-motivation and organisation are needed when participating in the program:

"You need to be very self-motivated during this trial and focused on eating habits, due to limited time and organisation I feel we did not complete the trial with great success."

5.5 Discussion

The current study assessed Back2Basics Family intervention fidelity as set out by National Institutes of Health Treatment Fidelity Framework:[204] delivery of intervention content as intended (delivery), participants' usage and comprehension of intervention (receipt), parents' perceived changes in eating habits and self-competency (enactment), and participants' acceptability and satisfaction of a novel family-focused technology-based child nutrition and weight management intervention.

Telehealth consultations were delivered by trained APDs with good adherence to the program structure (i.e. ≥83% planned content were delivered to all families). The APDs were able to tailor personalised dietary advice for individual families related to the goals and family-focused strategies. The telehealth consultations occurred within the expected appointment duration (around 30 minutes), which is a pragmatic requirement in clinical settings where back-to-back appointments are common. Additional resources complementary to the telehealth consultation were successfully delivered on an automated release schedule through the website, Facebook group, and SMS components. The minimal workload and time required to organise access to these complementary resources could potentially increase dietetic practice efficiency by allowing more time for consultations rather than administrative tasks such as mailing resources. Telehealth also has the potential to complement dietetic outreach services, such

as home visits, and save clinicians' time on commuting between clinics and patients' homes, especially those in remote areas.

Existing telehealth interventions found similar results where participants were satisfied with telehealth as a mode of intervention delivery, and reported that telehealth intervention was similar to previous face-to-face clinical experiences.[130, 195, 196] Parents in all groups of the current study reported that telehealth was convenient and easy to use, that the APD who conducted their session was approachable, and the consultation was informative and helpful; especially goal setting and strategies planning. The results identified that families accessed the online intervention via a number of modalities, including a desktop, smartphone or tablet. The overall advantage of using telehealth was demonstrated by the flexibility for participants to join the consultations from home or any place with internet connection, and for multiple participants to join from different sites/homes (e.g. separated parents). The use of telehealth has the potential to increase intervention accessibility, especially to remote areas, and save participants' time in traveling long distances (or time away from work) as these have all been previously identified as common barriers to accessing support for child weight management.[115] A previous study of childhood obesity intervention using telehealth as a supplementary component to in-person clinic visits found that the majority of the parents (n=14 of 21) would choose to have a telehealth session over an in-person clinic visit with an obesity specialist.[207] Fifteen of 26 parents of the study also reported that they would not have seen any obesity specialist if telehealth was not available.[207] This technology-based approach appears to be a promising mode of intervention delivery for personalised nutrition care for families with children with overweight and obesity.

The website served as an evidence-based resource library which was developed by experienced dietitians and contains information designed to support families seeking to improve child eating behaviours. The popular topics were Australian Dietary Guidelines, recipes and cooking videos, while the most downloaded resource was 'Plan for Change' which included a range of healthy eating tips and strategies. These strategies included ways to reduce fat intake, increase fibre intake and reduce refined sugar consumption. Some parents also suggested to have more information about goal setting on the website and more personalised strategies during the telehealth consultation. The results suggest that parents generally had a good level of knowledge about the importance of healthy eating but needed more support around specific practical strategies that are personalised to their family.

Most of the website activity occurred in the afternoon between Monday to Friday. This suggests that the Facebook posts and SMSs, which aimed to increase engagement and prompt participants to visit the website, should potentially be delivered at these times to

maximise both engagement and the consistency of messages received throughout the study duration. Although the majority of participants accessed the website using a desktop, just under one-third of participants accessed from a mobile phone, suggesting that a desktop- and mobile-friendly design should be considered when developing a website. However, the current program website was not optimised/designed for viewing on a mobile phone as it contains an extensive amount of information (texts and images) and requires participants to login to access. Given the increasing use of mobile phones in the Australian population,[118] future interventions should consider usability and accessibility on a mobile phone platform. Future studies should also compare the effectiveness and participants' engagements of intervention using website or mobile application.

Previous studies reported that parents would like to see some social support components in an online intervention where they can interact with other participants.[115] The Facebook group in the current study served to notify parents when new topics became available on the website and to spark discussions between parents during the intervention period. However, interactions between parents in the Facebook group were less than anticipated despite results indicating that parents used the Facebook group regularly (30% once per week, 27% once per month); meaning parents had been accessing the content on the Facebook group but chose not to leave a comment. This may be due to the small group size (less than 10 members) as a result of having to separate intervention groups and control group participants into different Facebook groups to reduce cross-contamination. An advantage of the Facebook group was its notification function which automatically nudges participants when new content is available. The Facebook group content includes links to the program website and accounted for 27% of the total website visits. Two-thirds of parents reported that the Facebook group had prompted them to visit the website more frequently. These findings supported that a push-notification/nudging function appeared to help increase participants' usage and engagement with an online intervention. Future studies could investigate the use of a mobile application to present evidence-based information found on a website in a mobile-friendly user interface; include a social support feature where participants can have discussions about the content; and include a notification function to alert participants when new content is available.

The majority of parents were satisfied with the SMS content and frequency of delivery. However, compared to telehealth and website (~90%), a smaller proportion (~50%) of the parents would have liked to continue using the Facebook group and SMS intervention. The reasons were not identified in the current study but may be attributed to the lower than anticipated member interaction in the Facebook group as discussed above, and the small number of SMS recipients (n=19 mothers and n=7 fathers) with about two-thirds being single-parent or the only parent from a two-parent household who consented to receive the SMS.

The SMS intervention was designed to target healthy eating behaviours within families and to leverage the important role that parents and their parenting partner play in influencing their child and family health outcomes.[125] Parents who received the SMS and had a parenting partner, reported that the SMS prompted them to work more closely with their partner and/or had improved the way they work together. This suggests that the SMS intervention can potentially be used to engage both parents in family-focused child behaviour change by communicating the corresponding information of family interventions to both parents, including the parent who was not able to attend consultations.

An important limitation is that given the overall small sample size, particularly a smaller group of mother-father dyads were included in the arm randomised to receive SMS intervention, results should be interpreted with caution. Furthermore, some of the results were self-reported and this may introduce some bias into these measures. The potential benefits of SMS intervention warrants investigation in future studies with a larger number of mother-father dyads in two-parent and single parent family contexts.

In summary, a family-focused technology-based child nutrition and weight management intervention using telehealth, website, Facebook and SMS can be delivered by trained APDs with high fidelity. Such interventions can also achieve high levels of acceptability and satisfaction among families with primary school aged children. The high scalability of the current intervention warrants the conduct of a fully powered RCT focusing on intervention effectiveness, cost effectiveness and translation into clinical health settings.

Chapter 6: Accuracy of parent-reported anthropometrics of their children

Emerging evidence in the use of telehealth consultations has allowed for increased uptake of treatment intervention outreach to families. One downfall, however, is telehealth consultations and online programs often rely on self-reported measures. For children these measures are often parent proxy-reported records.

This chapter aligns with Thesis Aim 5 and presents a study that assessed the level of agreement of parent-reported child height, weight, and calculated BMI compared to researcher-measured data using Lin's concordance correlation coefficient and Cohen's kappa coefficient.

Aim 5. To assess the accuracy of parent-reported child height, weight and calculated BMI to be able to interpret online parent-reported child anthropometrics.

The content of this chapter has been published in the Journal of Medical Research.

The work presented in this chapter was completed in collaboration with the co-authors (Appendix 13).

Suggested citation:

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6.1 Abstract

Background: eHealth interventions for children often rely on parent-reported child anthropometric measures. However, limited studies have assessed parental accuracy in reporting child height and weight via web-based approaches.

Objective: The study aimed to determine the accuracy of parent-reported child height and weight, as well as Body Mass Index (BMI) and weight category calculated from these data by the researchers. The study also aimed to explore whether parent report was influenced by age, sex, weight status, or exposure to participation in a 12-week brief web-based family lifestyle intervention.

Methods: This study is a secondary analysis using data from a 12-week childhood obesity pilot randomised controlled trial in families with children aged 4-11 years in Australia. Parents were asked to report demographic information including child height and weight using an online survey before their child's height and weight were objectively measured by a trained research assistant at baseline and week 12. Data were analysed using Lin's concordance correlation coefficient (ρc; ranges from 0 (poor) to ±1 (perfect) concordance), Cohen's kappa coefficient, and multivariable linear regression models.

Results: There were 42 families at baseline and 35 families (83%) at week 12. Overall, the accuracy of parent-reported child height was considered 'moderate' (ρc=0.94), accuracy of weight was considered 'substantial' (ρc=0.96), and accuracy of calculated BMI was 'poor' (ρc=0.63). Parents under-reported child height and weight by 0.9cm and 0.5kg at baseline and by 0.2cm and 1.6kg after participating in a 12-week brief web-based family lifestyle intervention. The overall inter-rater agreement of child BMI category was moderate at baseline (k=0.59) and week 12 (k=0.54). The weight category calculated from 74% (n=31) and 70% (n=23) of parent-reported child height and weight was accurate at baseline and week 12, respectively. Parental age was significantly (P=0.014; 95% CI -0.52 to -0.06) associated with accuracy of reporting child height. Child age was significantly (P=0.04; 95% CI -2.34 to -0.06) associated with reporting of child weight.

Conclusions: The majority of Australian parents in the current study were reasonably accurate in reporting child height and weight among a group of children aged four to 11 years. The weight category of the majority of children when calculated from parental reported data were in agreement with the objectively measured data despite the BMI calculated from parent-reported data having poor concordance at both time points. Online parent-reported child height and weight may be a valid method of collecting child anthropometric data ahead of participation in a web-based program. Future studies with larger sample sizes and repeated measures over time in the context of eHealth research are warranted. Future studies should

consider modelling the impact of calibration equations applied to parent-reported anthropometric data on study outcomes.

Keywords: eHealth; internet; parent-report; children; height; weight; body mass index

6.2 Introduction

The wide coverage of internet and the increase in technology use worldwide have led to the emergence of eHealth for lifestyle interventions.[42, 170] Web-based platforms are increasing in popularity and used for data collection and delivery of eHealth interventions.[42, 131] In Australia, technology use is increasing and not limited by socioeconomic status or location, with more than 97% of households with children under age 15 years having access to the internet via computer, smartphone or tablet.[172] Research suggests that online data collection and delivery of interventions is more cost effective than conventional face-to-face modes,[134] allows providers to connect with a large number of people simultaneously, and enhances access to services for communities living in rural and remote locations.[208]

One limitation, however, is that eHealth interventions and non-face-to-face programs were usually delivered over distance. Hence, interventionists had to rely on self-reported measures (e.g. anthropometrics, diet, physical activity) when objective measurements were not possible. For young children in eHealth lifestyle interventions, these measures often include parent-reported child height and weight data. The risk associated with self-reported height and weight data is that discrepancy with other objective measures can result in miscalculation of weight trajectories and weight category. Parental underestimation of child weight has important clinical implications due to the health consequences of childhood obesity [27] and the importance of early identification of a weight gain trajectory in order to seek early intervention. Misreporting may also influence a child's actual eligibility for research or treatment programs which recruit participants using self-reported screening surveys.

Existing studies have used face-to-face interviews or surveys completed at home visits or during clinic visits to collect parent-reported child data. However, differences may occur in data collection using remote non-person-to-person methods (e.g. web-based, posted paper surveys) compared to direct person-to-person methods (e.g. home visits, clinic visits, telephone interviews). Very few studies have evaluated parental accuracy in reporting height and weight of their children remotely without the presence of clinicians or researchers (i.e. online surveys). Furthermore, most of the previous research on parental reporting of child height and weight were conducted in Canada, Western Europe, or the United States,[177, 209-212] and none of the existing studies have included Australian children. Therefore, it is unknown whether Australian parents would perceive their children's height and weight in similar ways as parents in other countries. Moreover, previous studies have used limited measures to

assess agreement, such as the Pearson's correlation coefficients or paired t-tests. These measures were unable to adequately detect levels of agreements (i.e. accuracy and precision) and, instead are associations between parent-reported and researcher/clinician-measured anthropometric data only.[135] The current study aimed to determine: i) accuracy of parent-reported child height and weight, as well as Body Mass Index (BMI) and weight category calculated from these data by the researchers compared to data measured objectively by researchers as the gold standard, and ii) whether parent report was influenced by age, sex, weight category, or exposure to participation in a 12-week brief web-based family lifestyle intervention.

6.3 Methods

This is a secondary analysis using data from a pilot randomised controlled trial that aimed to investigate the feasibility of a 12-week web-based family lifestyle intervention to support parents in improving their child's weight status and eating habit.[206] The pilot trial received ethics approval from the Hunter New England Human Research Ethics Committee (16/07/20/4.04) and University of Newcastle Human Research Ethics Committee (H-2016-0329).

6.3.1 Participants

Families were recruited from New South Wales, Australia through clinician referrals, school newsletters, flyers and word of mouth. Eligible families were those who had a child aged four to 11 years with BMI ≥21.5kg/m^2 (International Obesity Task Force (IOTF) children cut-offs),[19] have access to the internet, and were able to attend lab measurement sessions at one of the three study sites (Newcastle, Tamworth, and Armidale). Parent written consents and child assents were procured prior to baseline lab measurement session.

6.3.2 Data collection

Parents were asked to report demographic information of themselves and an identified index child from the family participating in the intervention. Demographic information included age, sex, height, weight, highest education attained (parent only), and postcode (parent only). Parents provided these details using an online survey before their child's anthropometric measurements were clinically assessed at baseline and week 12, which is 3-month follow up from baseline.

There were no specific instructions provided to the parents when asked about reporting their child's height and weight (e.g. use a tape or scale or time of day to measure). The questions were: "What is your child's height in cm (if unsure, please estimate)" and "What is your child's weight in kg (if unsure, please estimate)". Subsequently, the child's height and weight were measured at baseline and week 12 using standard protocols by blinded research assistants.

Child height was measured to the nearest 0.1 cm while standing with their head and chin up, looking straight ahead (i.e. held in the Frankfurt plane) using the Biospace BSM370 Automatic Stadiometer. Child weight was measured to the nearest 0.1 kg without shoes and in light clothing using InBody 720™ body composition analyser. Measurements were performed twice and the difference between measures was required to be ≤0.3cm (height) and ≤0.4kg (weight). Otherwise, a third reading was obtained, and the two closest readings were used to compute an average height or weight measurement. Families were offered an AUD$10 gift voucher for participation in each lab measurement session. Analyses were conducted by a researcher not involved in the lab measurements.

6.3.3 Statistical analysis

All data manipulation and statistical analyses were undertaken using STATA, version 12 (Stata Corp LP, College Station, TX, USA). Descriptive statistics were calculated for baseline participants' characteristics. Parent-reported and researcher-measured child height and weight data were used to calculate child BMI, with weight category based on IOTF child cut-offs.[19] Lin's concordance correlation coefficient (CCC) was used to assess level of agreement of parent-reported child height, weight, and calculated BMI compared to researcher-measured data at baseline and week 12. This was chosen as a superior method as it measures both precision (i.e. Pearson's correlation coefficient) and accuracy, thus indicating how well a set of bivariate data compares to the "gold standard", measured data. Lin's CCC was expressed in ρc (ranged from 0 to 1) and interpreted as: almost perfect agreement (ρc > 0.99); substantial agreement (ρc > 0.95–0.99); moderate agreement (ρc = 0.90–0.95); and poor agreement (ρc < 0.90).[213] Cohen's kappa coefficient was used to ascertain inter-rater agreement between child weight category calculated from parent-reported child height and weight compared to researcher-measured data.[214] Cohen's kappa coefficient was expressed in k (ranged from 0 to 1) and interpreted as: almost perfect (k > 0.80); substantial (0.61 ≤ k ≤ 0.80); moderate (0.41 ≤ k ≤ 0.60); fair (0.21 ≤ k ≤ 0.40); slight (0.00 ≤ k ≤ 0.20); poor (k < 0.00).[215] Multivariable linear regression models for the outcomes of difference between parent-reported and researcher-measured height and weight (calculated by subtracting researcher-measured data from parent-reported data) were used to further investigate relationships between outcomes and age (years), sex, and weight status of parents and the index child. A sample size of 7 and 29 subjects per groups was calculated as needed to detect an expected correlation coefficient of 0.9 and 0.5, respectively, at an alpha of 0.05 and with 80% power for height and weight.

6.4 Results

Parent-reported and researcher-measured child height and weight data were available from 42 families at baseline and 35 families (83%) at week 12. Baseline characteristics of children

and parents who were lost to follow up, defined as not responding after three reminders to complete assessments, were not significantly different compared to those who completed the follow up at week 12.[206]

Parents were predominantly female (n=40; 95%) with a mean age 40.5 years, mean BMI 29.9 kg/m^2, from middle socioeconomic background (n=28; 67%) and attained a certificate/diploma level of education (n=13; 31%) followed by a university degree (n=11; 26%). Parents were classified into the obese (n=19; 46%), overweight (n=14; 33%) and healthy weight (n=9; 21%) categories based on the IOTF adult cut-offs.[19] Children were fairly evenly represented by sex (n=24 male; 57%) with a mean age 8.5 years, mean BMI 22.9 kg/m^2 and weight category of obesity (n=22; 52%), overweight (n=9; 21%), and healthy weight (n=11; 26%) based on the IOTF children cut-offs.[19] Detailed participants characteristics are presented in Table 6-1.

Table 6-1 Baseline characteristics of parents and their children

Characteristics	Intervention group (n=28)	Control group (n=14)	Combined (n=42)
Parents			
Age (years), mean (SD)	41 (7)	39 (8)	41 (7)
Gender, n female (%)	26 (93)	14 (100)	40 (95)
BMI (self-reported), mean (SD) kg/m^2	28.8 (5.2)	32.0 (7.8)	29.9 (6.3)
Weight category (self-reported), n (%)			
Healthy weight	6 (21)	3 (21)	9 (21)
Overweight	11 (39)	3 (21)	14 (33)
Obese	11 (39)	8 (57)	19 (46)
Education level, n (%)			
School certificate	1 (4)	2 (14)	3 (7)
Higher school certificate	4 (14)	2 (14)	6 (14)
Certificate/Diploma	11 (39)	2 (14)	13 (31)
Undergraduate degree	7 (25)	4 (29)	11 (26)
Postgraduate degree	5 (18)	4 (29)	9 (21)
Socioeconomic status, n (%)			
Low (IRSAD 1-3)	4 (14)	2 (14)	6 (14)
Mid (IRSAD 4-7)	17 (61)	11 (79)	28 (67)
High (IRSAD 8-10)	7 (25)	1 (7)	8 (19)
Children			
Age (years), mean (SD)	9 (2)	9 (2)	9 (2)
Gender, n female (%)	13 (46)	5 (36)	18 (43)
Anthropometry, mean (SD)			
Height (measured), cm	138 (16)	135 (16)	137 (16)
Weight (measured), kg	44 (17)	46 (19)	45 (17)
BMI (measured), kg/m^2	22.4 (4.7)	23.8 (5.9)	22.9 (5.1)

BMI: Body Mass Index; IRSAD: Index of Relative Socio-Economic Advantage and Disadvantage; Weight categories as per International Obesity Task Force age-appropriate cut-offs - Healthy weight: BMI 18.5-24.9 kg/m^2, Overweight: BMI 25-29.9 kg/m^2, Obesity: BMI ≥30 kg/m^2.

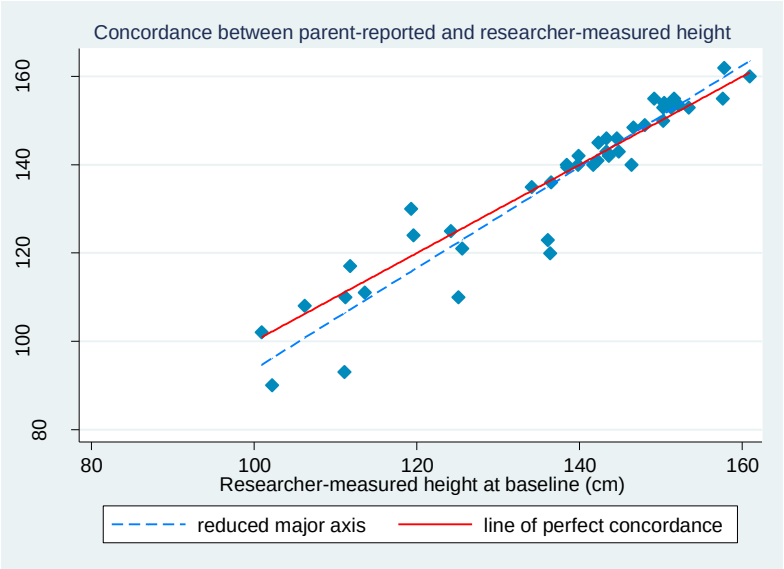
The level of agreement of parent-reported child height, weight, and calculated BMI compared to researcher-measured data are summarised in Table 6-2. At baseline, the level of agreement between parent-reported and researcher-measured data as determined by Lin's CCC was moderate (ρc = 0.94) for parent-reported child height and substantial (ρc = 0.96) for weight, and poor (ρc = 0.63) for calculated BMI. In this study parents tended to under-report child height and weight with a mean difference (SD) of -0.9 cm (6.0) and -0.5 kg (4.9) compared to researcher-measured data, respectively. Parents were more accurate in reporting child height for children who were taller than 140cm and were overall better reporters of child weight for children who weighed between 30-50 kg. BMI calculated using parent-reported data were higher than researcher-measured data with a mean difference (SD) of 0.7 kg/m^2 (4.7). Figure 6-1 demonstrates that child BMI calculated from parent-reported data was more accurate (i.e. closer to researcher-measured) for children whose BMI were between 15-25kg/m^2 compared to those whose BMI were at both ends of the spectrum (i.e. <15kg/m^2 or >25kg/m^2).

Table 6-2 *Level of agreement between parent-reported and researcher-measured child height, weight, and calculated Body Mass Index*

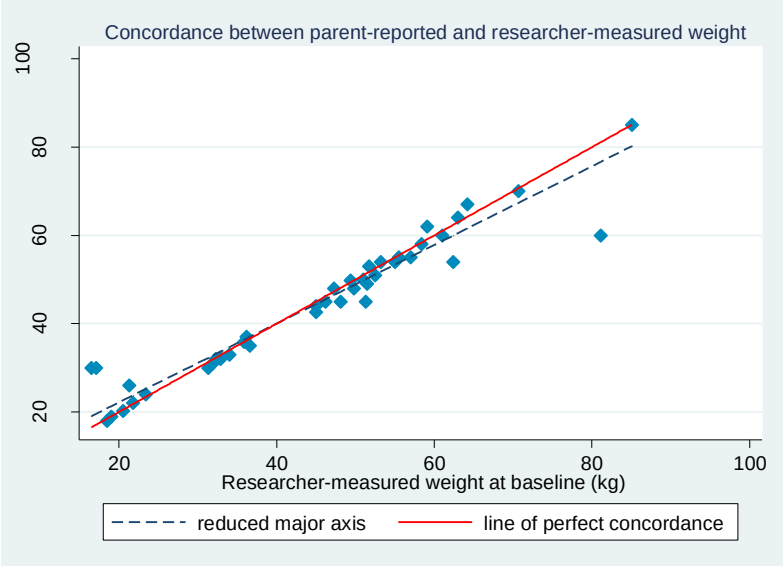
	Intervention group			Control group			Combined		
	MD (SD)	ρc	95% CI	MD (SD)	ρc	95% CI	MD (SD)	ρc	95% CI
Baseline		(n=28)			(n=14)			(n=42)	
Height, cm	-1.9 (5.7)	0.94	0.90, 0.98	1.0 (6.3)	0.94	0.87, 0.99	-0.9 (6.0)	0.94	0.91, 0.97
Weight, kg	-1.1 (5.3)	0.94	0.90, 0.98	0.7 (4.0)	0.98	0.95, 1.00	-0.5 (4.9)	0.96	0.93, 0.98
BMI, kg/m^2	0.7 (4.9)	0.53	0.26, 0.80	0.7 (4.2)	0.76	0.52, 1.00	0.7 (4.7)	0.63	0.45, 0.81
Week 12		(n=21)			(n=14)			(n=35)	
Height, cm	-0.2 (6.4)	0.93	0.87, 0.99	-3.9 (8.8)	0.86	0.74, 0.99	-1.7 (7.5)	0.90	0.84, 0.96
Weight[a], kg	-1.6 (3.3)	0.98	0.95, 1.00	-2.9 (2.6)	0.98	0.96, 1.00	-2.1 (3.0)	0.98	0.96, 0.99
BMI[a], kg/m^2	-0.9 (2.3)	0.85	0.73, 0.98	0.2 (3.6)	0.84	0.68, 1.01	-0.5 (2.9)	0.86	0.76, 0.95

[a] Data were available from n=19 intervention families due to missing parent-reported weight data. MD: mean difference (parent-reported value subtract researcher-measured value); SD: standard deviation; ρc: Lin's concordance correlation coefficient; CI: confidence interval; d: Cohen's d; BMI: Body Mass Index. Note: ρc ranges from 0 to ±1 where a value close to 1.0 (and a 45° fitted line of perfect concordance) would suggest perfect level of agreement. Lin's concordance correlation coefficient ranges from 0 to ±1 where >0.99 (perfect agreement), >0.95-0.99 (substantial agreement), 0.90-0.95 (moderate agreement), <0.90 (poor agreement).

(a)



(b)



(c)

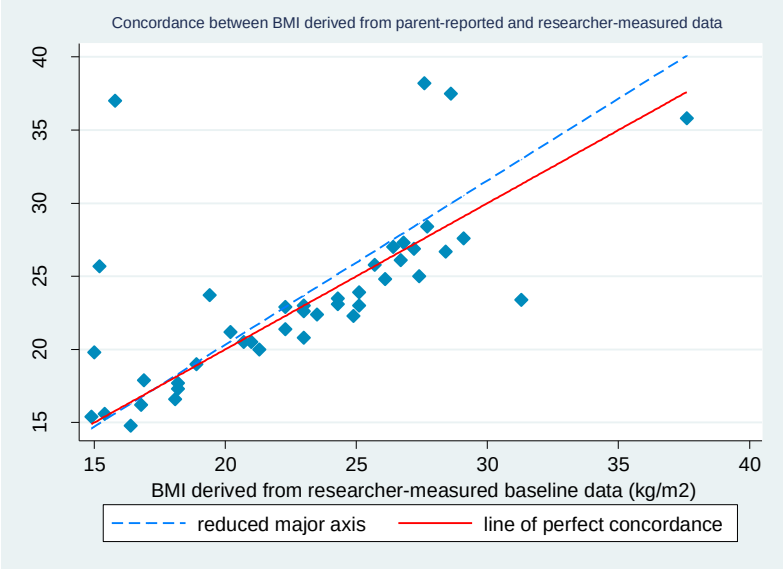


Figure 6-1 *Concordance between parent-reported and researcher-measured (a) height, (b) weight, and (c) calculated BMI at baseline*

At week 12, the level of agreement between parent-reported and researcher-measured child height remained moderate (ρc = 0.93) in the intervention group but declined from moderate to poor agreement (ρc = 0.86) in the control group. Parent accuracy in reporting their child's weight improved in the intervention group demonstrating substantial agreement (ρc = 0.98) with researcher-measured data, while control group parents remained at same level of agreement as baseline (ρc = 0.98). At week 12, parents in the intervention group continued to under-report their child's height and weight with a mean difference (SD) of -0.2 cm (6.4) and -1.6 kg (3.3) compared to researcher-measured data, respectively. However, these parents demonstrated improved accuracy in reporting child height (-0.9 cm to -0.2 cm), but not in reporting child weight (-0.5 kg to -1.6 kg). Parents in the control group over-reported their child's height and weight at baseline by +1 cm (6.3) and +0.7 kg (4.0), respectively. However, at week 12 the control group parents also under-reported their child's height and weight and to a greater extend compared to the intervention group and -3.9 cm (8.8) and -2.9 kg (2.6) lower than researcher-measured data, respectively. At week 12, the level of agreement for calculated BMI using parent-reported and researcher-measured data improved but remained poor for both the intervention group (ρc = 0.85 vs 0.53) and the control group (ρc = 0.84 vs 0.76). However, the mean differences of parent-reported and researcher-measured height, weight and BMI calculated from these data at baseline and week 12 were not statistically significant between the intervention and control group.

Inter-rater agreement of child weight category based on calculated BMI using parent-reported and researcher-measured child height and weight are summarised in Table 6-3. At baseline, the level of agreement was moderate (k = 0.59). Overall, the weight category (i.e. healthy weight, overweight, obesity) calculated from 74% (n=31) of parent-reported child height and weight at baseline was accurate (i.e. within the same category calculated based on objectively measured data). Of the 11 children in the healthy weight category, the weight category calculated from 55% of parent-reported data were accurate, while the weight category calculated from 45% of parent-reported data misclassified their child in overweight (27%) or obesity (18%) category. Of the 9 children in the overweight category, the weight category calculated from 89% of parent-reported data were accurate while 11% of parent-reported data misclassified their child who were overweight into healthy weight category. Among the 22 children in the obese category, the weight category calculated from 77% of parent-reported data were accurate while 23% of parent-reported data misclassified their child as overweight. At week 12, the inter-rater agreement for child weight category decreased in both intervention (71% vs 68%) and control groups (79% vs 71%). The level of agreement remained moderate in the intervention (k = 0.54) and control groups (k = 0.51), as well as for both groups combined (k = 0.54). Among the healthy-weight child category, the weight category calculated from

Table 6-3 *Inter-rater agreement between child weight category calculated using parent-reported versus researcher-measured child height and weight*

Calculated from parent-reported data	Calculated from researcher-measured data							
	Intervention group				Control group			
	HW	OW	Obesity	Total	HW	OW	Obesity	Total
Baseline, n (%)	(n=28)				(n=14)			
HW	4 (50)	1 (14)	0 (0)	5 (18)	2 (67)	0 (0)	0 (0)	2 (14)
OW	3 (38)	6 (86)	3 (23)	12 (43)	0 (0)	2 (100)	2 (22)	4 (29)
Obesity	1 (13)	0 (0)	10 (77)	11 (39)	1 (33)	0 (0)	7 (78)	8 (57)
Total	8 (100)	7 (100)	13 (100)	28 (100)	3 (100)	2 (100)	9 (100)	14 (100)
k, SE, % agree	0.57; 0.13; 71%				0.62; 0.19; 79%			
Week 12, n (%)	(n=19)[a]				(n=14)			
HW	5 (100)	2 (33)	0 (0)	7 (37)	2 (67)	0 (0)	0 (0)	2 (14)
OW	0 (0)	4 (67)	4 (50)	8 (42)	0 (0)	2 (67)	2 (25)	4 (29)
Obesity	0 (0)	0 (0)	4 (50)	4 (21)	1 (33)	1 (33)	6 (75)	8 (57)
Total	5 (100)	6 (100)	8 (100)	19 (100)	3 (100)	3 (100)	8 (100)	14 (100)
k, SE, % agree	0.54; 0.15; 68%				0.51; 0.19; 71%			

[a]Data were available from n=19 intervention families due to missing parent-reported weight data. HW: Healthy weight; OW: Overweight; k: Cohen's kappa coefficient; SE: standard error. IOTF cut-offs definition - Healthy weight: BMI 18.5-24.9 kg/m^2, Overweight: BMI 25-29.9 kg/m^2, Obesity: BMI ≥30 kg/m^2. Cohen's kappa coefficient ranges from 0-1, where almost perfect (k > 0.80); substantial (0.61 ≤ k ≤ 0.80); moderate (0.41 ≤ k ≤ 0.60); fair (0.21 ≤ k ≤ 0.40); slight (0.00 ≤ k ≤ 0.20); poor (k < 0.00).

100% of parent-reported data in the intervention group (vs 67% in the control group) were accurate at week 12. Among children who were overweight, the weight category calculated from 67% of parent-reported data in both the intervention and control group were accurate at week 12. Among children who were obese, the weight category calculated from 50% of parent-reported data in the intervention group (vs 75% in the control group) were accurate.

In all families except one, the same parent reported child height and weight at both time points. Overall, the weight category calculated from 55% of parent-reported data were accurate (i.e. closer to researcher-measured data) at both baseline and week 12 time points. The weight category calculated from a small number of parent-reported data was consistently one category under (9%) or above (3%) their child's correct weight category at both time points. Further analysis did not find statistically significant differences in demographic characteristics (e.g. age and sex of parent and child, parental BMI, education, and socioeconomic status) between under-reporters and over-reporters. A multivariable linear regression model identified that parental age was the only variable that had a significant association (P=0.014) with accuracy of reporting child height. Every one unit (in years) increase in the parent's age results in an under-reporting of 0.29cm (P=0.014; 95% CI -0.52 to -0.06) for child height. Child age

was the only variable that is significantly associated with reporting of child weight. Every one unit (in years) increase in the child's age results in an under-reporting of 1.2kg (P=0.04; 95% CI -2.34 to -0.06) for child weight.

6.5 Discussion

The current study evaluated accuracy of online parent-reported child height and weight, as well as BMI and weight category calculated from these data by the researchers, compared to researcher-measured data in a sample of Australian children aged four to 11 years. The current study also examined whether accuracy of parental-reporting is influenced by age, sex, BMI, and participation in a 12-week brief web-based family lifestyle intervention.

Key findings indicate that parents were relatively accurate in reporting child height and weight as shown by the overall high concordance correlation coefficients (ρc ≥ 0.9). Results indicate that parents in the current study under-reported child height and weight at both baseline and after participation in a 12-week web-based family lifestyle intervention. These findings were similar to existing studies which indicated that parents tended to under-report height and weight of American children aged six to 12 years.[216] Previous studies found that parents under-reported child height and weight by -1.4 cm and -2.3 kg (n=475 American children aged 11-12 years),[217] and -1 cm and -1.6 kg (n=116 Belgian children aged 7-9 years), respectively.[218] This compares to a study in 662 children in the USA which found that 35% of parents under-reported child height by at least 1 inch (2.54 cm) and 26% by at least 2 inches (5.08 cm).[200] There were 22% of parents of children aged three to five years (n=343) and 39% of parents of children aged six to 12 years (n=452) underestimated child weight by at least 2 lbs (0.9 kg).[200] It is evident across existing research that parents' inaccuracy in reporting child height and weight, though varied in extent and by country, was commonly due to under-reporting instead of over-reporting, regardless of the measurement systems used (Metric vs Imperial system).

Previous studies have highlighted that parents were more likely to under-report child height compared to weight.[200, 216] The current study arrived at similar findings where parents under-reported child height and weight, and were generally less accurate in reporting child height (ρc = 0.86-0.94) compared to weight (ρc = 0.94-0.98); as demonstrated by the consistently higher concordance correlation coefficient for child weight over time. This suggests that children may be weighed more regularly or accurately than measured for height. It is possible that parents measured their child's weight at home using a weighing scale, which is a common household item. Furthermore, enrolling in a weight management program may make them more aware of their child's weight compared to height. In contrast, child height may not be measured as regularly due to not having a stadiometer at home; or as accurately due to not

using the Frankfurt plane position, which is the standard protocol of measuring height. However, there are discrepancies between the current study and a previous study which found poor concordance between parent-reported and researcher-measured child height (ρc = 0.007), weight (ρc = -0.039) and BMI (ρc = -0.005).[135] It was suggested that a sample of parents in California, USA may be inclined to report child height in whole inches, resulting in a greater degree of under-report, or over-reporting by 2.54 cm.[135] Using the smaller increments of metric system may therefore enhance parents' accuracy and precision in reporting their child's height in 'centimetres', which is a smaller unit.[135] Due to the differences in Metric versus Imperial systems, study findings in United States population may not be generalisable to countries using the metric measurement system.[216]

Despite the current study finding of a consistent trend in under-reporting over time, parents who completed a 12-week brief web-based family lifestyle intervention demonstrated improved accuracy in reporting child weight (ρc increased from 0.94 to 0.98) across time-points in the study, while the control group maintained their high accuracy since baseline (ρc remained at 0.98). Parents may become more attentive to child weight information received at clinic or intervention visits or from other sources or may have recorded height and weight measures at home more regularly after participating in the baseline survey and the intervention program. Studies also suggest that parent accuracy in reporting child height and weight may be influenced by whether the parents know that their child's height and weight will be measured by treating clinicians at a later time-point,[209-211, 219] and whether or not parents were asked to self-measure their child's height and weight before reporting.[220] Hence, suggesting to parents that their child's measurements will be validated and/or providing instructions to parents to measure their child's height and weight themselves may improve accuracy in parent reporting.[135]

The under-reported child height and weight in the current study resulted in poor concordance (ρc = 0.86) between BMI calculated from parent-reported and researcher-measured data. Overall, BMI was underestimated by 0.5 kg/m^2 when calculated from parent-reported data. Similar findings were reported in other studies in which BMI calculated by researchers from parent-reported child height and weight data was 0.5 kg/m^2 lower than BMI calculated from objective measures (n=475 children aged 12-13 years),[217] and in another study BMI was 0.6 kg/m^2 lower than the BMI calculated from researcher-measured data (n=116 children aged seven to nine years).[218] The current study found that child BMI calculated from parent-reported data was more accurate for children whose BMI was between 15-25 kg/m^2 compared to those whose BMI was at either end of the spectrum. Similar findings were reported in a study (n=864 Dutch children aged 4 years) in which parents tended to misreport weight among children in the lowest and highest BMI quartiles, and authors suggested that the turning point for over-

and under-reporting of child BMI appeared to be around 15.4 kg/m^2.[177] The significance of a misreported BMI depends on whether the BMI value is close to the lower or upper range of a weight category. For example, a nine-year old boy whose measured BMI is 19 kg/m^2 (overweight category), an under-report by 0.5 kg/m^2 would result in a reported BMI of 18.5 kg/m^2, incorrectly placing the child into healthy-weight category. Studies indicated misclassification of children as obese based on parent-reported data was associated with under-reporting of child height,[200, 212] as the misreporting was magnified through the BMI calculation formula (i.e. weight in kg divided by height in metre square). For this reason, the use of a height or weight percentile might be useful in future studies when interpreting parent-reported child height and weight, instead of calculating BMI to determine child weight category. Future studies may consider modelling a calibration equation for adjusting BMI calculated from parent-reported data to improve accuracy.

Parent under-reporting of child height and weight resulted in underestimation of child BMI and misclassification of weight category among 30% of children in the current study. Overall, child weight category calculated using parent-reported child height and weight at baseline was accurate for 74% of families, and this was reduced to 70% at week 12. Similar findings were reported in two other studies in which child weight category was calculated by researchers using parent-reported child height and weight data, and found that the BMI category were accurate for 80% (n=558)[200] and 76% (n=600 Austrian children aged 0-15 years),[176] respectively. Among the overweight children of the current study, the overall proportion of parents who underestimated child weight category ranged from 11% to 22% over time. Among children in the obese category, the overall proportion of parents who underestimated child weight category ranged from 23% to 38% over time. Existing studies regularly reported misclassifications of overweight/obese children.[176, 177] One study reported that 46% of 116 overweight children were misclassified as healthy weight when parent-reported data were used.[177] In another study in 600 children aged 0-15 years, parents reported that 37% obese children were incorrectly classified in the overweight category.[176] Such misclassifications, if not addressed and corrected, or accounted for in interpretation, could have an impact on obesity prevalence statistics or intervention programs calculated using parent-reported child height and weight data.

The current study has a number of limitations that need to be acknowledged. In particular, the small sample size which has impeded the modelling of calibration equations to improve the validity of parent-reported data. A large sample would be needed to generate a viable predictive model. Parents tend to be less accurate in reporting for children with excess body weight. Therefore, the sample included in this study was children with a BMI above the mid-point of the healthy weight category (≥ 21.5kg/m^2) in order to assess parent's accuracy in

reporting child height and weight of children with higher weight. This means that results from the current study may not be generalizable or applicable to other populations and ethnicities and hence, results should be interpreted with caution. The study, although not population-based, is the first Australian study to assess parental accuracy in online reporting of child height and weight, and weight status determined by BMI calculated using parent-reported data compared to objective researcher-measured data in a sample of children aged four to 11 years. Given no specific instructions about how to take height and weight measures were provided to parents, a limitation is that parents may or may not have measured their child before reporting the measures. Future studies should explore whether parents' accuracy in reporting child anthropometrics will improve when specific guidance[221] on when and how to perform the measurements are provided. However, it could be challenging to assess parents' adherence to the specific guidance. Moreover, parents may be less likely to measure a child who is sensitive about weight and body image. Future studies should collect information on whether parent-reported data were based on estimates or measurements, and whether the measurements were done at home, school or clinic, to further the understanding on parents' accuracy in measuring and/or estimating child height and weight. A key strength of the current study is the use of Lin's CCC to assess level of agreement between parent-reported and researcher-measured data and hence offer some confidence in the findings. Many existing studies to date have measured correlations between data which is insufficient in terms of assessing levels of agreements (i.e. accuracy and precision). For example, Pearson's correlation coefficients only provides a measure that describes the extent of correlation to which the parent-reported data conform to the best fitting straight line, but not how close or far the data fall from the line which represents perfect agreement.[215]

6.6 Conclusions

In the current study, Australian parents of children aged four to 11 years were reasonably accurate in reporting their child's height and weight online. The weight category for the majority of children calculated using parent-reported data were in agreement with the objectively measured data despite the BMI calculated from parent-reported data having poor concordance at both time points. It appears that online parent-reported child height and weight may be a valid method of collecting child anthropometric data ahead of participation in a web-based health, diet and lifestyle program. Future studies with larger sample sizes and repeated measures over time in the context of eHealth research are warranted.

Chapter 7: Thesis Discussion and Conclusion

The overarching purpose of my thesis is summarised in Table 7-1. The thesis *is presented as a series of reviews and studies aiming to address the five specific research aims corresponding to the overarching research purpose. The key findings from the individual studies have been discussed comprehensively in previous chapters.*

This chapter presents a summary of the key findings related to the research aims (Section 7.1), strengths and limitations of each of the studies (Section 7.2), discussion of the overall findings in relation to current literature (Section 7.3), followed by implications and future directions for research and practice (Section 7.4). These have also been synthesised in a policy brief to inform key stakeholders and policy developers in regard to the major research findings and implications of this thesis (Section 7.5). The policy brief presented in this chapter was completed in collaboration with the co-authors (Appendix 14).

***Table 7-1** Overarching research purpose with specific questions and thesis aims*

<table>
<tr><th colspan="4">Purpose</th></tr>
<tr><td colspan="4">To develop and test a novel technology-based approach to providing families with a timely, comprehensive and personalised child weight management intervention that has the potential to be translated to health services and up-scaled to complement existing services in Australia. (Chapter 1)</td></tr>
<tr><th colspan="4">Questions</th></tr>
<tr><td>What interventions and strategies are effective?</td><td>How to engage the whole family in interventions?</td><td colspan="2">Would technology-based interventions work in a family-based program?</td></tr>
<tr><th>Aims 1 & 2</th><th>Aim 3</th><th>Aim 4</th><th>Aim 5</th></tr>
<tr><td>To synthesise the evidence from systematic reviews of experimental studies on the effectiveness of family-based behavioural weight management interventions for children with overweight or obesity.

To identify the key strategies employed in family-based weight management programs for children with overweight or obesity that result in weight loss and/or behaviour change.</td><td>To develop a set of evidence-based text messages, targeted to mothers and fathers, that is complementary to a family-focused nutrition intervention to improve child weight status and dietary intake.</td><td>To develop and test the feasibility, acceptability, and efficacy of a novel family-focused online telehealth nutrition intervention in improving child weight status and dietary intake, and the impact of the addition of evidence-based text messages targeted to mothers and fathers.</td><td>To assess the accuracy of parent-reported child height, weight and calculated BMI to be able to interpret online parent-reported child anthropometrics.</td></tr>
<tr><td>Chapter 2</td><td>Chapter 3</td><td>Chapters 4 and 5</td><td>Chapter 6</td></tr>
</table>

7.1 Summary of findings

7.1.1 Umbrella review of weight management interventions for families of children with overweight or obesity

The published umbrella review presented in Chapter 2 synthesised evidence from a range of existing systematic reviews and meta-analyses of weight management interventions for families of children with overweight or obesity to identify the effectiveness and strategies used for family-based childhood obesity interventions with parental involvement in improving child weight-related outcomes (Thesis Aims 1 and 2). The findings of the umbrella review address the overarching research purpose (Table 7-1) by synthesising key strategies identified in previous research targeting parents for future efficacious child weight management intervention.

Of the 14 included systematic reviews, which synthesised findings from 47 independent trials conducted in over 16 countries and published between 1975 and 2015, 13 reviews reported that family-based behavioural interventions were effective for weight management in children aged between two and 18 years. The most common population groups involved within the studies were children aged between six and 13 years with parents usually being the gate keeper of the family food supply.

Evidence suggested that if parents recognise the importance of having a healthy weight, they are motivated to influence their children in terms of lifestyle behaviours related to weight management.[46] However, across the systematic reviews, there was a lack of reporting on post-intervention lifestyle behaviour outcomes, such as dietary intake and physical activity levels. Therefore, it was difficult to establish whether there were any specific intervention strategies that were more likely to facilitate child dietary and physical activity behaviour change.

Systematic reviews for children aged less than 18 years supported that interventions that involved parents and children were equally effective as interventions that involved parents only, if not greater.[41, 52, 91, 144, 156] Furthermore, parent-involved interventions (with and without child) were more effective in reducing the child BMI and/or percentage of children with overweight compared to interventions that involved the child only.[49, 52, 155, 157] Despite the diversity of intervention designs and components used (i.e. single vs multicomponent, low vs high intensity)[40, 50, 148] in family-based behavioural interventions for children with obesity, the intervention strategies employed in effective studies were found to be consistent, and involved:

- Targeting a change in behaviour of both the index child and their parents and/or family members.[45, 91]

- Behavioural modification including dietary change (e.g. The Stoplight Diet),[50, 156] physical activity (increase activity, reduce sedentary behaviour),[91, 156] or cognitive behavioural therapy.[41, 45, 52]
- Using intervention techniques, such as nutrition and physical activity education, and set goals for behaviour change.[45, 91]

Key strategies targeting the parents to encourage positive healthy eating/exercise behaviours in children and/or whole family included:

- Nutrition and physical activity face-to-face education sessions
- Positive parenting skills
- Role modelling
- Child behaviour management

7.1.2 Development of text messages targeting healthy eating for children in the context of parenting partnerships

The SMS development study presented in Chapter 3 developed a set of evidence-based SMS text messages targeted to mothers and fathers that are complementary to a family-focused nutrition intervention to improve child weight status and dietary intake (Thesis Aim 3). Parental involvement in child weight management is essential as shown in Chapter 2. However, few studies have specifically targeted both parents in child weight management interventions. The SMS development study employed a three-phase systematic approach, guided by the TDF and COM-B model,[103, 104] and developed a set of SMS with a focus on healthy eating that target both mothers and fathers. This work contributes to the gap in the literature by presenting a systematic process for the development of SMS which were grounded in theory and research evidence concerning the importance of the relationship that parents share in the raising of children, the parenting partnership. The impact of these SMS when delivered in conjunction with a novel telehealth intervention presented in Chapter 4 will be discussed next in Section 7.1.3.

7.1.3 Pilot study of a technology-based nutrition intervention for families of children with overweight or obesity

The pilot study (B2BF program) presented in Chapter 4 and Chapter 5 aimed to develop and test the feasibility, acceptability, and efficacy of a novel family-focused online telehealth nutrition intervention in improving child weight status and dietary intake, and the impact of the addition of evidence-based SMS targeted to mothers and fathers (Thesis Aim 4). Findings from the 12-week pilot study demonstrate that a tailored family-focused online telehealth nutrition intervention that was dietitian-led with family-initiated telehealth connection using household electronic devices was feasible. Preliminary results highlighted that children in the

intervention groups maintained BMI and waist circumference, and improved dietary intake at week 12 compared to a waitlist control group.

The addition of evidence-based SMS targeted to mothers and fathers in combination with an online telehealth nutrition intervention significantly improved child dietary intake (percentage energy from ENDP and healthy core foods) compared to control group ($p<0.05$). However, the child dietary intake between the two intervention groups (i.e. with SMS vs without SMS) was not statistically significantly different, which is likely due to the small samples size. This led to the hypothesis that both intervention groups may be just as effective in improving child dietary intake. However, the potential benefits of additional SMS in enhancing intervention effectiveness should be explored further in a future trial that is fully powered.

The overall retention rate of the B2BF program (78%) was higher than the rates reported in previous childhood obesity intervention studies (ranging from 27% to 73%).[197] However, the study took a prolonged period (11 months) to enrol the target sample of 48 families, despite the recruitment campaigns reported to have reached over 800 viewers and received over 100 expressions of interests, in addition to clinician referrals from general practitioners and allied health professionals.

Evaluation of B2BF program fidelity (Chapter 5) found that telehealth intervention delivered by trained APDs had good adherence where ≥83% planned content were delivered as intended. Process evaluation results indicated that parents who completed the program found the telehealth intervention convenient and easy to use and would recommend telehealth to other parents. Most parents also agreed that the program has improved their family and child eating habits, respectively. Based on the results presented and reported, the B2BF program was successfully delivered with good fidelity and received high levels of acceptability and satisfaction among families with primary school aged children. The findings of the pilot study address the overarching research purpose (Table 7-1) by contributing to the evidence of technology-based approaches for delivering child weight management intervention that can be used as a standalone treatment option or to complement other services that exist in both the community and clinical realm of practice by offering more personalised dietary counselling and goal setting.

7.1.4 Accuracy of parent-reported anthropometrics of their children

A solely online program offers the benefits and flexibilities to be completed online and at home,[137] and addresses parents' need for an online healthy lifestyle program with a focus on child diet rather than weight.[115] However, limited studies have assessed parental accuracy in proxy-reporting anthropometrics of their children using web-based approaches. This is an important gap to be addressed to allow online programs to have the full scope of being able

to be offered to families in rural or remote locations, while child weight-related anthropometrics and lifestyle behaviour (i.e. diet, physical activity) can be reported and monitored online. The study presented in Chapter 6 assessed the accuracy of parent-reported child height, weight and calculated BMI to be able to interpret online parent-reported child anthropometrics (Thesis Aim 4). Overall, 74% parent-reported child height and weight data correctly estimated the child weight category at baseline, and this was reduced to 70% at week 12. Results indicated that parents under-reported child height and weight and were generally less accurate in reporting child height compared to weight. The under-reporting of child height and weight in the study have resulted in poor agreement between the BMI calculated using parent-reported and researcher-measured data. Therefore, parent-reported child height and weight should only be used to derive weight category (i.e. underweight, healthy weight, overweight, obesity) of the child, and not to be used in generating the mean BMI of a group of children. However, parents who completed the 12-week B2BF program (Chapter 4) demonstrated improved accuracy in reporting child weight over time. This suggests that parental reporting may be improved through giving further instructions and/or intervention in measuring and reporting their child's height and weight. The findings of the study will help to address the overarching research purpose (Table 7-1) through validating online parent-reported child height and weight which could potentially remove barriers to intervention participation as families no longer need to travel to clinics or labs for child anthropometric data collection assessments.

7.2 Strengths and limitations

7.2.1 Umbrella review of weight management interventions for families of children with overweight or obesity

Results of the umbrella review should be interpreted with the understanding that: i) search strategy was limited to publications in English; ii) potential inherent bias due to errors in data extraction, appraisal, and reporting carried over from initial systematic reviews; iii) low methodological quality of trials included in systematic reviews due to inadequate reporting, and iv) 9 of 14 included systematic reviews had unclear reporting related to risk of bias assessments and only two systematic reviews reported assessment for the likelihood of publication bias against weight outcomes. However, the umbrella review has a number of strengths including: i) a systematic approach consistent with the PRISMA Statement; ii) a comprehensive search strategy across seven databases and key registers covering an extensive publication period from 1990 to May 2016; iii) methodological quality of systematic reviews were critically appraised; and iv) quality of evidence synthesised across all included systematic reviews were assessed using the GRADE approach. The GRADE approach is a recommended tool for ranking the quality of evidence against targeted outcomes.[154] The tool involves critical evaluation of a range of criteria, including methodological quality of primary

studies, risk of bias, consistency in intervention effects, relevance of intervention outcomes to population and context, participants sample size, number of studies included, and publication bias.[154]

7.2.2 Development of text messages targeting healthy eating for children in the context of parenting partnerships

A few limitations should be noted in the SMS development study including: i) the sample size of SMS reviewers were relatively small and predominantly female; and ii) the SMS were developed specifically for parents of school aged children in the context of improving children's eating habits. Despite the limitations, the SMS development study has a number of strengths including: i) the systemic development approach was grounded in behaviour change framework within the context of family as a system; ii) the study is one of the few published studies which reported the face validity of SMS content and construct with key stakeholders, including health practitioners, behavioural researchers, and parents; and iii) the final set of SMS is versatile for delivery to a large number of parents as part of child weight management interventions, regardless whether the intervention is individual-, group-, internet-, or telephone-based, or face-to-face sessions in person.

7.2.3 Pilot study of a technology-based nutrition intervention for families of children with overweight or obesity

The study was a feasibility, pilot study and it was novel as it was the first personalised telehealth technology-based nutrition intervention for child weight management in Australia. The pilot study has a few limitations including: i) a short intervention period and follow up time frame; ii) small sample size; and iii) inadequate statistical power to detect significant changes in child anthropometry outcomes due to pilot feasibility study design. Moreover, telehealth session evaluations were self-reported by dietitians and this may have introduced some biases into these measures, especially adherence to the structured content. However, findings from parent-reported process evaluation suggested that such risk of bias is minimal as the majority of parents indicated that the telehealth sessions were informative and helpful, especially the discussion about goal settings and strategies planning. These findings affirm that the key topics of telehealth sessions were delivered with good adherence. The study also has a number of strengths including: i) the intervention was informed by best practice recommendations, behaviour change theories, and parents' opinions; and ii) intervention modalities which use existing technology available in New South Wales Hunter New England health service facilities and are highly scalable to provide services to a large population at relatively low cost.

7.2.4 Accuracy of parent-reported anthropometrics of their children

A few limitations should be noted in the study including: i) the small sample size, meaning that results from this study may not be representative of other populations and ethnicities; ii) parents were families who were motivated and looking to participate in a child weight management intervention, therefore, may have been be more aware of or regularly monitoring their child's growth and weight status. "Given no specific instructions about how to take height and weight measures were provided to parents, nor the option for parents to indicate if 'they had no idea', a limitation is that parents may have reported their child measures based on presumptions without knowing their child's actual measurements. Future studies should explore whether parents' accuracy in reporting child anthropometrics will improve when specific guidance on when and how to perform the measurements are provided.[221] Despite the limitations, the study has a number of strengths including: i) being the first Australian study to assess parental accuracy in online reporting of child height, weight, calculated BMI and weight status category in a sample of children aged four to 11 years; ii) using Lin's CCC to assess level of agreement between parent-reported and researcher-measured data as opposed to many studies which measured correlations between data which is insufficient in terms of assessing levels of agreements (i.e. accuracy and precision).

7.3 Discussion of thesis findings in relation to the literature

The overarching research purpose of my thesis was to develop and test a novel technology-based approach for a personalised family-based child weight management intervention that has the potential to be translated to health services and scaled up and complementary to existing services in Australia. The main findings presented in my thesis indicated that a family-based parent-involved behavioural intervention is effective in improving child weight outcomes. Furthermore, the results suggested that technology-based approaches, including telehealth, website, and SMS, are feasible for delivering child weight management interventions to families. These findings have contributed to the evidence base and marked the first personalised telehealth technology-based nutrition intervention for child weight management in Australia, and the first study to assess Australian parental accuracy in online reporting of child anthropometrics

7.3.1 Effectiveness of family-based behavioural intervention

Family-based behavioural intervention is recommended as best practice for lifestyle weight management for children under 12 years of age[41] and this is supported by WHO Commission on Ending Childhood Obesity[43] (Section 1.2). However, previous systematic reviews and meta-analyses have reported challenges in recommending effective intervention strategies and/or components for family-based child weight management due to the heterogeneity of

existing studies. The umbrella review (Chapter 2) synthesised the effectiveness of family-based behavioural interventions with parental involvement for children with overweight or obesity based on findings from 14 systematic reviews. Findings from the umbrella review are consistent with a recent overview of systematic reviews which assessed only RCTs with longer term intervention duration (≥6 months) in child weight management.[56] Both reviews indicated that multicomponent family-based behavioural interventions and interventions that involved parents were more effective in improving child weight and/or behavioural outcomes compared to single component interventions and interventions without parental involvement, respectively.[56, 87] Family-based behavioural interventions remain as the gold standard for child weight management with evidence suggesting that a comprehensive multicomponent intervention delivers the best outcomes overall.[54-56] The positive outcomes of parental involvement in child weight management interventions were consistently highlighted across the evidence,[40, 50, 58, 59] hence, future interventions should involve parents as the agent of change where possible.

A recent systematic review and meta-analysis by Hammersley et. al.,[42] which would have otherwise been included in the umbrella review, was not retrieved as it was published after the database searches was completed. However, that review included eight RCTs of parent-focused eHealth interventions for obesity prevention and/or treatment in children and adolescents (total n=1487 dyads).[42] Of the eight included RCTs, only one was conducted outside the United States (in France), five were obesity treatment intervention, and all eight interventions have focused on diet in combination with physical activity and/or screen time.[42] Five studies used an internet intervention, where four interventions used the internet combined with face-to-face sessions and/or phone coaching.[42] Another two studies used interactive voice response (i.e. IVR; computerised voice prompts over the phone, which participants respond to via the phone keypad) and only one study[195] used a telehealth intervention. The meta-analysis found that differences in BMI or zBMI outcomes were not statistically significant between eHealth intervention and control group.[42] However, a significant improvement in at least one dietary or physical activity outcome measure was reported in four of eight included studies.[42] The authors suggested that the intervention effect on BMI outcomes may have been weaken due to a high proportion (91%) of children were already in the healthy weight range.[42]

7.3.2 Key intervention strategies targeted at parents

The results of this thesis are that parents should be involved in child weight management interventions. However, little evidence is documented about how parents should be involved or targeted in interventions aiming to achieve behavior changes in their children.[36, 41, 52] The umbrella review (Chapter 2) synthesised a range of parent-targeted strategies reported in efficacious child weight management interventions. In general, interventions which involved

parents have used behaviour change techniques and targeted lifestyle behaviour change in parents and their children.[45, 91] Findings from the umbrella review are consistent with evidence-based guidance on management of childhood obesity which recommended the use of behaviour change strategies to tailor interventions to individual needs with family-focused content that were age appropriate.[58, 93, 94] The common parent-targeted strategies used were face-to-face education related to health behaviour and positive parenting, and role modelling. A systematic review found similar results in which modelling appropriate behaviour, prompting practice, and social support were the most effective behaviour change techniques for improving child and adolescent physical activity and dietary intake.[96] These findings strengthen the important role that parents play in child weight management interventions and how they can facilitate positive behaviour change in their children.

While findings from the umbrella review support effective interventions that include greater parental involvement, the majority of interventions that involved parents did not clearly specify whether mothers or fathers were involved.[39] Similarly, the systematic review by Hammersley et. al.[42] found that seven of the eight included studies did not report parent gender, while only one study reported parent gender, 96% parent participants were female. The issue was also highlighted in a narrative review which recommended researchers to clearly describe which parent/s were targeted or engaged with in child weight management interventions to improve the reporting of childhood obesity research.[68] Evidence also points to the importance of family systems in determining children's weight and behaviour outcomes,[67] and that interventions which included both mothers and fathers resulted in more positive changes in child behaviour (Section 1.2.1). Future research should consider strategies for behaviour change at family level by targeting both mothers and fathers and/or primary caregivers (which may include grandparents) and actively engage the whole family unit in intervention. This approach is likely to ensure healthy lifestyle messages were consistent and encourage parents and/or caregivers to be good role models for their children by improving their lifestyle behaviours.

7.3.3 Barriers to family participation in childhood obesity intervention

Previous childhood obesity research[199, 222] has reported that participant recruitment and engagement were challenging and these findings are supported by the pilot study, discussed in Chapter 4 and Chapter 5. The issue was also highlighted in a recent internet-based childhood obesity prevention program (2019) where study recruited only 54% of the target sample size of 160 Australian families.[222] Evaluation of a state-wide community-based program, Go4Fun, indicated that the program only reached a small proportion (1.6%) of children with overweight or obesity across New South Wales.[223] Research has demonstrated that parents were not aware or concerned about their child's overweight status.[224] Hence, they may not know or be aware that they need to participate in a healthy lifestyle intervention. When

it comes to feeding their children, many parents reported that the internet, family, and friends are their most regular sources of nutrition information.[225] Furthermore, some parents may be aware of their child's weight status but were unsure how to discuss the weight issue or whether to involve their child due to the stigmatisation related to obesity or not being aware of how to get help.[226] NSW Health has developed new resources on the Healthy Kids for Professionals website (https://pro.healthykids.nsw.gov.au) to support health professionals in raising the overweight issue and discussing a child's weight status. The website includes a weight status calculator which plots data on a BMI chart and provides information regarding appropriate lifestyle education and secondary referrals. Families also frequently reported difficulties in participating in treatments/programs due to geographical limitations, and lack of time and/or transportation to attend appointments.[115, 116] Technology-based approaches may be used to address some of the barriers to family participation in child weight management intervention, especially those who are motivated to change but lacking capacity (e.g. knowledge and skills) and/or opportunity (e.g. service availability and accessibility). However, ongoing challenges remain in raising awareness among families of the need for child weight management intervention and to be motivated to change lifestyle behaviour.

7.3.4 Technology-based childhood obesity intervention

The wide coverage of internet and the increase in technology use worldwide have led to the emergence of eHealth for lifestyle interventions.[42, 170] However, eHealth intervention for child weight management remains an emerging area of practice.[42] Results from the current pilot study (Chapter 4 and Chapter 5) indicated that technology-based intervention using telehealth, website, and SMS, was feasible for delivering child weight management intervention to families. No such research has been undertaken previously in Australia. Similar findings were reported in studies in the United States where group-based telehealth sessions were delivered by a psychologist to a group of parents without major issues.[130, 195, 196] A systematic review of telehealth and paediatric obesity treatment studies indicated that telehealth may be a reasonable approach for reaching a wider population for child weight management intervention, especially geographically isolated families.[129] It is important to ensure adequate services are available and accessible to families who live in rural areas where resources are limited. These families often have low SES and their children are more likely to be affected by overweight or obesity.[173] Results from the pilot study supported that telehealth can be used for reaching geographically isolated families where 40% of participants of the B2BF program were families living in medium to small regional areas of New South Wales and 65% of participants were of middle SES, defined by Index of Relative Socio-Economic Advantage and Disadvantage 4th to 7th deciles (with 1st decile being the most disadvantaged and 10th being the most advantaged).

The use of technology-based intervention, especially when it is accessible via the internet and mobile phone, could potentially overcome common barriers to participation as previously described in Section 7.3.3. Parents expressed their interests in receiving personalised child weight management interventions using online technology.[115] The novel B2BF program telehealth intervention had not only enhanced intervention accessibility beyond geographical boundaries but also offered flexibility for separated parents with shared custody to participate in the same consultation online. Post hoc analysis showed that the intervention effect size for BMI, waist circumference, healthy core food intake, and discretionary food intake were generally smaller in children of single-parent families compared to children of two-parent families. Despite the differences not being statistically significant due in part to the small sample size, future research should consider family structure in childhood obesity intervention and provide more support to children of single-parent families.

Furthermore, telehealth intervention could be used by health professionals to deliver consultations to families who can access the online service from home. While parents reported in previous research that the clinic environment was not preferable for some children,[117] this model of care may help children to feel comfortable to participate in a consultation when they are in a familiar and safe environment (e.g. home). In situations where some families who do not have access to the internet or technology devices, or those who prefer to not connect from home, they can access the facilities in a local centralised health clinic where a support staff can assist in connecting the families to a dietitian via telehealth. Telehealth can also be used by health services to increase capacity and extend service reach to rural regions, while reducing time and cost associated with staff travelling to service outreach and home visits.[131]

The B2BF program has demonstrated high levels of feasibility, fidelity and acceptability, as well as preliminary efficacy in improving child dietary intake significantly, especially in the intervention group with additional SMS for the parents. The findings support results of previous group-based telehealth childhood obesity interventions where child dietary intake was improved significantly but weight change was not significant.[195, 196] A systematic review has suggested that studies need a longer term follow up (≥6 months) as it may need a longer period of time to demonstrate the weight changes resulted from an intervention effect.[58] Given the B2BF program was evaluated in a feasibility study, there is insufficient power to detect a statistically significant change in child weight or BMI. Therefore, further testing of the B2BF program in a fully powered trial is warranted and effectiveness of the intervention should be explored through a large-scale study in health service setting. Further research is also warranted to explore the effectiveness of SMS interventions in engaging both fathers and mothers, as well as the influence of the type of parental involvement in child eating behaviour.

Process evaluation of the B2BF program indicated that parents were highly satisfied with the intervention and the majority intended to continue using the telehealth, website and SMS intervention. The technology-based intervention was able to engage more parents who would have otherwise missed out on participating in the intervention by delivering SMS targeted at both parents individually and allowing telehealth connections from multiple sites (e.g. one parent and child at home, another parent at workplace or a separate home). While existing research highlighted that engaging families in an intervention is challenging,[170, 227] the B2BF program has demonstrated higher retention rate (78%) compared to other child weight management interventions (27% to 73%).[197] A systematic review[42] on eHealth interventions for child weight management indicated that the average retention rate, reported in seven of eight included studies, was 80%, which is similar to the B2BF program. These findings suggest that technology-based interventions are likely to increase retention rate and perhaps achieving greater parents' engagement in the intervention.

A solely online telehealth intervention, such as the B2BF program, offers families the benefits and flexibilities to complete the intervention consultation online and at home. The majority of parents from a previous cross-sectional survey reported that they would be interested in participating in an online technology-based family lifestyle program.[115] Hence, it remains uncertain whether the requirement for families to travel to university sites for data collection at baseline, 3-month, and 6-month follow up as part of the research study was one of the barriers to recruitment to the study. Future studies should explore whether a solely online program could attract a greater number of families to enrol into the program, thereby addressing recruitment barriers.

The B2BF program uses the validated AES to collect child dietary intake,[228] which parents could complete online at home, to minimise the duration of in-person data collection appointments. Existing validation studies identified that parents are relatively accurate reporters of their child height and weight.[176, 200] A sub-analysis, discussed in Chapter 6, using data from the B2BF study showed that the weight category derived from the majority of parent-reported child height and weight were reliable at both the start and conclusion of the program. Presuming parents are reliable proxy-reporters for their child's dietary intake, height, and weight measures when appropriate instructions were given, these data could be collected online to eliminate the need for families to travel long distance for clinic appointments. Furthermore, this will allow families who could not access clinic services previously due to geographical boundaries, transportation, and traveling time, to have the opportunity to speak with a health expert using online technology at the convenience of their home.

7.4 Recommendations

This body of work has identified several implications for research and practice. Based on the findings from my thesis, the following recommendations are proposed:

7.4.1 For practice

1. Health professionals need to be more proactive in referring children with overweight and obesity to intervention as this is a significant health issue affecting 25% of children in Australia. Importantly, health professionals should routinely monitor and screen the child weight status to be able to identify early trend of excessive weight gain trajectory. Given the busy workload and back-to-back appointments in most clinics, clinicians usually have limited time for a long consultation. However, discussion about overweight and obesity with families should be communicated in a sensitive way due to the social stigma associated with overweight and obesity. Many clinicians reported difficulties in addressing obesity in children and the common barriers were time constraints, lack of financial incentive, lack of health system support, and parental resistance.[229, 230] Therefore, clinicians need to be supported to provide suitable advice and referrals through education, training, incentive and policy implementation. The Healthy Kids for Professionals website (https://pro.healthykids.nsw.gov.au) has been developed by NSW Health to support health professionals in raising the issue of childhood obesity. It would be beneficial to make it mandatory for all child health workers to complete the online learning modules on the website. Furthermore, health services need to identify and provide new strategies for clinicians to make referrals easier without associating with stigma. Healthcare policy development and implementation providing standards for the routine measures, provision of lifestyle education, and strategies to refer children to appropriately qualified allied health professionals would facilitate families to obtain required intervention.
2. Current public health service for child weight management in Australia is insufficient to meet the needs of urban families and particularly restrictive for rural families who are required to travel to major metropolitan areas for services.[108, 110] Furthermore, there is no universal referral pathway to child weight management services for families in Australia.[107] In order to provide timely child weight management intervention to families, there is a need to establish more services (or to increase service capacity) for child weight management and to provide a clear referral pathway in referring families to suitable intervention. It is particularly important to guide clinician referrals and assessment on whether an individual weight management consultation or a group-based healthy lifestyle program would be suitable for the family, depending on the child's and family's circumstances, such as literacy, location, time and transport. A list

of available service options needs to be communicated to clinicians through regular newsletters and professional development meetings, especially general practitioners and paediatricians who often were the ones who had initial contact with children with overweight and obesity.

3. Family-based behavioural interventions remain the best practice for child weight management with evidence suggesting that a comprehensive multicomponent intervention delivers the best outcomes overall.[54-56] The positive outcomes of parental involvement in child weight management were consistently highlighted across the research evidence.[40, 50, 58, 59] Health professionals can work with parents, as the key agents of change for their children, to encourage behaviour change in both the index child and themselves, including dietary change,[50, 156] physical activity,[91, 156] or cognitive behavioural therapy,[41, 45, 52] through education and goal setting.[45, 91] Parent-targeted consultations can focus on fostering positive parenting skills in order to promote positive lifestyle behaviour in children and to cope with difficult situations related to behaviour change (e.g. family mealtime's challenges). Positive parenting skills, such as monitoring, reinforcement, role modelling, and provide a nurturing environment, are relevant to support parents in facilitating healthy lifestyle change in family.
4. Telehealth is an existing technology available in New South Wales health services. Given the high retention rate and preliminary efficacy shown in B2BF intervention, telehealth can be used by clinicians to increase health service capacity and extend service reach to rural regions, while reducing time and cost associated with staff travelling to service outreach and home visits. Technology-based approaches, such as SMS and website, can be used to deliver healthy lifestyle information complementary to the intervention which may subsequently increase participants' engagement in the intervention, especially for the other parent or caregiver who were not able to attend intervention/consultation sessions. The technology-based components can be used in isolation or in combination to further personalised health care delivery to families while keeping the cost low.

7.4.2 For research

1. Systematic reviews in child obesity have consistently reported that the majority of studies were low in methodological quality due to small sample size, intervention without a true control group, short-term follow up, inadequate reporting of intervention fidelity and lacking the implications to be translated into health practice setting.[39, 41, 45, 143, 144] We conducted a post hoc sample size calculation using standard deviation of child BMI (i.e. 5.1) from the B2BF study and recommend that a future study informed by the current pilot would need to recruit 104 children per group to be able to detect

two unit difference in BMI, with 80% power. However, this sample size recommendation would likely be applicable to Australian children aged four to 11 years with a BMI above 21.5 kg/m^2. Future studies involving population groups with a different demographic background, including age, weight status, and ethnicity should calculate sample size based on relevant data to improve the statistical power to detect intervention efficacy.

2. Studies which aim to improve weight outcomes should be adequately powered with appropriate sample sizes and have a longer term follow up (≥6 months). Studies may need a longer period of time to demonstrate the weight changes arising from an intervention effect.[58] Furthermore, a longer term follow up, especially after a weight maintenance phase (i.e. a period after which the intervention has ceased), will be able to demonstrate whether the intervention outcomes are sustained. Studies which reported effectiveness in improving weight outcomes have only achieved this in the short term, while intervention effects were often not sustained at a later follow up (e.g. 12 months) time point. Future studies should examine the impact of interventions of longer duration and follow-up and include a larger sample size and more representative population of various demographic, SES, and geographic background. However, the challenge for a longer study duration is to maintain participants' engagement to increase retention in the intervention.
3. Research has recommended the importance of clear descriptions as to whether mothers or fathers were targeted or engaged within child weight management interventions, in order to improve the reporting of childhood obesity research.[68] It is recommended for researchers to explicitly describe the role of individual parents (e.g. mothers, fathers, caregivers) involved in the interventions as opposed to using the term 'parents' when referring to the participants; who are commonly mothers. This information will contribute to further understanding of mothers', fathers' and caregivers' roles and their influences within child weight management interventions. This is an important gap that warrants further research including whether intervention targeted at parents should be gender-tailored and whether this enhances intervention effectiveness.
4. Future family-based intervention should consider behaviour change strategies at the family level (instead of individual level of the child) by targeting both mothers and fathers and/or primary caregivers (which may include grandparents). The majority of the interventions were underpinned by behaviour change theory focusing on individual (personal) level instead of family system (interpersonal) level. A family-based intervention should engage the whole family in the intervention and recognise that the

family is a social system where family members and the home environment can have an impact on the child's behaviour change.

5. Future studies should explore various modalities for delivering child weight management interventions to improve participants engagement and retention rates. Results from the B2BF study suggest that technology-based interventions are likely to attract a family's interest in enrolment and participating in child weight management interventions. Online interventions are likely to increase participant retention rates and perhaps achieve greater parental engagement in the intervention. Future studies should explore whether a solely online program could attract a greater number of families to enrol into the program, thereby addressing recruitment barriers. Further testing of the B2BF program in a fully powered trial is warranted and effectiveness of the intervention should be explored through a large-scale study in health service setting.
6. The majority of the included SRs did not adequately report on statistical significance (p-values) of the intervention trials, hence, the umbrella review, while synthesizing current evidence, has not led to any clear preference for intervention types which were significantly more effective than the other intervention types on various outcomes of interest. Future SRs need to present more comprehensive reporting of health behaviour outcomes (e.g. dietary intake, physical activity levels) in order to allow further synthesis of which intervention components contribute to effectiveness and their relationship with change in health risk factors that are also associated with overweight and obesity.
7. Previous SRs have indicated that parent-only interventions were equally as effective as parent-child interventions, if not greater. Future research should explore whether parent-only interventions are more cost-effective and sustainable compared to parent-child interventions, and to examine the barriers to participation and other complexities behind higher attrition rates in parent-only interventions through qualitative research.
8. Findings from my thesis indicated that SMS intervention can potentially be used to engage both parents in family-focused child behaviour change by communicating the corresponding information of family interventions to both parents. Future studies should explore the potential benefits of SMS intervention with a statistically powered sample of mother-father dyads, in two-parent and/or single parent family contexts, and using gender-targeted recruitment strategies to engage fathers in order to address the evidence gap of which fathers were generally underrepresented.

7.5 Policy brief

Key findings from this body of work has been synthesised in a policy brief to inform key stakeholders and policy developers in regard to the major research findings and implications of this thesis. The identified key stakeholders are health service providers, policy makers, health ministers, dietitians and health professionals.

The content of Section 7.5 has been published in the form of a policy brief report within the University of Newcastle. The printed report has since been distributed to delegates at the National Health and Medical Research Council symposium, while an electronic copy has been distributed to New South Wales Preventive Health Department, and Health and Wellbeing Queensland, as well as submitted to the National Obesity Strategy Committee during the Community Consultation rounds in December 2019.

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The right care, in the right place, at the right time

Summary

Children with overweight and obesity are at greater risk of developing chronic diseases at younger ages, along with a range of health conditions and comorbidities that affect their quality of life across their lifetime.

In 2017, more than 35 leading community, public health, medical and academic groups united for the first time to call for urgent Federal Government action to address Australia's serious obesity problem and published the 'Tipping the Scale' report which calls for the establishment of a national obesity taskforce. In 2018, Australian ministers agreed that a National Obesity Strategy would be developed and that the initial development phase would include a Commonwealth funded National Obesity Summit held in February 2019.

Given the adverse health impact of obesity on children with excess weight, the NSW Premier has prioritised timely and accessible interventions to optimise lifestyle factors contributing to excess adiposity to "efficiently reduce overweight and obesity rates of children by five percentage points by 2025".

Problems

Prevalence of childhood overweight and obesity remains alarming; currently impacting one in four (25%) children aged 5-17 years in Australia. The Australian Bureau of Statistics (ABS) Australian Health Survey 2014-15 reported there were around 750,000 children aged 5-14 years (26% of children within this age group) with overweight or obesity across the nation.[231]

Compared to peers with a healthy weight, children with overweight and obesity often:

- Experience bullying or teasing at school.[31]
- Have significant mental health issues, including depression, anxiety, and disordered eating, exacerbated by weight stigma and bias.[30]
- Have greater risk of having heart attacks or stroke in adulthood.[28, 29]
- Have increased risk for developing type 2 diabetes,[25-27] of which 90% of cases are preventable through healthy lifestyle interventions that incorporate improvements in dietary patterns and physical activity levels.

The latest Australian Health Survey 2017-18 showed that:[9]

- 6% of children aged 2-17 years met the Australian Dietary Guidelines recommended number of serves of both fruit and vegetables.

- 41% of children aged 2-17 years consume sugar sweetened beverages at least once a week, 31% consume one to three days per week, and 7% consume them daily, with the highest consumption in adolescent boys.
- <2% of children aged 15-17 years met the physical activity guidelines.

Australian public health services for personalised child overweight and obesity treatment have limited geographical reach.[107-109] There were only nine identified tertiary child weight management treatment services across Australia, some of which have waiting lists of up to 12 months.[108, 110] Three of these services were in NSW, two in Victoria, one in Queensland and one in South Australia, while no services were identified in Western Australia, the Northern Territory, the Australian Capital Territory and Tasmania.[108] It is evident that some services have attempted to obtain funding to develop a child weight management program in these states/territories but had not been successful.[108]

Further, there is no universal/national strategy and referral pathway to public health services for child weight management for families in Australia.[107] Queensland Health has developed a new model of care which integrates a comprehensive referral pathway for children with overweight or obesity, in line with the Queensland Health Clinical Prioritisation Criteria.[232] However, child weight management services and intervention programs vary between states and depend on funding support from local state and territory governments.

One jurisdiction, NSW, delivers a free community based obesity treatment program, Go4Fun,[233] which has been delivered at scale since 2011. While this program supports the obesity prevention and treatment effort in NSW, similar programs are not widely available in other jurisdictions. A case study of NSW services shows a range of complementary services available for child overweight and obesity treatment and include:

As part of the NSW Healthy Eating and Active Living (HEAL) strategy,[234] the NSW Healthy Children Initiative (HCI)[235] delivers a suite of primary and secondary childhood obesity prevention programs, Go4Fun is one of this suite of programs. The HEAL Strategy has four strategic directions: Environments to support healthy eating; State-wide healthy eating and active living programs (including HCI); Healthy eating as a part of routine service delivery; and Education and information to enable healthy choices.

Go4Fun Program

- A free 10-week group-based weight management program, delivered by trained qualified health professionals which focuses on improving child eating habits, fitness and confidence. The program has reached over 12,000 children with overweight or obesity across NSW since 2011.[236]

- The standard program is delivered face-to-face (typically after school once a week in selected locations). There is also an online version comprising self-paced website modules and weekly health professional phone coaching, as well as a culturally adapted version of the program for Aboriginal families and currently being delivered in partnership with over 35 Aboriginal communities in NSW.
- To be eligible to participate, children must be aged 7 to 13 years above a healthy weight and have a family member available to participate. A gap does, however, exist for some families, including those of children with complex comorbidities, outside the Go4fun target age group, or special needs may still require individualised treatment.
- A wider program uptake is needed in order to reach a larger proportion of children with overweight or obesity. Based on the 2016 ABS report, there were 951,988 children aged 5-14 years living in NSW, and among them 25% (n=237,997) were above a healthy weight. The program had reached only about 5% of this population.

Tertiary children's hospitals (outpatient weight management clinic)

- Suitable for families with children who cannot participate or fall outside the eligibility criteria (e.g. aged <7 years or >13 years) for Go4Fun.
- Suitable for children who have difficulties participating in a group-based program due to psychosocial issues, learning difficulties, weight associated social stigma, or following a specific/selective diet because of health or personal preferences (e.g. coeliac disease, vegetarian).
- The weight management clinics at tertiary children's hospitals are scheduled once a week (4 hours) and can have long waiting lists due to the limited service capacity compared to population needs.[108, 110]
- The prolonged waiting time to see paediatric dietitian for child weight management can be concerning for parents as their children will usually continue to gain weight, experience stigmatisation and endure ongoing poorer quality of life.[108, 110]
- The extent of clinical waiting lists presents an opportunity for recruiting children to early intervention and to trial novel, scalable models of care which, if successful, could be employed in other services that are struggling to address obesity concerns.

Private practice dietitians

- Private healthcare and consultation fees are substantially less affordable than services offered through public systems.
- Families can only claim Medicare rebates for five appointments per year to cover all allied health services (including dietitian) only if the child was referred by a general

practitioner and has a chronic illness, and requires ongoing care from a multidisciplinary team.[113, 114]

- Families with children who have excess weight or obesity (which is considered a risk factor, not a chronic health condition) but are generally healthy, are not eligible to obtain Medicare rebates when accessing private practice dietitian services.[113, 114]

Gaps exist in the services' geographical coverage and capacity to meet the population needs. The scale of the childhood obesity problem far exceeds the capacity of many currently available public health services to address the national epidemic of childhood obesity.[108] (Figure 7-1) The limited tertiary child weight management treatment services are insufficient to meet the needs of urban families, and particularly restrictive for rural families who are usually required to travel to services located in major metropolitan areas.

This service gap is of a major concern as overweight and obesity rates are higher in:

- Lower socio-economic groups.
- Aboriginal and Torres Strait Islander Australians.
- People living in regional and remote areas compared to those living in major cities.

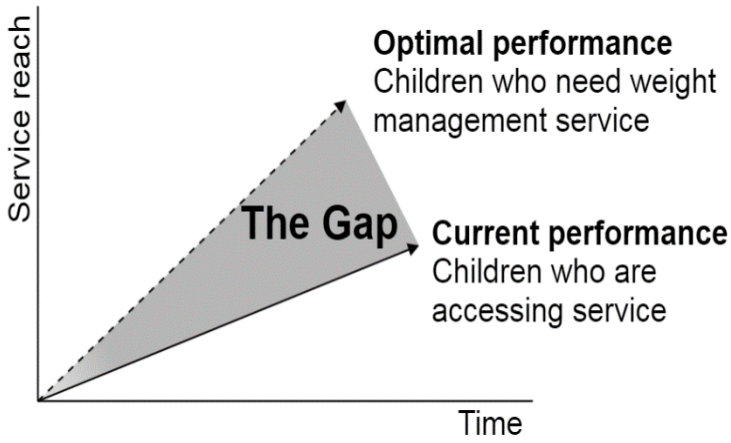

Figure 7-1 *A model of gap in service delivery*

To close the gap, we need to address the barriers and inequalities in access to child weight management services.

Barriers to health professional referrals to weight management service[108, 109]

- Insufficient support in some public health services, especially for routine monitoring and screening of child weight status to enable early detection of excessive weight gain trajectory and refer to appropriate services.
- Shortage of professional training opportunities for communicating child weight issues and management strategies in some jurisdictions.
- Absence of a clear referral pathway and incentives in referring families to child weight management services.
- Knowledge of the beneficial effects of improving weight status for non-communicable disease prevention.

It should be noted that NSW Health has been supporting health professionals through the Healthy Kids for Professionals website (https://pro.healthykids.nsw.gov.au) and Weight4KIDS module in raising the issue of childhood obesity and to identify and refer children above a healthy weight to appropriate services. There is an extensive program in NSW which supports health professionals through training, professional development and quality improvements to clinical practice to routinely identify children above a healthy weight and refer to appropriate services. It would be beneficial to make it mandatory for all child health workers to complete the online learning modules, and implement routine monitoring and screening of child weight status.

Barriers to family participation in weight management service[115, 116]

- Geographical limitations.
- Time constraints for traveling to clinic, especially families not living in the area.
- Transportation to clinic appointments.
- Taking children out of school and parent/s taking leave from work.
- Non-traditional family structure which complicates shared care where a child regularly lives in multiple households due to separation of parents.
- Clinic environment was viewed as not age-appropriate for some children and did not match the expectations of some families.[117]

Clinical telehealth – a potential approach

The University of Newcastle researchers partnered with clinicians at the John Hunter Children's Hospital to address service needs by developing an alternate treatment option using Telehealth (an online videoconferencing platform) which may be used to address some of the barriers mentioned above. Telehealth can be used by clinicians to increase health service delivery capacity and extend service reach to rural regions, while reducing time and cost associated with staff travelling to service outreach and home visits. Telehealth technology for delivering child weight management intervention can be used as a standalone treatment option or to complement other services that exist in both the community and clinical realm of practice by offering more personalised dietary intervention to families. This approach can help to scale up the provision of dietary services which are low cost and widely accessible. It will allow more appointment times as less clinician time was used to travel between appointments (i.e. home visits).

Back2Basics Family healthy lifestyle program

The Back2Basics Family (B2BF) program is informed by extensive evidence in family-based child weight management treatments research[35, 89] and stakeholders opinions[115, 125] and involved a combination of telehealth and technology-based intervention. (Figure 7-2)

Figure 7-2 *Back2Basics Family 12-weeek intervention program*

The online Australian Eating Survey (AES) generates an automated personalised nutrition report which provides an in-depth analysis of the child dietary intake compared to the Australian Dietary Guidelines. This tool maximises the dietitian appointment time to discuss child dietary feedback, goal setting, and tailoring personalised dietary strategies for families. The B2BF program also offered complementary components, including an evidence-based website with information on healthy eating, easy recipes, and physical activities. Both mothers and fathers (or primary caregivers) also received weekly nutrition text messages[125] and were invited to join B2BF parents Facebook group, to increase participants' engagement in the intervention.

The B2BF program has demonstrated high levels of feasibility and acceptability from parents and dietitians. After the 12-week program, children in intervention groups have maintained weight and significantly improved dietary intake (i.e. reduced percentage energy from energy-dense nutrient-poor food, and increased percentage energy from healthy core food). Parents were also highly commended the telehealth and text messages components of the B2BF program, with the majority reported they would like to continue to use them and would recommend to other parents.

The B2BF program may be used by health professionals to provide personalised child weight management advice and support to families who are unable or prefer not to participate in community lifestyle program or families who need more personalised advice could access child weight management treatment services. These could include children or families with special needs (e.g. learning difficulties, autism, coeliac disease).

Telehealth will likely reduce healthcare cost and the rate of failure-to-attend (FTA) as the online appointments are easier and more convenient to access, especially for families who live a fair distance away from the health service. The overall retention rate for the B2BF program (78%) is higher compared to existing childhood obesity intervention studies (ranging from 27% to 73%).[197] In addition, a requirement for families to complete the child AES prior to confirming their telehealth appointment is likely to help identify motivated families who need the intervention and are ready to change. This will therefore reduce the loss of clinicians' time related to FTA and thereby increase health services' efficiency and productivity.

Recommendations and Implications

1. B2BF program is a novel technology-based approach which can be used to provide families with a timely, comprehensive and personalised child weight management intervention that has the potential to be up-scaled and complementary to existing services in NSW or anywhere in Australia.
2. To establish telehealth dietetic clinic in health services, especially in rural health services, so more families can access personalised child weight management intervention.
3. To provide telehealth service delivery guidelines, and train dietitians in delivering telehealth dietetic services for child weight management, to complement service of children's hospital weight management clinic, and only offer face-to-face appointment to families who need it.
4. To establish a referral pathway for clinicians to refer families who are ineligible for Go4Fun, and those who need personalised dietary intervention and support after completing Go4Fun to Telehealth dietetic clinic.

Key Policy Options

Policy interventions that have been identified as most pressing for Australian governments in addressing obesity include:

- Establishment of a national obesity taskforce.
- Adoption of a whole-of-government obesity prevention and treatment strategy.
- Provision of funding for sustained, effective remotely delivered child obesity treatment interventions such as telehealth weight management clinic.

7.6 Conclusions

In view of the currently stable but considerably high prevalence of childhood obesity, Australian public health services need innovative and cost-effective approaches to providing personalised and timely child weight management support to families. My thesis has presented a comprehensive body of work related to improving personalised weight management for children with overweight or obesity using technology-based approaches.

To date, family-based behavioural interventions remain the best practice for management of children with obesity. Parental involvement in child weight management interventions is strongly recommended. Effective parent-targeted strategies were face-to-face education related to health behaviour and positive parenting, and role modelling. The importance of engaging the whole family unit in the intervention also arose from the literature review. Results from this body of work suggests that the use of telehealth, website, and/or SMS intervention may increase families' engagement in the intervention.

The 12-week family-focused online nutrition intervention, B2BF program, delivered using telehealth, website, Facebook and SMS to support parents in improving their child's eating habits is feasible, acceptable, and has achieved positive dietary outcomes in children aged 4 to 11 years. It appears that online parent-reported child height and weight may be a valid method of collecting child anthropometric data ahead of participation in a web-based healthy lifestyle program. The feasibility of the intervention and modest improvements in child outcomes warrant further investigation in a fully-powered randomised controlled trial assessing intervention efficacy and whether a solely online program can increase intervention participation, retention and reach.

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Appendices

Appendix 1: Classification of overweight and obesity in children based on International Obesity Task Force

		Boys		Girls	
		BMI (kg/m²) at age 18 years			
Age (months)	Age (years)	25	30	25	30
48	4	17.52	19.23	17.35	19.16
49	4.08	17.5	19.21	17.34	19.15
50	4.17	17.48	19.21	17.32	19.15
51	4.25	17.46	19.2	17.31	19.14
52	4.33	17.45	19.2	17.29	19.14
53	4.42	17.44	19.2	17.28	19.14
54	4.5	17.43	19.2	17.27	19.14
55	4.58	17.42	19.2	17.26	19.15
56	4.67	17.41	19.21	17.25	19.15
57	4.75	17.4	19.22	17.24	19.16
58	4.83	17.4	19.23	17.24	19.17
59	4.92	17.39	19.25	17.23	19.19
60	5	17.39	19.27	17.23	19.2
61	5.08	17.39	19.29	17.23	19.22
62	5.17	17.4	19.32	17.23	19.24
63	5.25	17.4	19.35	17.23	19.27
64	5.33	17.41	19.38	17.24	19.3
65	5.42	17.41	19.42	17.24	19.33
66	5.5	17.42	19.46	17.25	19.36
67	5.58	17.44	19.5	17.26	19.4
68	5.67	17.45	19.55	17.27	19.43
69	5.75	17.46	19.59	17.28	19.48
70	5.83	17.48	19.65	17.3	19.52
71	5.92	17.5	19.7	17.31	19.57
72	6	17.52	19.76	17.33	19.61
73	6.08	17.54	19.82	17.35	19.67
74	6.17	17.56	19.88	17.37	19.72
75	6.25	17.59	19.94	17.39	19.78
76	6.33	17.62	20.01	17.42	19.84
77	6.42	17.64	20.08	17.45	19.9
78	6.5	17.67	20.15	17.48	19.96
79	6.58	17.7	20.22	17.51	20.03
80	6.67	17.73	20.29	17.54	20.1
81	6.75	17.77	20.36	17.58	20.17
82	6.83	17.8	20.44	17.61	20.24
83	6.92	17.84	20.51	17.65	20.32
84	7	17.88	20.59	17.69	20.39
85	7.08	17.91	20.66	17.73	20.47
86	7.17	17.95	20.74	17.78	20.55
87	7.25	17.99	20.82	17.82	20.63

		Boys		Girls	
		BMI (kg/m²) at age 18 years			
Age (months)	Age (years)	25	30	25	30
88	7.33	18.04	20.9	17.87	20.72
89	7.42	18.08	20.98	17.91	20.8
90	7.5	18.12	21.06	17.96	20.89
91	7.58	18.17	21.14	18.01	20.98
92	7.67	18.21	21.22	18.07	21.07
93	7.75	18.26	21.3	18.12	21.16
94	7.83	18.31	21.39	18.17	21.25
95	7.92	18.36	21.47	18.23	21.35
96	8	18.41	21.56	18.28	21.44
97	8.08	18.46	21.65	18.34	21.54
98	8.17	18.51	21.74	18.39	21.64
99	8.25	18.56	21.83	18.45	21.74
100	8.33	18.62	21.92	18.51	21.84
101	8.42	18.67	22.02	18.57	21.94
102	8.5	18.73	22.11	18.63	22.04
103	8.58	18.78	22.21	18.69	22.14
104	8.67	18.84	22.31	18.75	22.24
105	8.75	18.9	22.41	18.81	22.35
106	8.83	18.95	22.51	18.87	22.45
107	8.92	19.01	22.61	18.93	22.56
108	9	19.07	22.71	18.99	22.66
109	9.08	19.13	22.82	19.05	22.77
110	9.17	19.19	22.92	19.12	22.88
111	9.25	19.25	23.03	19.18	22.99
112	9.33	19.31	23.13	19.24	23.09
113	9.42	19.37	23.24	19.31	23.2
114	9.5	19.43	23.34	19.38	23.31
115	9.58	19.49	23.45	19.44	23.42
116	9.67	19.55	23.55	19.51	23.53
117	9.75	19.61	23.66	19.58	23.64
118	9.83	19.67	23.76	19.64	23.75
119	9.92	19.74	23.86	19.71	23.86
120	10	19.8	23.96	19.78	23.97
121	10.08	19.86	24.06	19.85	24.08
122	10.17	19.92	24.16	19.92	24.19
123	10.25	19.97	24.25	19.99	24.29
124	10.33	20.04	24.35	20.07	24.4
125	10.42	20.09	24.44	20.14	24.51
126	10.5	20.15	24.54	20.21	24.62
127	10.58	20.21	24.63	20.28	24.72
128	10.67	20.27	24.72	20.36	24.83
129	10.75	20.33	24.81	20.43	24.94
130	10.83	20.39	24.9	20.51	25.04

		Boys		Girls	
		BMI (kg/m²) at age 18 years			
Age (months)	Age (years)	25	30	25	30
131	10.92	20.45	24.98	20.58	25.15
132	11	20.51	25.07	20.66	25.25
133	11.08	20.56	25.15	20.73	25.36
134	11.17	20.62	25.24	20.81	25.46
135	11.25	20.68	25.32	20.89	25.57
136	11.33	20.74	25.4	20.96	25.67
137	11.42	20.79	25.48	21.04	25.77
138	11.5	20.85	25.56	21.12	25.87
139	11.58	20.91	25.64	21.2	25.98
140	11.67	20.97	25.72	21.27	26.08
141	11.75	21.03	25.79	21.35	26.18
142	11.83	21.08	25.87	21.43	26.28
143	11.92	21.14	25.94	21.51	26.38
144	12	21.2	26.02	21.59	26.47

Adapted from IOTF[19]

Appendix 2: Sample of Australian Eating Survey personalised dietary report

The Australian Eating Survey™

Your Dietary Analysis Report

Hello,

Understanding how your food intake measures up to current Australian recommendations is an important step towards improving your eating habits. This report contains the results of your Australian Eating Survey™ that was completed on **01 May 2018**

The report compares your usual dietary intake to Australian dietary recommendations, which are based on the best available scientific evidence for nutrition and health. For more information on how your Australian Eating Survey™ report is generated, please refer to website (http://www.australianeatingsurvey.com.au)

Your report contains two sections. The first section has two parts:

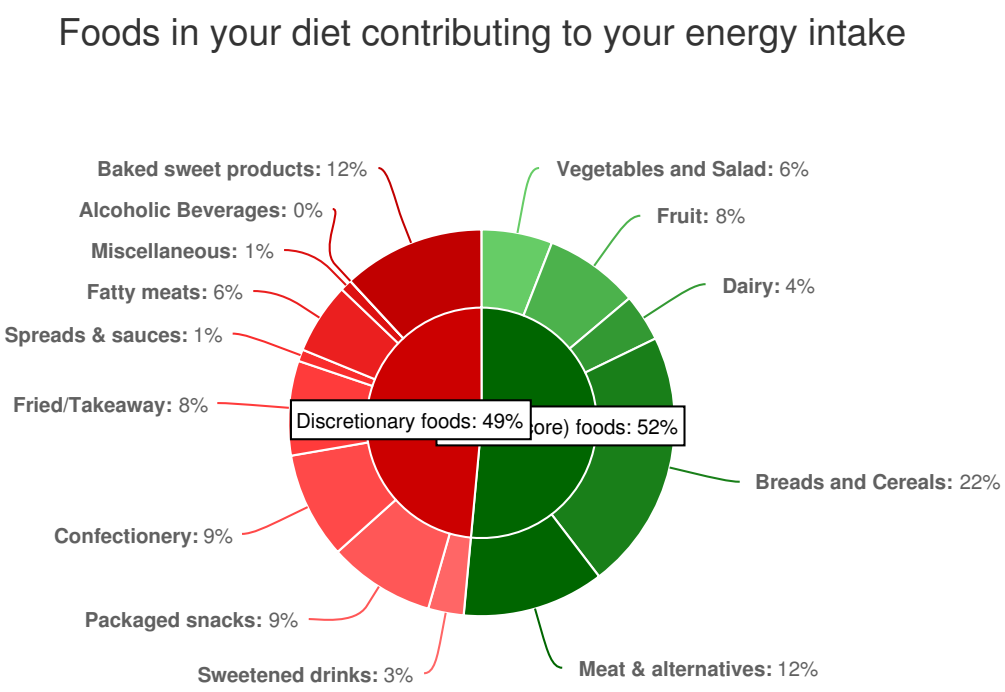
a. Your overall energy intake and the contribution of specific food groups to your average daily energy intake. It details how much of your daily energy intake (kilojoules) usually comes from healthy food groups (core foods) compared to the amount coming from less healthy foods, also called discretionary choices.
b. Your Australian Recommended Food Score (ARFS). This is a measure of how much variety within each of the healthy food groups you usually have over a week. Your ARFS is a summary score of the overall healthiness and nutritional quality of your usual eating patterns.

This section helps to identify the food groups where your intake is close to recommendations. It also shows you which areas you can try to make improvements in, either by cutting back on the amount you eat, or increasing the number of serves, or increasing the variety.

The second section gives detailed information about your nutrient intake based on the detailed analysis from your Australian Eating Survey™ responses. This includes how your macronutrient (protein, fat and carbohydrate) and micronutrient intakes (vitamins and minerals) compare with national recommended intake targets. This section also provides information on key food sources of these nutrients to help you improve your eating habits.

Your Daily Energy Intake is: 8094 kJ/day

What proportion of your food intake comes from healthy (core) foods?



Due to rounding, the percentages from healthy (core) foods and discretionary foods may not add up to 100%.

This graph shows the contribution of the "healthy" and "discretionary" foods you eat as a proportion of your overall energy intake (kilojoules).

Ideal ratios:
Healthy (core) foods - aim for 85-90%
Discretionary foods - aim for a maximum of 10-15%

Healthy foods, also called "core" foods, are needed by your body every day to provide essential nutrients.

In this graph these foods have been split into five groups:

1. Vegetables
2. Fruit
3. Breads and cereals (breakfast cereals, breads, rice, noodles, pasta)
4. Milk, yogurt and cheese (including non-dairy sources)
5. Meat, chicken and fish, and meat alternatives (vegetarian choices), such as eggs, nuts, and seeds, legumes, beans.

Most Australians need to eat larger portions and have more variety of vegetables and salad, smaller portions of meat and potato, and less discretionary food choices.

Discretionary foods are energy-dense, nutrient-poor foods and drinks. The recommendation is to consume them only occasionally and in small amounts. These are foods that may be enjoyable, but your body does not need them.

Most Australians need to eat less discretionary foods.

The Australian Recommended Food Score focuses on the variety of healthy core foods you usually eat. It takes a sub-set of foods from the Australian Eating Survey™ and calculates an overall diet quality score. Your ARFS score is made up from the scores from each food group category. Higher scores indicate healthier eating patterns and a dietary intake that is of higher nutritional quality.

Category *(maximum score)*	**Your score**
Vegetables *(21 points)*	**7**
Fruit *(12 points)*	**8**
Meat, chicken and fish *(7 points)*	**1**
Vegetarian** choices (eggs, legumes, nuts) *(6 points or 12 points**)* **If you are vegetarian you can double the points for this category.	**0**
Grains *(13 points)*	**4**
Dairy *(11 points)*	**3**
Condiments *(2 points)*	**1**
Water *(1 points)*	**1**
Overall *(73 points)*	**25**

Overall ARFS (out of 73)	**Rating**
<33	Needs work
33-38	Getting there
39-46	Excellent
47+	Outstanding

Your Nutrient Intake

This section summarises your nutrient intake analysis that has been calculated from the Australian Eating Survey™*. Your results have been compared to the Nutrient Reference Values for health developed by the National Health and Medical Research Council.

Macronutrients

Protein, carbohydrate and fat are all macronutrients and contribute to your kilojoule intake (energy intake). While alcohol is not a nutrient required by the body, it does contain kilojoules and so it contributes to your energy intake.

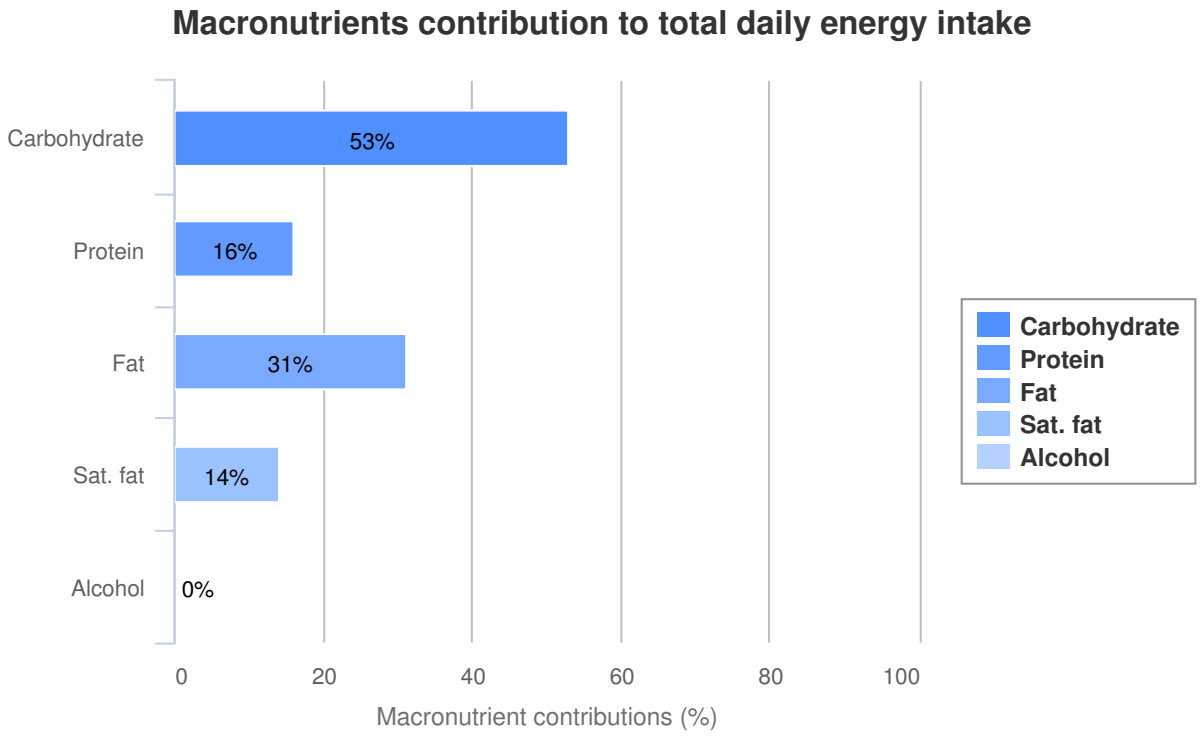
Carbohydrate: Dietary sources of ***complex carbohydrates*** include grains and cereals (e.g. pasta, rice), breakfast cereals, breads, fruits, potato, corn and sweet potato, beans and lentils, dairy foods. Processed and refined carbohydrates are found in discretionary foods such as savoury snack foods (e.g. potato crisps, biscuits), some drinks (e.g. soft drink, fruit juice), confectionary and desserts.

Protein: Rich sources of ***protein*** include lean meats, chicken, fish, eggs, legumes (e.g. lentils, beans, soy), nuts, dairy products.

Fat: There are four types of ***fat***: saturated, trans, monounsaturated and polyunsaturated. Major sources of saturated and trans fats include fatty cuts of meat, full fat dairy foods, butter, cream, most commercially baked products (e.g. biscuits and pastries), most deep-fried fast foods, coconut and palm oil. Food sources of monounsaturated fats include margarine spreads (canola or olive oil-based), olive, canola and peanut oils, avocado, and nuts such as peanuts, hazelnuts, cashews and

almonds. Food sources of polyunsaturated fat include oily fish (e.g. salmon, tuna, sardines), margarines and oils made from safflower, sunflower, corn or soy, and nuts such as walnuts and brazil nuts, and seeds.

How does your macronutrient intake compare to recommendations?*



Ideal intake ranges of macronutrients (as % of energy intake)*:

- Carbohydrate: 45-65%
- Protein: 15-25%
- Fat: 20-35%; Saturated fat plus Trans Fat: <10%
- Alcohol: less than 5%

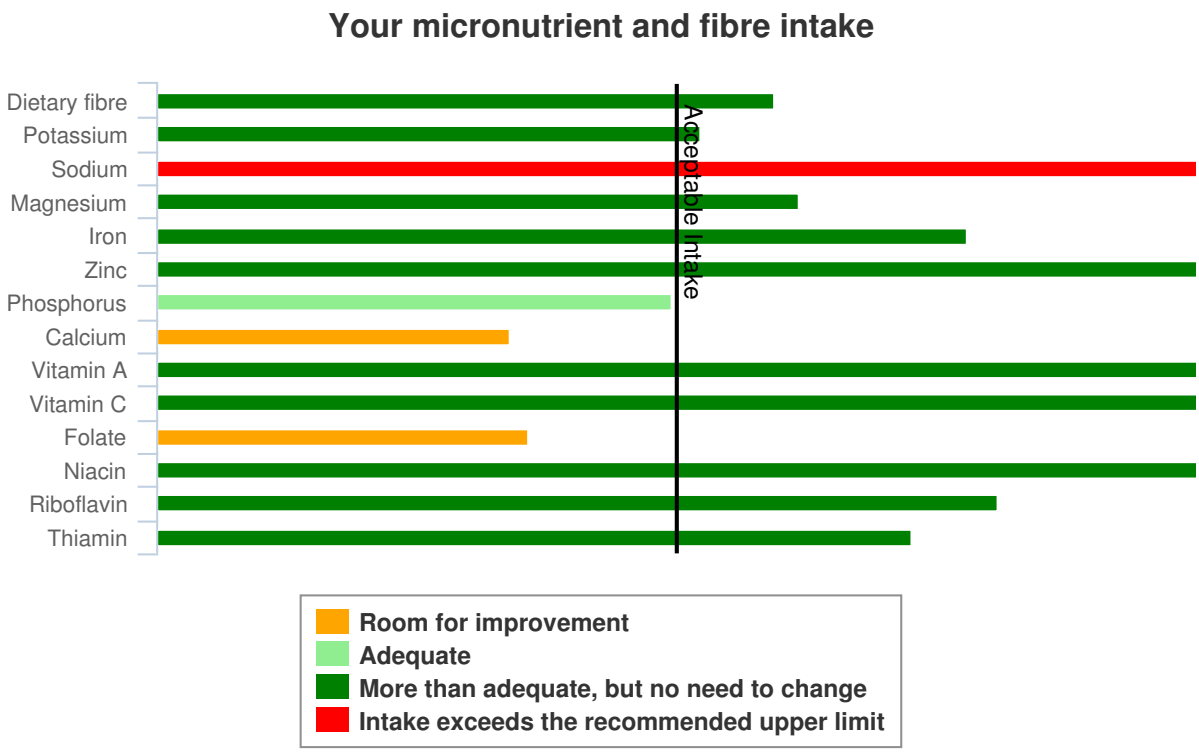
This graph shows your intake of macronutrients as proportions of your total energy intake*. A food intake that has carbohydrate, protein and fat intakes within the ideal ranges helps you to meet your requirements for general health. An increase in one macronutrient often leads to a decrease in others. If your nutrient intake is high in carbohydrate it tends to be lower in fat (and vice versa). Intakes higher in protein tend to be lower in carbohydrate and/or fat.

If you choose to consume ***alcohol***, moderation is the key. Adult recommendations are for no more than two standard drinks per day. Children, adolescents (aged less than 18 years) and women who are pregnant, planning pregnancy or breastfeeding should not drink alcohol.

Micronutrients and Fibre

Micronutrients are the vitamins and minerals that your body requires. Although the exact micronutrient requirements will vary from person to person, recommendations are made based on age, gender and life stage (i.e. pregnancy or breastfeeding). These recommendations can be used to determine whether your current food intake contains sufficient amounts of these key micronutrients.

How does your micronutrient and fibre intake measure up to recommendations?



The graph above shows your micronutrient and fibre intake* compared to the ideal intake range (i.e. Recommended Dietary Intake or Adequate Intake) for each nutrient.

For each nutrient on the graph above:

- An orange bar indicates that your usual intake for that nutrient is low and trying to eat more foods higher in this nutrient will help you reach the recommended intake.
- A light green bar indicates that your usual intake for that nutrient is in the target range but you could eat more foods that are high in this nutrient.
- A dark green bar indicates that your usual intake for that nutrient is adequate and there is no need to change.
- A red bar indicates that your usual intake for that nutrient is above the recommended limit and you should aim to cut back on foods high in this nutrient to avoid health problems. Not all nutrients have an upper limit.

Your intake of each micronutrient is shown in the table below.

Your micronutrient and fibre intake based on your usual eating patterns*:

Thiamin	**1.3** mg/day
Riboflavin	**1.5** mg/day
Niacin	**32.8** mg/day
Folate	**215.1** µg/day
Vitamin C	**109.5** mg/day
Vitamin A	**1257.8** µg/day
Calcium	**679.1** mg/day
Phosphorus	**1242.4** mg/day
Zinc	**12.2** mg/day

Iron	**12.5** mg/day
Magnesium	**297.0** mg/day
Sodium	**2429.3** mg/day
Potassium	**2616.6** mg/day
Fibre	**23.8** g/day

Please note: Your micronutrient analysis above does not include any vitamin and/or mineral supplements that you may currently take.

Do I need to take a vitamin and/or mineral supplement?

This will depend on your situation. The nutrient analysis provided above does not account for any vitamin and/or mineral supplements that you may be taking currently nor any pre-existing medical condition or allergies. The Australian Eating Survey™ is a validated tool for measuring dietary intake, but it asks you only about foods that are most commonly eaten in Australia.

If your analysis revealed your usual food intake is inadequate in one or more micronutrients, then try to increase your intake of foods that are good sources of those nutrients. If you need more help you could discuss the results from your Australian Eating Survey™ with your doctor or an Accredited Practising Dietitian before taking a supplement. Simple changes to the foods that you usually eat will improve your nutrient intakes. Sometimes a supplement is required and your dietitian or doctor can provide you with the appropriate advice.

How do I improve my intake of vitamins, minerals and fibre?

As a guide, you may need to consume more of the foods that are good sources of the micronutrients and fibre that have been flagged in orange and light green in your graph above, and then cut back on those nutrient sources that appear in red. The table below contains general information about these nutrients, including the key food sources.

I would like further advice on how to improve my diet, what should I do?

An Accredited Practising Dietitian is best placed to provide you with individualised dietary advice based on your Australian Eating Survey™ results. Click here to find a dietitian. (https://daa.asn.au/find-an-apd/)

Nutrient	Food sources^
Thiamin (Vitamin B1)	Wholemeal cereal grains, sesame seeds, soy beans and other dried beans and peas, wheatgerm fortified breakfast cereals, bread, yeast extracts including Vegemite® and Promite®, watermelon, yeast and pork.
Riboflavin (Vitamin B2)	Milk, yoghurt, cheese, wholegrain breads and cereals, egg white, leafy green vegetables, mushrooms, Vegemite® and Promite®, meat, liver and kidney.
Niacin (Vitamin B3)	Lean meats, milk, eggs, wholegrain breads and cereals, tuna, salmon, nuts, leafy green vegetables.
Folate (folic acid)	Green leafy vegetables, legumes, seeds, liver, poultry, eggs, cereals and citrus fruits. Many cereal-based foods in Australia, such as bread and breakfast cereals, are fortified with folate.
Vitamin C	Fruit, especially citrus, pineapple, mango and pawpaw. Vegetables, especially capsicum, broccoli, Brussels sprouts, cabbage, spinach.
Vitamin A	Dark yellow, orange and dark green vegetables and fruit such as apricots, mango and rockmelon, carrots, sweet potato and pumpkin, spinach and broccoli.
Zinc	Meat, chicken, fish, oysters, legumes, nuts, wholemeal and wholegrain products.
Iron	There are two types of iron. **Haem iron** (which is more easily absorbed) - found in animal foods such as beef, chicken and fish and in liver and kidney. **Non-haem iron** - found in plant foods such as beans, nuts, lentils and leafy green vegetables. Vegetarian sources include iron-fortified breakfast cereals, flours and grains. Vitamin C and cooking boost iron absorption.
Calcium	Dairy foods, such as milk, cheese, yoghurt, canned salmon and sardines with the bones, fortified soy milks, leafy green vegetables, such as broccoli, bok choy, Chinese cabbage and spinach, brazil nuts, almonds and sesame seed paste (tahini).
Phosphorous	Lean meats, chicken, fish, milk, yogurt and cheese.
Magnesium	Tofu, soy beans, nuts, seeds, lean meat, spinach, barley, wheatgerm, brown rice, avocado, bananas, peanut butter and peas.
Sodium	Processed meats (e.g. ham, bacon, sausages), snack foods (e.g. biscuits, potato crisps), takeaway foods (e.g. pies, sausage rolls), canned foods (e.g. soups), and savoury cooking sauces (e.g. pasta and stir-fry sauces) and condiments (e.g. tomato sauce, mayonnaise). Breads and fat spreads, breakfast cereals and cheese can also be high in sodium but provide many other important nutrients.
Potassium	Most fruits and vegetables, particularly leafy greens, potatoes, tomatoes, pumpkin, legumes, bananas, oranges, dairy products, and nuts.
Fibre	Wholemeal and wholegrain breads, pastas, rices, and breakfast cereals, psyllium, bran.

^The suggestions regarding the food sources of these nutrients are general and do not take into consideration if you need to avoid certain foods due to any pre-existing medical condition, allergies, intolerances or personal preference.
If you are concerned about your nutrient intake, please consult an Accredited Practising Dietitian for advice.

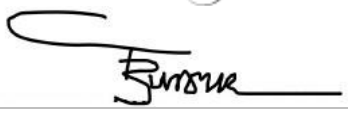
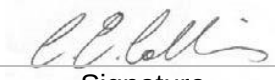
Appendix 3: Supplementary materials for umbrella review protocol

Statement of contribution and collaboration for umbrella review protocol

By signing below I confirm that Li Kheng Chai contributed to the following paper entitled:

> **Chai LK**, Burrows T, May C, Brain K, Wong See D, Collins C. Effectiveness of family-based weight management interventions in childhood obesity: an umbrella review protocol. *JBI Database System Rev Implement Rep*. 2016;**14**(9):32-9.

LKC prepared the initial manuscript and developed the search strategy of the study. LKC and her PhD supervisors (TLB, CM and CEC) contributed to the methodological design and search strategy. All authors contributed to the revision of the manuscript and approved the final manuscript.

Ms Li Kheng Chai		25/04/2019
PhD candidate	Signature	Date
A/Prof Tracy Burrows		25/04/2019
PhD supervisor	Signature	Date
Dr Chris May		25/04/2019
PhD supervisor	Signature	Date
Ms Katherine Brain		25/04/2019
Co-author	Signature	Date
Ms Denise Wong See		25/04/2019
Co-author	Signature	Date
Prof Clare Collins		25/04/2019
PhD supervisor	Signature	Date
Prof Liz Sullivan		29/04/2019
Deputy Head of Faculty of Health and Medicine	Signature	Date

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Title: Effectiveness of family-based weight management interventions in childhood obesity: an umbrella review protocol

Author: Li Chai, Tracy Burrows, Chris May, et al

Publication: JBI Database of Systematic Reviews and Implementation Reports

Publisher: Wolters Kluwer Health, Inc.

Date: Sep 1, 2016

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BACK CLOSE WINDOW

Effectiveness of family-based weight management interventions in childhood obesity: an umbrella review protocol

Li Kheng Chai[1] · Tracy Burrows[1] · Chris May[2] · Katherine Brain[1] · Denise Wong See[3] · Clare Collins[1,4,5]

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Review question/objective: The main objective of this umbrella review is to identify the effectiveness of family-based interventions that target overweight or obesity in children aged 18 years and under. The umbrella review intends to compare and summarize existing systematic reviews of experimental studies that address a range of family-based interventions for overweight children. Family-based is defined as the involvement of first- or second-degree relatives or carers who are cohabiting under one roof.[1] The second objective of this umbrella review is to identify strategies that are effective in improving children's body weight or body mass index (primary outcomes) and, where applicable, changes in child/family behavior, including dietary intake or physical activity.

The review questions are as follows: What is the effectiveness of family-based behavioral or lifestyle weight management interventions for overweight children? What are the strategies or characteristics of effective interventions in combating child obesity?

Keywords Children; family; intervention; obesity; overweight

Background

In the last few decades, childhood obesity has become a public health crisis worldwide and has a higher prevalence, especially in developed countries, including the United States, United Kingdom and Australia.[2] It is estimated that 42 million children under the age of five were overweight or obese in 2013, across the world.[3] A report of the International Obesity Task Force in the year 2000 estimated that, globally, approximately 155 million children aged five to 17 years were overweight, of whom 30-45 million were obese.[4,5] Overweight or obese children have an increased risk of both childhood cardiovascular risk factors, including elevated low-density lipoprotein, cholesterol and blood pressure,[6-8] as well as longer term health conditions including type 2 diabetes and heart disease.[9-11] In addition, obesity carries a social stigma that adversely affects children as well as their families.[12] Many obese children suffer from significant emotional problems ranging from overt depression to disturbed eating behavior.[12]

Obesity primarily develops from a prolonged excessive energy imbalance caused by calorie consumption that exceeds an individual's energy requirements.[13] Risk factors include genetic predispositions to obesity, obesogenic environment and increased sedentary behaviors.[13] Extensive research has been conducted examining both obesity prevention and treatment in children and adolescents, with a number of systematic reviews completed in recent years.[14-18] Despite advances in obesity research, the prevalence of overweight and obesity remains on the rise in almost all countries during the last decade.[2] The American Medical Association officially recognized obesity as a disease in June 2013 and it is anticipated that this decision will lead to a more focused approach around the world regarding an individual's access to treatment and in relation to the type of treatment that they receive.[19,20] In 2014, the World Health Organization (WHO) established the Commission on Ending Childhood Obesity to better inform and develop a

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There is no conflict of interest in this project.

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comprehensive response to childhood obesity.[3] The Commision on Ending Childhood Obesity aims to review and address gaps in current strategies and to advocate and raise awareness for action to halt childhood obesity.[3]

Homes and schools have commonly been targeted as settings for child obesity interventions, while evidence suggests that parental involvement has resulted in effective interventions.[21,22] Parents' attitudes, beliefs and behaviors can influence their child's risk of being overweight. Parental characteristics such as high body mass index (BMI), regular smoking, high alcohol intake, low education level and low socio-economic status have all been associated with increased likelihood of their children being overweight.[23] Although children are known to influence food choices in many families, parents are the key mediators of the obesogenic family environments. Parents make the final decision on the food provided and meal preparation methods at home, hence impacting their children's food preferences. The presence of parents at family meals can promote a positive atmosphere and model appropriate food-related behaviors and healthy food choices. Combined, these factors are associated with improved child diet quality. In order to reduce the prevalence of childhood obesity, it is essential to identify the elements that underpin effective interventions including prevention, weight management and treatment. As parental influences are closely associated with child weight or weight-related outcome, the parental role in the treatment of childhood obesity is likely to be a critical element for effective interventions.[17,24]

Family-based interventions for childhood obesity are not uncommon; however, it remains a challenge for healthcare professionals aiming to treat childhood obesity to work effectively with both parents as a collective unit. Yet, the ability to work effectively with both parents is likely to be important when aiming to influence the complex dynamics of family systems.[25] There is an abundance of literature on childhood obesity interventions with parental involvement.[14,17,26] Yet, systematic reviews of childhood obesity interventions have reported difficulties in assessing the effectiveness of family-based interventions on children's weight and weight-related behavior due to both the scarcity of quality programs[27,28] and the diversity of existing strategies.[16] A Cochrane review[28] acknowledged that research in the area of childhood obesity treatment is challenging as it is difficult to suggest that one intervention component is more effective than the other given the heterogeneity of current literature. Therefore, it is warranted to address this gap through a comprehensive review of current systematic reviews summarizing existing strategies that have been reported to be effective in supporting parents with an overweight child to better manage their child's weight.

The current study aims to systematically review the literature, including existing systematic reviews to identify the key strategies employed in effective family-based weight management programs for overweight children that result in weight loss and/or behavior change. This review would therefore address current gaps in the literature concerning this area of research by summarizing the strategies that could effectively facilitate parents in managing their child's weight. A search of the systematic review repositories (PROSPERO, the *JBI Database of Systematic Reviews and Implementation Reports*) has shown that there is no current umbrella review or overview underway for this topic.

Inclusion criteria

Types of participants

Systematic reviews in which study populations have included children and adolescents aged 18 years and under who were classified as overweight or obese at baseline, based on WHO Child Growth Standards, Centers for Disease Control and Prevention Growth Charts or Cole's LMS method, will be included.[29-31]

Types of intervention(s)/phenomena of interest

This umbrella review will include reviews considering family-based behavioral or lifestyle interventions for child weight management. For the purpose of this review, ''family-based'' is defined as the involvement of first- or second-degree relatives or carers cohabiting under one roof.[1] Interventions that involve parents only, the parent and child separately or the parent and child together will be included, regardless of the setting (home environment, schools, clinical sites and community settings). Interventions of interest are those that aim for weight loss as a primary outcome through changes to behavioral or lifestyle habits, including, but not limited to, dietary intake, physical activity, sedentary behavior, mealtime patterns and sleep. Comparison groups

may include usual care, other interventions or no intervention control.

Outcomes

The primary outcome of interest is children's body weight or BMI. Existing reviews that reported synthesis of children's body weight or BMI change, measured from baseline to intervention-end or post-intervention follow-up, will be considered for this review. Where available, ''behavior change'' such as dietary intake or physical activity may be included as secondary outcomes of interest. Behavior change outcomes could be measured using various methods including, but not limited to, the food frequency questionnaire, weighed food record (food diary), diet history, 24-hour recall, accelerometer, pedometer and physical activity questionnaire. Other outcomes, such as waist circumference, adiposity, blood glucose levels or blood lipid levels, which may be of interest in relation to change in weight or behavior will also be reported in the same way as the included reviews. Adverse outcomes that have resulted from interventions such as deterioration of disordered eating, depression or anxiety will be documented if reported within the reviews.[28]

Types of studies

Systematic reviews (both quantitative and mixed methods) and meta-analyses of intervention studies will be included in this review. Systematic reviews of solely qualitative studies or reviews of nonexperimental studies (such as cohort study, case study and cross-sectional study) or narrative reviews will be excluded. Where mixed method reviews are available, only quantitative results will be extracted for inclusion in the umbrella review, qualitative results will be excluded. For reviews that include both experimental and nonexperimental studies, only results from experimental studies will be extracted for inclusion in the umbrella review. If results are not reported or not separable between experimental and nonexperimental studies, the review will be excluded.

Search strategy

The search strategy is designed to identify syntheses of research evidence such as systematic reviews and meta-analyses exclusively. As there were limited systematic reviews published prior to 1990,[32] the current review aims to focus on reports available from 1990 to present that were published in the English language. A three-stage search method will be used in this review. Initial keywords will be identified in MEDLINE first, the text words contained in the title and abstract will be analyzed subsequently, and then the index terms used to describe related reviews. Second, a search will be performed in the following databases – MEDLINE, EMBASE, CINAHL, PsycInfo, Scopus, Database of Abstracts of Reviews of Effects and the Cochrane Database of Systematic Reviews using a search strategy (Appendix I), which comprises all identified keywords and index terms, reviewed by an experienced academic librarian. The third phase will include manually searching reference lists of all included reviews for additional studies.[33]

Two independent reviewers, with experience in the field, will examine titles and abstracts of all identified reviews. Relevant reviews will be obtained in the form of full articles and assessed against the inclusion and study quality criteria as described in the protocol. Any disagreements that arise will be resolved through discussion or with a third reviewer, who will perform an additional independent evaluation.

Assessment of methodological quality

All included systematic reviews will be critically appraised by two reviewers individually using the JBI Critical Appraisal Checklist for Systematic Reviews and Research Syntheses (Appendix II).[33] When consensus cannot be reached between the two reviewers, a third reviewer will perform an additional appraisal independently.

Data extraction

The JBI Data Extraction Form for Review for Systematic Reviews and Research Syntheses (Appendix III) will be used for data extraction from the studies included in the review.[33] Characteristics of studies will be included in the Table of Included Study Characteristics to be attached to the review report.

- Review characteristics: author/year, objectives, participants (characteristics/total number), setting/context (cultural factors: ethnicity/socioeconomic status/minority group), interventions of interest, number of databases/sources searched, date range of included studies, detailed

description of the included studies (number/type/country of origin of included studies), appraisal instrument and rating, type of review/method of analysis and outcomes.
- Results: significant findings/outcomes of the review and comments.

Data summary

Findings of included reviews will be presented with overall effect size evaluations extracted from the reports. Quantitative data will be presented by reporting the number of studies that inform the outcome, the number of participants from included studies, and the heterogeneity of the results of included reviews. In the cases of included reviews reporting a high level of homogeneity, pooled estimates will be presented. Any overlap of original research studies in all included reviews (e.g. one study is included in multiple included reviews) will be clearly indicated in the report.

The results of the umbrella review will be summarized in the ''Summary of Evidence'' table, presenting information including the intervention names, the included systematic reviews, and a simple visual indicator of the intervention effectiveness using the JBI ''stop-light'' indicator, where green indicates an effective or beneficial intervention, amber indicates no intervention effect or no difference when compared to the comparator and red indicates a detrimental or less-effective intervention when compared to the comparator.[33] An overall assessment of the quality of evidence for each intervention of interest will be performed using the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) approach.[34] The GRADE framework includes evaluation of the following criteria: quality of primary studies, design of primary studies, consistency and directness.

Acknowledgements

The current systematic literature review will form part of the theses work for PhD candidate Li Kheng Chai from The University of Newcastle, Australia.

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Appendix I: Search strategy

Platform: OVID
Database(s): MEDLINE 1946 to Present with Daily Update

No.	Searches
1	systematic review.mp,pt.
2	systematic*.mp,pt.
3	review*.mp,pt.
4	meta analys*.mp,pt.
5	metaanalys*.mp,pt.
6	meta-analys*.mp,pt
7	1 or 2 or 3 or 4 or 5 or 6
8	lifestyle*.mp.
9	behavio?r*.mp.
10	family.mp.
11	families.mp.
12	family-based.mp.
13	parents.mp.
14	parent*.mp.
15	mother*.mp.
16	father*.mp.
17	carer*.mp.
18	guardian*.mp.
19	grandparent*.mp.
20	grandfather*.mp.
21	grandmother*.mp.
22	sibling*.mp.
23	coparent*.mp.
24	co-parent*.mp.
25	8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24
26	p?ediatric*..mp.
27	child*.mp.
28	kid*.mp.
29	toddler*.mp.
30	(preschooler* or pre-schooler*).mp.
31	adolescent*.mp.
32	teenager*.mp.
33	youth*.mp.
34	youngster*.mp.
35	26 or 27 or 28 or 29 or 30 or 31 or 32 or 33 or 34
36	overweight.mp.
37	obese.mp.
38	obes*.mp.
39	weight manag*.mp.
40	weight loss.mp.
41	weight control*.mp.
42	(overweight* adj5 intervention*).mp.
43	(overweight* adj5 treatment*).mp.
44	(overweight* adj5 program*).mp.
45	(weight* adj5 intervention*).mp.
46	(weight* adj5 treatment*).mp.
47	(weight* adj5 program*).mp.
48	(obes* adj5 intervention*).mp.
49	(obes* adj5 treatment*).mp.
50	(obes* adj5 program*).mp.
51	36 or 37 or 38 or 39 or 40 or 41 or 42 or 43 or 44 or 45 or 46 or 47 or 48 or 49 or 50
52	7 and 25 and 35 and 51
53	limit 52 to (English language and yr = "1990-Current")

Appendix II: JBI critical appraisal checklist for systematic reviews and research syntheses

Reviewer _____ Date _____

Author _____ Year _____ Record Number _____

		Yes	No	Unclear	Not Applicable
1.	Is the review question clearly and explicitly stated?	☐	☐	☐	☐
2.	Were the inclusion criteria appropriate for the review question?	☐	☐	☐	☐
3.	Was the search strategy appropriate?	☐	☐	☐	☐
4.	Were the sources and resources used to search for studies adequate?	☐	☐	☐	☐
5.	Were the criteria for appraising studies appropriate?	☐	☐	☐	☐
6.	Was critical appraisal conducted by two or more reviewers independently?	☐	☐	☐	☐
7.	Were there methods to minimize errors in data extraction?	☐	☐	☐	☐
8.	Were the methods used to combine studies appropriate?	☐	☐	☐	☐
9.	Was the likelihood of publication bias assessed?	☐	☐	☐	☐
10.	Were recommendations for policy and/or practice supported by the reported data?	☐	☐	☐	☐
11.	Were the specific directives for new research appropriate?	☐	☐	☐	☐

Overall appraisal: Include ☐ Exclude ☐ Seek further info ☐

_____

_____

Appendix III: JBI data extraction form for review for systematic reviews and research syntheses

Study details
Author/year
Objectives
Participants (characteristics/total number)
Setting/context
Description of interventions/phenomena of interest
Search details
Sources searched
Range (years) of included studies
Number of studies included *I*
Types of studies included
Country of origin of included studies
Appraisal
Appraisal instruments used
Appraisal rating
Analysis
Method of analysis
Outcome assessed
Results/findings
Significance/direction
Heterogeneity
Comments

Appendix 4: Statement of contribution and collaboration for umbrella review

By signing below I confirm that Li Kheng Chai contributed to the following paper entitled:

> **Chai LK**, Collins C, May C, Brain K, Wong See D, Burrows T. The effectiveness of weight management interventions for families of children with overweight or obesity: an Umbrella Review. *JBI Database System Rev Implement Rep*. 2019 Jul;**17**(7):1341-1427. doi: 10.11124/JBISRIR-2017-003695.

LKC contributed to searches, reviewing of titles, abstracts and full texts (as the first reviewer), data extraction and preparation of the manuscript. Co-authors jointly reviewed as the second reviewer of titles and abstracts (TLB, CM, KB, DWS, CEC), and full texts (TLB, CM, CEC). LKC and TLB independently assessed the quality of studies and evidence. All authors contributed to the revision of the manuscript and approved the final manuscript.

Ms Li Kheng Chai		25/04/2019
PhD candidate	Signature	Date
Prof Clare Collins		25/04/2019
PhD supervisor	Signature	Date
Dr Chris May		25/04/2019
PhD supervisor	Signature	Date
Ms Katherine Brain		25/04/2019
Co-author	Signature	Date
Ms Denise Wong See		25/04/2019
Co-author	Signature	Date
A/Prof Tracy Burrows		25/04/2019
PhD supervisor	Signature	Date
Prof Liz Sullivan		29/04/2019
Deputy Head of Faculty of Health and Medicine	Signature	Date

Appendix 5: Search strategy

Database: MEDLINE 1946 to Present with Daily Update (searched on 2nd May 2016)

#	Searches
1	systematic review.mp,pt.
2	systematic*.mp,pt.
3	review*.mp,pt.
4	meta analys*.mp,pt.
5	metaanalys*.mp,pt.
6	meta-analys*.mp,pt
7	1 or 2 or 3 or 4 or 5 or 6
8	lifestyle*.mp.
9	behavio?r*.mp.
10	family.mp.
11	families.mp.
12	family-based.mp.
13	parents.mp.
14	parent*.mp.
15	mother*.mp.
16	father*.mp.
17	carer*.mp.
18	guardian*.mp.
19	grandparent*.mp.
20	grandfather*.mp.
21	grandmother*.mp.
22	sibling*.mp.
23	coparent*.mp.
24	co-parent*.mp.
25	8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24
26	p?ediatric*..mp.
27	child*.mp.
28	kid*.mp.
29	toddler*.mp.
30	(preschooler* or preschooler*).mp.
31	adolescent*.mp.
32	teenager*.mp.
33	youth*.mp.
34	youngster*.mp.
35	26 or 27 or 28 or 29 or 30 or 31 or 32 or 33 or 34
36	overweight.mp.
37	obese.mp.
38	obes*.mp.
39	weight manag*.mp.
40	weight loss.mp.
41	weight control*.mp.
42	(overweight* adj5 intervention*).mp.
43	(overweight* adj5 treatment*).mp.
44	(overweight* adj5 program*).mp.
45	(weight* adj5 intervention*).mp.
46	(weight* adj5 treatment*).mp.

47	(weight* adj5 program*).mp.
48	(obes* adj5 intervention*).mp.
49	(obes* adj5 treatment*).mp.
50	(obes* adj5 program*).mp.
51	36 or 37 or 38 or 39 or 40 or 41 or 42 or 43 or 44 or 45 or 46 or 47 or 48 or 49 or 50
52	7 and 25 and 35 and 51
53	limit 52 to (english language and yr="1990 -Current")

Database: Embase 1974 to 2016 Week 18 (searched on 2nd May 2016)

#	Searches
1	systematic review.mp.
2	systematic*.mp.
3	review*.mp.
4	meta analys*.mp.
5	metaanalys*.mp.
6	1 or 2 or 3 or 4 or 5
7	lifestyle*.mp.
8	behavio?r*.mp.
9	family.mp.
10	families.mp.
11	family-based.mp.
12	parents.mp.
13	parent*.mp.
14	mother*.mp.
15	father*.mp.
16	carer*.mp.
17	guardian*.mp.
18	grandparent*.mp.
19	grandfather*.mp.
20	grandmother*.mp.
21	sibling*.mp.
22	coparent*.mp.
23	co-parent*.mp.
24	7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23
25	p?ediatric*.mp.
26	child*.mp.
27	kid*.mp.
28	toddler*.mp.
29	(preschooler* or pre-schooler*).mp.
30	adolescen*.mp.
31	teenager*.mp.
32	youth*.mp.
33	youngster*.mp.
34	25 or 26 or 27 or 28 or 29 or 30 or 31 or 32 or 33
35	overweight.mp.

36	obese.mp.
37	obes*.mp.
38	weight manag*.mp.
39	weight loss.mp.
40	weight control*.mp.
41	(overweight* adj5 intervention*).mp.
42	(overweight* adj5 treatment*).mp.
43	(overweight* adj5 program*).mp.
44	(weight* adj5 intervention*).mp.
45	(weight* adj5 treatment*).mp.
46	(weight* adj5 program*).mp.
47	(obes* adj5 intervention*).mp.
48	(obes* adj5 treatment*).mp.
49	(obes* adj5 program*).mp.
50	35 or 36 or 37 or 38 or 39 or 40 or 41 or 42 or 43 or 44 or 45 or 46 or 47 or 48 or 49
51	6 and 24 and 34 and 50
52	limit 51 to (english language and yr="1990 -Current")

Database: PsycINFO 1806 to April Week 4 2016 (searched on 2nd May 2016)

#	Searches
1	systematic review.mp.
2	systematic*.mp.
3	review*.mp.
4	meta analys*.mp.
5	metaanalys*.mp.
6	1 or 2 or 3 or 4 or 5
7	lifestyle*.mp.
8	behavio?r*.mp.
9	family.mp.
10	families.mp.
11	family-based.mp.
12	parents.mp.
13	parent*.mp.
14	mother*.mp.
15	father*.mp.
16	carer*.mp.
17	guardian*.mp.
18	grandparent*.mp.
19	grandfather*.mp.
20	grandmother*.mp.
21	sibling*.mp.
22	coparent*.mp.
23	co-parent*.mp.
24	7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23
25	p?ediatric*.mp.

26	child*.mp.
27	kid*.mp.
28	toddler*.mp.
29	(preschooler* or pre-schooler*).mp.
30	adolescen*.mp.
31	teenager*.mp.
32	youth*.mp.
33	youngster*.mp.
34	25 or 26 or 27 or 28 or 29 or 30 or 31 or 32 or 33
35	overweight.mp.
36	obese.mp.
37	obes*.mp.
38	weight manag*.mp.
39	weight loss.mp.
40	weight control*.mp.
41	(overweight* adj5 intervention*).mp.
42	(overweight* adj5 treatment*).mp.
43	(overweight* adj5 program*).mp.
44	(weight* adj5 intervention*).mp.
45	(weight* adj5 treatment*).mp.
46	(weight* adj5 program*).mp.
47	(obes* adj5 intervention*).mp.
48	(obes* adj5 treatment*).mp.
49	(obes* adj5 program*).mp.
50	35 or 36 or 37 or 38 or 39 or 40 or 41 or 42 or 43 or 44 or 45 or 46 or 47 or 48 or 49
51	6 and 24 and 34 and 50
52	limit 51 to (english language and yr="1990 -Current")

Database: CINAHL Complete (searched on 2nd May 2016)

#	Searches
S1	(MM "Systematic Review") OR (MH "Meta Analysis")
S2	TI ‘systematic review’ OR AB ‘systematic review’ OR PT ‘systematic review’
S3	TI systematic* OR AB systematic* OR PT systematic*
S4	TI review* OR AB review* OR PT review*
S5	TI ‘meta analys*’ OR AB ‘meta analys*’ OR PT ‘meta analys*’
S6	TI metaanalys* OR AB metaanalys* OR PT metaanalys*
S7	TI meta-analys* OR AB meta-analys* OR PT meta-analys*
S8	S1 OR S2 OR S3 OR S4 OR S5 OR S6 OR S7
S9	(MH "Life Style Changes") OR (MH "Life Style, Sedentary") OR (MH "Life Style") OR (MH "Health Behavior") OR (MH "Family Health") OR (MH "Family Services") OR (MH "Family Centered Care") OR (MH "Parents")
S10	TI lifestyle OR AB lifestyle
S11	TI behavio?r* OR AB behavio?r*
S12	TI family OR AB family
S13	TI families OR AB families

S14	TI family-based OR AB family-based
S15	TI parents OR AB parents
S16	TI parent* OR AB parent*
S17	TI mother* OR AB mother*
S18	TI father* OR AB father*
S19	TI carer* OR AB carer*
S20	TI guardian* OR AB guardian*
S21	TI grandparent* OR AB grandparent*
S22	TI grandfather* OR AB grandfather*
S23	TI grandmother* OR AB grandmother*
S24	TI sibling* OR AB sibling*
S25	TI coparent* OR AB coparent*
S26	TI co-parent* OR AB co-parent*
S27	S9 OR S10 OR S11 OR S12 OR S13 OR S14 OR S15 OR S16 OR S17 OR S18 OR S19 OR S20 OR S21 OR S22 OR S23 OR S24 OR S25 OR S26
S28	TI (p?ediatric*) OR AB (p?ediatric*)
S29	TI child* OR AB child*
S30	TI kid* OR AB kid*
S31	TI toddler* OR AB toddler*
S32	TI (preschooler* or pre-schooler*) OR AB (preschooler* or pre-schooler*)
S33	TI adolescen* OR AB adolescen*
S34	TI teenager* OR AB teenager*
S35	TI youth* OR AB youth*
S36	TI youngster* OR AB youngster*
S37	S28 OR S29 OR S30 OR S31 OR S32 OR S33 OR S34 OR S35 OR S36
S38	(MM "Pediatric Obesity") OR (MM "Obesity+") OR (MH "Weight Control") OR (MH “Weight Reduction Programs”)
S39	TI overweight OR AB overweight
S40	TI obese OR AB obese
S41	TI obes* OR AB obes*
S42	TI ‘weight manag*’ OR AB ‘weight manag*’
S43	TI ‘weight loss’ OR AB ‘weight loss’
S44	TI ‘weight control*’ OR AB ‘weight control*’
S45	TI (overweight* N5 intervention*) OR AB (overweight* N5 intervention*)
S46	TI (overweight* N5 treatment*) OR AB (overweight* N5 treatment*)
S47	TI (overweight* N5 program*) OR AB (overweight* N5 program*)
S48	TI (weight* N5 intervention*) OR AB (weight* N5 interventIon*)
S49	TI (weight* N5 treatment*) OR AB (weight* N5 treatment*)
S50	TI (weight* N5 program*) OR AB (weight* N5 program*)
S51	TI (obes* N5 intervention*) OR AB (obes* N5 intervention*)
S52	TI (obes* N5 treatment*) OR AB (obes* N5 treatment*)
S53	TI (obes* N5 program*) OR AB (obes* N5 program*)
S54	S38 OR S39 OR S40 OR S41 OR S42 OR S43 OR S44 OR S45 OR S46 OR S47 OR S48 OR S49 OR S50 OR S51 OR S52 OR S53
S55	S8 AND S27 AND S37 AND S54 (Limiters - Published Date: 19900101-; English Language)

Database: Cochrane Library – DARE and CDSR (searched on 2nd May 2016)

#	Searches
#1	"systematic review":ti,ab,kw or "systematic review":pt (Word variations have been searched)
#2	"systematic":ti,ab,kw or "systematic":pt (Word variations have been searched)
#3	"review":ti,ab,kw or "review":pt (Word variations have been searched)
#4	"meta analys*":ti,ab,kw and "meta analys*":pt (Word variations have been searched)
#5	metaanalys*:ti,ab,kw or metaanalys*:pt (Word variations have been searched)
#6	meta-analys*:ti,ab,kw or meta-analys*:pt (Word variations have been searched)
#7	MeSH descriptor: [Review] explode all trees
#8	MeSH descriptor: [Meta-Analysis] explode all trees
#9	MeSH descriptor: [Meta-Analysis as Topic] explode all trees
#10	#1 or #2 or #3 or #4 or #5 or #6 or #7 or #8 or #9
#11	lifestyle:ti,ab,kw (Word variations have been searched)
#12	behaviour:ti,ab,kw (Word variations have been searched)
#13	family:ti,ab,kw (Word variations have been searched)
#14	"families":ti,ab,kw (Word variations have been searched)
#15	family-based:ti,ab,kw (Word variations have been searched)
#16	parents:ti,ab,kw (Word variations have been searched)
#17	"parent":ti,ab,kw (Word variations have been searched)
#18	mother:ti,ab,kw (Word variations have been searched)
#19	"father":ti,ab,kw (Word variations have been searched)
#20	carer:ti,ab,kw (Word variations have been searched)
#21	guardian:ti,ab,kw (Word variations have been searched)
#22	grandparent:ti,ab,kw (Word variations have been searched)
#23	grandfather:ti,ab,kw (Word variations have been searched)
#24	grandmother:ti,ab,kw (Word variations have been searched)
#25	sibling:ti,ab,kw (Word variations have been searched)
#26	coparent:ti,ab,kw (Word variations have been searched)
#27	co-parent:ti,ab,kw (Word variations have been searched)
#28	MeSH descriptor: [Life Style] this term only
#29	MeSH descriptor: [Behavior] this term only
#30	MeSH descriptor: [Family] this term only
#31	MeSH descriptor: [Parents] explode all trees
#32	MeSH descriptor: [Siblings] explode all trees
#33	#11 or #12 or #13 or #14 or #15 or #16 or #17 or #18 or #19 or #20 or #21 or #22 or #23 or #24 or #25 or #26 or #27 or #28 or #29 or #30 or #31 or #32
#34	"p*ediatric*":ti,ab,kw (Word variations have been searched)
#35	child:ti,ab,kw (Word variations have been searched)
#36	kid:ti,ab,kw (Word variations have been searched)
#37	toddler:ti,ab,kw (Word variations have been searched)
#38	"preschooler":ti,ab,kw or "pre-schooler":ti,ab,kw (Word variations have been searched)
#39	adolescen*:ti,ab,kw (Word variations have been searched)
#40	teenager:ti,ab,kw (Word variations have been searched)
#41	youth:ti,ab,kw (Word variations have been searched)

#42	youngster:ti,ab,kw (Word variations have been searched)
#43	#34 or #35 or #36 or #37 or #38 or #39 or #40 or #41 or #42
#44	overweight:ti,ab,kw (Word variations have been searched)
#45	obese:ti,ab,kw (Word variations have been searched)
#46	"obes*":ti,ab,kw (Word variations have been searched)
#47	"weight manag*":ti,ab,kw (Word variations have been searched)
#48	"weight loss":ti,ab,kw (Word variations have been searched)
#49	"weight control*":ti,ab,kw (Word variations have been searched)
#50	overweight* near intervention*:ti,ab,kw (Word variations have been searched)
#51	overweight* near treatment*:ti,ab,kw (Word variations have been searched)
#52	overweight* near program*:ti,ab,kw (Word variations have been searched)
#53	weight* near intervention*:ti,ab,kw (Word variations have been searched)
#54	weight* near treatment*:ti,ab,kw (Word variations have been searched)
#55	weight* near program*:ti,ab,kw (Word variations have been searched)
#56	obes* near intervention*:ti,ab,kw (Word variations have been searched)
#57	obes* near treatment*:ti,ab,kw (Word variations have been searched)
#58	obes* near program*:ti,ab,kw (Word variations have been searched)
#59	MeSH descriptor: [Pediatric Obesity] explode all trees
#60	MeSH descriptor: [Weight Loss] explode all trees
#61	MeSH descriptor: [Weight Reduction Programs] explode all trees
#62	MeSH descriptor: [Body Weight Changes] explode all trees
#63	#44 or #45 or #46 or #47 or #48 or #49 or #50 or #51 or #52 or #53 or #54 or #55 or #56 or #57 or #58 or #59 or #60 or #61 or #62
#64	#10 and #33 and #43 and #63
#65	#10 and #33 and #43 and #63 Publication Year from 1990 (Word variations have been searched)

Database: Scopus (searched on 2nd May 2016)

#	Searches
#1	(TITLE-ABS-KEY ("systematic review") OR TITLE-ABS-KEY (systematic*) OR TITLE-ABS-KEY (review*) OR TITLE-ABS-KEY ("meta analys*") OR TITLE-ABS-KEY (metaanalys*) OR TITLE-ABS-KEY (meta-analys*))
#2	TITLE-ABS-KEY (lifestyle*) OR TITLE-ABS-KEY (behavio?r*) OR TITLE-ABS-KEY (family) OR TITLE-ABS-KEY (families) OR TITLE-ABS-KEY ("family-based") OR TITLE-ABS-KEY (parents) OR TITLE-ABS-KEY (parent*) OR TITLE-ABS-KEY (mother*) OR TITLE-ABS-KEY (father*) OR TITLE-ABS-KEY (carer*) OR TITLE-ABS-KEY (guardian*) OR TITLE-ABS-KEY (grandparent*) OR TITLE-ABS-KEY (grandfather*) OR TITLE-ABS-KEY (grandmother*) OR TITLE-ABS-KEY (sibling*) OR TITLE-ABS-KEY (coparent*) OR TITLE-ABS-KEY ("co-parent*")
#3	TITLE-ABS-KEY (p?ediatric*) OR TITLE-ABS-KEY (child*) OR TITLE-ABS-KEY (kid*) OR TITLE-ABS-KEY (toddler*) OR TITLE-ABS-KEY (preschooler*) OR TITLE-ABS-KEY (pre-schooler*) OR TITLE-ABS-KEY (adolescen*) OR TITLE-ABS-KEY (teenager*) OR TITLE-ABS-KEY (youth*) OR TITLE-ABS-KEY (youngster*)
#4	TITLE-ABS-KEY (overweight) OR TITLE-ABS-KEY (obese) OR TITLE-ABS-KEY (obes*) OR TITLE-ABS-KEY ("weight manag*") OR TITLE-ABS-KEY ("weight loss") OR TITLE-ABS-KEY ("weight control*") OR TITLE-ABS-KEY (overweight* W/5 intervention*) OR

	TITLE-ABS-KEY (overweight* W/5 treatment*) OR TITLE-ABS-KEY (overweight* W/5 program*) OR TITLE-ABS-KEY (weight* W/5 intervention*) OR TITLE-ABS-KEY (weight* W/5 treatment*) OR TITLE-ABS-KEY (weight* W/5 program*) OR TITLE-ABS-KEY (obes* W/5 intervention*) OR TITLE-ABS-KEY (obes* W/5 treatment*) OR TITLE-ABS-KEY (obes* W/5 program*)
#5	#1 AND #2 AND #3 AND #4 AND PUBYEAR > 1989
#6	#5 AND (LIMIT-TO (EXACTKEYWORD , "Child"))

Appendix 6: List of relevant primary studies included in systematic reviews

Primary studies included in systematic reviews (n=47)	Included systematic reviews (n=14)													
	Barr-Anderson (2013)	Berge (2011)	Berry (2004)	Ewald (2014)	Jang (2015)	Jull (2013)	Kelishadi (2014)	Kitzman-Ulrich (2010)	Knowlden (2012)	Kothandan (2014)	Lovemann (2015)	Sung Chan (2013)	Upton (2014)	Young (2007)
Aragona 1975											v	v		
Bean 2012							v							
Beech 2003		v												v
Boutelle 2001				v		v					v			
Coates 1982			v					v						
Collins 2011				v							v			
Coppins 2011													v	
Danielsen 2013							v							
Epstein 2000		v					v							
Epstein 2001		v												
Esfarjani 2013											v			
Estabrooks 2009					v						v			
Golan 1998		v		v					v					
Golan 2004		v							v					
Golan 2006		v		v		v		v	v	v	v			
Golley 2007		v									v			
Gunnarsdottir 2012							v							
Hughes 2008							v							
Janicke 2008		v		v		v		v		v	v	v		
Janicke 2011	v													
Jansen 2011					v						v			
Jiang 2005		v					v			v		v		
Kalarchian 2009										v				

Primary studies included in systematic reviews (n=47)	Included systematic reviews (n=14)													
	Barr-Anderson (2013)	Berge (2011)	Berry (2004)	Ewald (2014)	Jang (2015)	Jull (2013)	Kelishadi (2014)	Kitzman-Ulrich (2010)	Knowlden (2012)	Kothandan (2014)	Lovemann (2015)	Sung Chan (2013)	Upton (2014)	Young (2007)
Kalavainen 2007		v					v							
Kalavainen 2012							v							
MacDonell 2011	v													
Mazzeo 2012					v									
Mazzeo 2014					v						v			
Munsch 2008				v				v			v			
Nowicka 2008								v						
Okely 2010				v										
Raman 2010	v													
Resnick 2009											v			
Resnicow 2015	v										v			
Rodearmel 2006												v		
Sacher 2010							v						v	
Savoye 2011							v							
Shelton 2007					v			v	v			v		
Small 2013											v			
Stark 2011							v		v					
van Grieken 2013											v			
Vos 2012							v							
Wadden 1990	v													
West 2010					v		v		v		v	v		
Wheeler 1976												v		
White 2004												v		
Williamson 2006	v													

Note: ‘v’ indicates a primary study was included in a systematic review.

Appendix 7: List of excluded studies

Studies excluded	†
Acosta MC, Manubay J, Levin FR. Pediatric obesity: parallels with addiction and treatment recommendations. Harvard Review of Psychiatry. 2008;16(2):80-96.	B
Agras WS, Mascola AJ. Risk factors for childhood overweight. Current Opinion in Pediatrics. 2005;17(5):648-52.	B
Aguilar Cordero MJ, Ortegón Piñero A, Mur Vilar N, Sánchez García JC, García Verazaluce JJ, García García I, et al. Physical activity programmes to reduce overweight and obesity in children and adolescents; a systematic review]. Nutricion Hospitalaria. 2014;30:727-40 14p.	A
Aikenhead A, Knai C. Child obesity: Is surgery effective and cost-effective? A literature review. Obesity Reviews. 2010;11:253-4.	B
Ajie WN, Chapman-Novakofski KM. Impact of computer-mediated, obesity-related nutrition education interventions for adolescents: a systematic review. Journal of Adolescent Health. 2014;54(6):631-45.	E
Al Marzooqi MA, Christine Nagy M. Childhood obesity intervention programs: A systematic review. Life Science Journal. 2011;8(4):45-60.	D
Allender S, Cowburn G, Foster C. Understanding participation in sport and physical activity among children and adults: a review of qualitative studies. Health Education Research. 2006;21(6):826-35.	B
Allison DB, Faith MS, Gorman BS. Publication bias in obesity treatment trials? International Journal of Obesity. 1996;20(10):931-7.	B
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Al-Shawwa BA, Al-Huniti NH, DeMattia L, Gershan W. Asthma and insulin resistance in morbidly obese children and adolescents. Journal of Asthma. 2007;44(6):469-73.	B
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[†]Reasons for exclusion - A: Not in English (68); B: Not a systematic review (440); C: Irrelevant population (12); D: Not behavioural obesity treatment intervention (48); E: Not targeting family involvement in interventions (112); F: Not reporting child's weight or BMI outcome (3).

Appendix 8: Table of included study characteristics (systematic reviews)

Author (Year)	Search strategy for identifying relevant studies	Inclusion criteria for study selection	Characteristics of included primary trials
Barr-Anderson (2013)	• 26 databases: including PubMed, Medline, PsycINFO, Embase, Cochrane Library, CINAHL • Searched in March 2012 • Retrieved publications from 1887 to Mar 2012	*Population:* African–American girls aged 5–18 years. *Interventions*: Some degree of family involvement at home or community setting (i.e. school, local theatre, clinic, park or recreational centre, etc.) with intervention strategies targeting physical activity, eating/nutrition or weight.	*Included trials and year range:* 6 of 27 included trials were relevant (1990-2011) *Study designs and countries of interventions:* RCT (n=5) and NRCT (n=1), conducted in USA only as per inclusion criteria. *Participants:* Children aged 6-17 years (sample size ranged from n=36-165; overall total n=465). 3 trials included male and female children, while 3 trials included female children only.
Berge (2011) Meta-analysis	• 6 databases: PubMed, Medline, PsycINFO, Cochrane Library, CINAHL, Social Science Abstracts • Searched between Dec 2009 and Apr 2010 • Retrieved publications from 2000 to 2009	*Population:* Children aged 5-18 years. *Interventions:* Include parent/family member in intervention (direct engage or support child behaviour change).	*Included trials and year range:* 11 of 20 included trials were relevant (2011-2008) *Study designs and countries of interventions:* RCT (n=10) and NRCT (n=1). Countries not reported. *Participants:* Children aged 6-15 years.
Berry (2004)	• 3 databases: Medline, CINAHL, and PSYCLIT • Searched date not provided, • Retrieved publications from Jan 1980 to Jan 2004	*Population:* Children (age not specified). *Interventions:* Include child and at least one parent for nutrition, exercise, or behavioural changes with duration follow up at least 6 months.	*Included trials and year range:* 13 included trials (1981-2000) *Study designs and countries of interventions:* RCT with at least 6-month follow-up as per inclusion criteria. Countries not reported. *Participants:* Children aged 5-17 years.
Ewald (2014)	• 6 databases: Medline, PsycINFO, Embase, Cochrane Library, CINAHL, ASSIA	*Population:* Overweight/obese children aged 5-12 years. *Interventions:*	*Included trials and year range:* 6 of 8 included trials were relevant (1998-2011) *Study designs and countries of interventions:*

Author (Year)	Search strategy for identifying relevant studies	Inclusion criteria for study selection	Characteristics of included primary trials
	• Searched in July 2012 and updated in March 2013 • Retrieved publications up to Jun 2013	Targeting parents only compared with interventions including the child for the treatment of child overweight/obesity	RCT (n=6) with at least 6-month follow-up as per inclusion criteria, conducted in USA (n=2), Australia (n=1), Israel (n=2), Switzerland (n=1). *Participants:* Children aged 8-11 years (overall sample n=466). All trials included male and female children and both parents, apart from one trial, which was restricted to only mothers due to recruitment issues.
Jang (2015)	• 4 databases: PubMed, PsycINFO, CINAHL, SCOPUS • Searched date not provided • Retrieved publications from Jan 1990 to Apr 2015	*Population:* Not specified. *Interventions:* Treatment of childhood overweight or obesity that targeted only parent(s)/guardian(s).	*Included trials and year range:* 7 included trials (2007-2014) *Study designs and countries of interventions:* RCT only as per inclusion criteria, conducted in USA (n=3), Australian (n=2), Netherlands (n=1), Belgium (n=1). *Participants:* Children aged 3-13 years (sample size ranged from n=43-220). Limited information was provided about which parent participated or whether both parents participated in the trial.
Jull (2013) Meta-analysis	• 5 databases: Medline, PsycINFO, Embase, Cochrane Controlled Trials Register, CINAHL • Searched in Dec 2011 • Date range included in searches not reported	*Population:* Children up to age 14 years with overweight or obesity. *Interventions:* Weight loss interventions that compared a parent-only condition to a parent[s] and child condition.	*Included trials and year range:* 4 included trials (2006-2011) *Study designs and countries of interventions:* RCT only as per inclusion criteria, conducted in USA (n=2), Israel (n=1), Switzerland (n=1). *Participants:* Children aged 6-14 years (overall sample n=266; 56% female).
Kelishadi (2014)	• 4 databases: PubMed, Medline, ISI Web of Science, and Scopus scientific databases • Searched date not provided	*Population:* Children aged 2-18 years with overweight or obesity. *Interventions:*	*Included trials and year range:* 26 of 104 included trials were relevant* (2005-2013) *Study designs and countries of interventions:* RCT (n=26), conducted in USA (n=9), UK (n=3), Sweden (n=3), Australia (n=2), Finland (n=2), Turkey (n=1),

Author (Year)	Search strategy for identifying relevant studies	Inclusion criteria for study selection	Characteristics of included primary trials
	• Retrieved publications from 2000 to 2002	Family-based interventions within community, family, school, and clinic settings or a combination of them conducted among obese/overweight children	Scotland (n=1), China (n=1), Norway (n=1), Holland (n=1), Iceland (n=1), and one study involved European countries of interventions (authors from Netherlands, Denmark, UK, Greece, Germany, Spain, Bulgaria, and Crezch Republic). *Participants:* Children aged 2-18 years.
Kitzman-Ulrich (2010)	• 2 databases: PubMed, PsycINFO, and Google Academic Search • Searched date not provided • Date range included in searches not reported	*Population:* Youth from elementary school through adolescence. *Interventions:* Targeted parent behaviours; inclusion of the family in innovative formats (e.g., incorporating the family in school-based programs); inclusion of family functioning or family therapy components (e.g., promoting cohesion, family warmth, healthy communication styles, and reductions in family conflict); inclusion of parent training, parenting styles, or child-management principles (e.g., encouraging authoritative parenting, setting appropriate boundaries, providing reinforcement of positive behaviours).	*Included trials and year range:* 21 included trials (1981-2008) *Study designs and countries of interventions:* RCT (n=20) and NRCT (n=1). Countries not reported. *Participants:* Children aged 5-19 years.
Knowlden (2012)	• 5 databases: Medline, CINAHL, Education Resources Info Center (ERIC), Psychology and Behavioural Sciences Collection and CENTRAL databases • Searched date not provided • Retrieved publications from 2001 to 2011.	*Population:* Children 2-7 years old in any weight category. *Interventions:* Tertiary prevention studies that included home-based component (home visit, home-based activities) and at least one parent/caregiver.	*Included trials and year range:* 9 included trials (2003-2011) *Study designs and countries of interventions:* RCT only as per inclusion criteria, conducted in USA (n=2), Australian (n=5), Israel (n=2). *Participants:* Children aged 2-16 years with overweight or obesity. One study evaluated outcomes at 7-year follow up and children had mean age of 16 years.

Author (Year)	Search strategy for identifying relevant studies	Inclusion criteria for study selection	Characteristics of included primary trials
Kothandan (2014)	• 5 databases: PubMed, Medline, CINAHL, Science Direct, DARE. • Searched date not provided • Retrieved publications from Jan 2000 to Aug 2010.	*Population:* Children aged less than 18 years with obesity. *Interventions:* School- and family-based interventions for treatment of childhood obesity through two comparing strategies. Results for school-based and family-based were separable.	*Included trials and year range:* 8 of 13 included trials were relevant (2001-2010) *Study designs and countries of interventions:* RCT only as per inclusion criteria. Countries not reported. *Participants:* Children aged 6-14 years (overall sample n=721; males and females)
Loveman (2015) Meta-analysis	• 9 databases: Medline, PsycINFO, Embase, Cochrane Library (CDSR, CENTRAL, DARE, HTA), and LILACS as well trial registers. • Searched date not provided • Retrieved publications up to Feb/March 2015.	*Population:* Children aged 5-11 years with overweight or obesity. *Interventions:* Directed at parents as the agents of change; lifestyle intervention to treat overweight/obesity in children, intervention involved parents only (without children), duration of intervention/follow up at least 6 months, parents as agent of change	*Included trials and year range:* 20 included trials (1975-2015) *Study designs and countries of interventions:* RCT only as per inclusion criteria, conducted in USA (n=10), Australia (n=4), Israel (n=1), Switzerland (n=1), Iran (n=1), Belgium (n=1), Netherlands (n=2). *Participants:* Children aged 4-13 years. The proportion of girls in the trials ranged from 40% to 70% where reported (except 4 trials did not report this), and 1 study included girls only.
Sung Chan (2013)	• 6 databases: PubMed, PsycINFO, CINAHL, Cumulative Index to Nursing and Allied Health Literature, Family & Society Studies Worldwide, Social Work Abstracts, and SocINDEX. • Searched date not provided • Retrieved publications from 1975 to Jun 2012.	*Population:* Children aged 2-19 years with overweight or obesity. *Interventions:* At least one family member in addition to the overweight child in a weight loss or weight control intervention	*Included trials and year range:* 15 included trials (1975-2010) *Study designs and countries of interventions:* RCT only as per inclusion criteria. Countries not reported. *Participants:* Children aged 5-15 years.
Upton (2014)	• 4 databases: PubMed, Medline, Academic search, and PsycARTICLES. • Searched date not provided	*Population:* Children aged 2-19 years with overweight or obesity.	*Included trials and year range:* 5 of 10 included trials were relevant* (2008-2012) *Study designs and countries of interventions:*

Author (Year)	Search strategy for identifying relevant studies	Inclusion criteria for study selection	Characteristics of included primary trials
	• Retrieved publications from Jan 1990 to Jun 2013.	*Interventions:* Family-based, include at least one family member in addition to the overweight child for weight management intervention	RCT (n=4) and NRCT (n=1), conducted in UK only as per inclusion criteria. *Participants:* Children aged 4-16 years.
Young (2007) Meta-analysis	• 3 databases: Medline, PsycINFO, CINAHL. • Searched date not provided • Retrieved publications from 1967 to present (no further details reported).	*Population:* Children aged 5-12 years. *Interventions:* Family involvement was defined as having a minimum of one parent or guardian involved in at least one aspect of treatment. Behavioural treatment was determined by a study's use of behavioural or cognitive–behavioural techniques, defined as the authors' inclusion of any combination of the following methods: psychoeducation, stimulus control, developing behavioural awareness, identifying problematic behaviour, modifying current behaviour, and maintaining behaviour change. Weight loss treatment was defined as a program conducted with the primary goal of child weight-loss.	*Included trials and year range:* 16 included trials (1982-2004) *Study designs and countries of interventions:* All trials had at least 2 groups (intervention, control, and alternate condition) except for 1 trial (which was a single-group trial). No further details provided for study designs and countries. *Participants:* Children aged 5-13 years.

RCT: randomized controlled trial; NRCT: non-randomized controlled trial.

Appendix 9: Statement of contribution and collaboration for text messages development study

By signing below I confirm that Li Kheng Chai contributed to the following paper entitled:

Chai LK, May C, Collins CE, Burrows TL. Development of text messages targeting healthy eating for children in the context of parenting partnerships. *Nutr Diet*. 2019 Nov;**76**(5):515-520. doi: 10.1111/1747-0080.12498

LKC contributed to acquiring ethics approval, data collection, data analysis and writing of the initial manuscript. LKC, CM, CEC and TLB contributed to the methodological design of the study. LKC and CM developed the text messages which were reviewed and revised by CEC and TLB. All authors contributed to the revision of the manuscript and tables, and approved the final manuscript.

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Appendix 10: Final set of 48 text messages by Theoretical Domains Framework (TDF) domains and intervention functions

TDF Domains	INT Functions	Parent recipients	Final set of 48 text messages	Revised*
Social influence	Reflection	Dad	I look up to you dad. Show me that you can make healthy choices too. This will encourage everyone in the family to make healthy choices.	N
Goals	Action	Mum	Men and kids have many things in common - they will eat more fruit when it's cut up for them. Try offering cut up fruit platter today and see what happens?	N
Social influence	Reflection	Dad	Fathers food & health choices have a big influence on the family. If you want your family to be healthy take the lead in choosing healthy meals and snacks.	N
Social influence	Reflection	Mum	Hey Mum, fathers' food & health choices have a big influence on the family. *Encourage dad and support him* in choosing healthy meals and snacks.	Y
Social influence	Discussion	Dad	When you see mum making a healthy change remember to tell her she is doing a great job. This is really important for her now.	N
Social influence	Discussion	Mum	Praising dad for healthy food choices could be more powerful than praising your child. If he is giving it a go then give him all the encouragement you can.	N
Knowledge	Reflection	Dad	Hey Dad, when families use a shopping list they buy less junk food and save money. How can you help your family to make this happen? [*Static Link*]	N
Social influence	Reflection	Mum	Your child looks up to you and your choices. Continue to help your child by setting a good example *by* choosing healthy food and beverages! [*Static Link*]	Y
Social influence	Discussion	Dad	Praising mum for healthy food choices could be more powerful than praising your child. If she's giving it a go then give her all the encouragement you can.	N
Social influence	Discussion	Mum	When you see dad making a healthy change remember to tell him he is setting a good example. Your encouragement is really important for him now.	N
Social influence	Action	Dad	Hey dad. Try setting up a 'family production line' to make homemade pizzas. Everyone can add favourite ingredients and create their own Signature pizza.	N
Social influence	Discussion	Mum	Helping your children to change will be easier when you work well together at this with your partner. Encourage dad to be *involved* every chance you get.	Y
Knowledge	Information	Both	Fry-day does not have to be *full of* fat! Quick healthy stir-fry or homemade pizza would be a great dinner. For recipes go to [*Static Link*]	Y
Knowledge	Information	Both	Kids learn through hands on activities. Cooking helps them to be more comfortable with new foods. See [*Static Link*] for great tips!	N
Knowledge	Information	Both	"Yucky" is often a young child's reaction to new foods that they later learn to like. They learn about new foods through touch and play. Enjoy the fun.	N

Knowledge	Information	Both	*It's not a good idea* to go shopping when you're hungry or don't have a list. *You're likely* to buy all junk foods and other stuffs you don't need.	Y
Knowledge	Information	Both	Kids often *mixed up* hunger and thirst, so try a drink of water first before something to eat. *Spice up* sparkling water with lemon slices for more fun!	Y
Knowledge	Information	Both	Don't worry when kids don't eat new or different foods. Offer it again in a day or two. It can take several offers before many kids will try new foods.	N
Knowledge	Reflection	Both	We can change the kind of food we keep at home and where we keep it. What is the first thing your child sees when going to the cupboard, pantry or fridge?	N
Knowledge	Discussion	Both	We can encourage behaviours we want in our children by looking for them and praising them when they happen. Try saying "I saw that you……*well done*!"	Y
Knowledge	Discussion	Both	Young children will often find it easier to make a healthy choice when offered the option to choose between 2 *healthy* food. Do you want broccolli or beans?	Y
Knowledge	Action	Both	Out of sight, out of mind. Keeping healthy food where we can see it & junk food where we can't we usually eat better. What's *at the front of* your pantry?	Y
Knowledge	Action	Both	Children will often reject new foods at first. When offered a new food many times and in different ways (soup, stirfry, lasagne) they are *likely to try it*.	Y
Knowledge	Action	Both	Healthy eating can be cheap and affordable. A packet of chips would cost $3. For the same price you could get a kilo of bananas! Shop healthy, shop smart!	N
Knowledge	Action	Both	When we have smaller meals and eat slowly we get satisfied with less food. Put less on your plate and take your time. These simple things really help.	N
Goals	Information	Both	Set family goals. It's easier to take small steps and repeat them over long periods of time. This creates health habits.	N
Goals	Information	Both	If you want your family to try new foods you need to plan ahead. Try offering something they normally eat and adding something that is new.	N
Goals	Information	Both	When healthy behaviours become healthy habits, *you're* making a difference. Keep healthy foods available and keep up the praises.[*Static Link*]	Y
Goals	Reflection	Both	*Healthy* choices such as decreasing soft drinks and having more fruits and vegetables can make healthier minds and bodies! Your choices matter.	Y
Goals	Reflection	Both	People *often* want a snack when they first come home. This is a great time to dig into cut up fruit or veggie sticks. If it's there they will eat it.	Y
Goals	Reflection	Both	Healthy lifestyle changes are a lifetime goal. Start with small steps and value the effort your child and family has made to reach this point!	N
Goals	Discussion	Both	Find ways to praise your child for making healthy changes. Starting with "I like the way you…" You will see these new changes becoming habits in no time!	N

Goals	Discussion	Both	Be generous when praising your child's healthy choices and try to do this often. You could start these conversations with words like "I like the way you…"	N
Goals	Action	Both	Busy day? No time to prepare a healthy meal? Try one of these 20 minute recipes tonight! [*Static Link*]	N
Goals	Action	Both	Keep offering healthy snacks in different ways. Children get comfortable with foods they see often. Have fruit and veggies available at all times.	N
Goals	Action	Both	Weekend? Eating out? Choose grilled or baked, *trim the fat*, and *try* salad or vegetables on the side. More tips at [*Static Link*]	Y
Goals	Action	Both	Can the whole family include vegetable sticks and fruit wedges in tomorrow's lunch? For more snack ideas go to... [*Static Link*]	N
Goals	Action	Both	*Did your child try* a new food today? Praise your child for *every* mouthful they try. That's one step forward!	Y
Goals	Action	Both	Try a new food with food your child already likes. How about macaroni cheese and *mushrooms*? Add little bits at a time to make these meals more interesting.	Y
Social influence	Information	Both	The way we talk about our food can change the way our family thinks about it.	N
Social influence	Information	Both	The way that you support and encourage your family will have a big influence on everyone's belief in their ability to make healthy lifestyle changes.	N
Social influence	Reflection	Both	Healthy changes aren't always easy to make. Try to set a good example with your own lunch Dad.	N
Social influence	Reflection	Both	Children worry about their parents' health. Look after yourself so you can *be there for them rain and shine*.	Y
Social influence	Reflection	Both	You are the best person to provide your child with the love, comfort, and confidence they need to support healthy choices. Keep up the encouragement Dad.	N
Social influence	Discussion	Both	When you praise your child's efforts to help in the kitchen it makes them feel *valued* and their confidence grows. Focus on their effort & enjoyment.	Y
Social influence	Discussion	Both	Kids thrive on positive attention and encouragement. When you see them make good choices *praise* them and tell them that they are doing great!	Y
Social influence	Action	Both	When you speak positively about fruit, vegetables and trying new foods your children will listen. When you eat fruit and vegetables they will too.	N
Social influence	Action	Both	Your children are more likely to make healthy food choices and be active when they see you eating well and being active. Children do as you do, Dad!	N

TDF: Theoretical Domains Framework; INT: intervention; N: No, message was not revised; Y: Yes, message was revised. *Note: *Italicised* words indicate a change that was made based on panel reviewers' feedback.

Appendix 11: Statement of contribution and collaboration for pilot study

By signing below I confirm that Li Kheng Chai contributed to the following paper entitled:

> **Chai LK**, Collins CE, May C, Ashman A, Holder C, Brown LJ, Burrows TL. Feasibility and efficacy of a web-based family telehealth nutrition intervention to improve child weight status and dietary intake: a pilot randomised controlled trial. J Telemed Telecare. 2019 Jul 31:1357633X19865855.

LKC contributed to acquiring ethics approval, designing intervention materials, data collection, program implementation and writing of the initial manuscript. LKC, CEC, CM and TLB contributed to the methodological design of the study. AA and LJB contributed to data collection and program implementation. LKC performed data analysis with assistance from CH. All authors contributed to the revision of the manuscript and tables and approved the final manuscript.

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Appendix 12: Statement of contribution and collaboration for process evaluation of pilot study

By signing below I confirm that Li Kheng Chai contributed to the following paper entitled:

> **Chai LK**, Collins CE, May C, Brown LJ, Ashman A, Burrows TL. Fidelity and acceptability of a family-focused technology-based telehealth intervention for child weight management. J Telemed Telecare. 2019 Aug 7:1357633X19864819.

LKC contributed to acquiring ethics approval, designing intervention materials, data collection, program implementation, data analysis and writing of the initial manuscript. LKC, CEC, CM and TLB contributed to the methodological design of the study. AA and LJB contributed to data collection and program implementation. All authors contributed to the revision of the manuscript and tables and approved the final manuscript.

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Prof Clare Collins		25/04/2019
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Dr Chris May		25/04/2019
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Prof Liz Sullivan		29/04/2019
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Appendix 13: Statement of contribution and collaboration for study of parent-reported child anthropometrics

By signing below I confirm that Li Kheng Chai contributed to the following paper entitled:

> **Chai LK**, Collins CE, May C, Holder C, Burrows TL. Accuracy of parent-reported child height and weight and calculated body mass index compared to objectively measured anthropometrics. J Med Internet Res. 2019 Sep 16;21(9):e12532. doi: 10.2196/12532.

LKC contributed to acquiring ethics approval, data collection, and writing of the initial manuscript. LKC, CEC, CM and TLB contributed to the methodological design of the study. LKC performed data analysis with assistance from CH. All authors contributed to the revision of the manuscript and tables and approved the final manuscript.

Ms Li Kheng Chai		25/04/2019
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Dr Chris May		25/04/2019
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Mr Carl Holder		25/04/2019
Co-author, Statistician	Signature	Date
A/Prof Tracy Burrows		25/04/2019
PhD supervisor	Signature	Date
Prof Liz Sullivan		29/04/2019
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Appendix 14: Statement of contribution and collaboration for policy brief

By signing below I confirm that Li Kheng Chai contributed to the following policy brief entitled:

> **Chai LK**, Collins C, May C, Littlewood R, Burrows T. The right care, in the right place, at the right time – A Policy Brief. Callaghan, NSW: The University of Newcastle, 2019. Print. ISBN: 978-0-7259-0106-6.

LKC contributed to program implementation, data collection and analysis and writing of the initial policy brief. LKC, CEC, CM and TLB contributed to the conceptualisation of the policy brief. All authors contributed to the revision of the policy brief and approved the final policy brief.

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Co-author, Children's Health Queensland Hospital and Health Service	Signature	Date
A/Prof Tracy Burrows		26/06/2019
PhD supervisor	Signature	Date
Prof Liz Sullivan		02/07/2019
Deputy Head of Faculty of Health and Medicine	Signature	Date

Appendix 15: Recruitment flyer for Back2basics Family pilot study

Would You and Your Family Like To Get Healthier?

Back2basics Family is an online program aimed at getting children and their families healthier! Participating in the program is **free** and your family may receive 2 online face-to-face consultations with an Accredited Practising Dietitian, plus 3 months online resources including free subscriptions to our Nutrition website custom-design for families and a Facebook support group exclusively for program participants only.

Your family can participate in the program, if:

- ✓ You have access to the internet via a smartphone, tablet, laptop, or computer
- ✓ You have a child aged 4–11 years (before 12th birthday)
- ✓ At least one parent or carer is willing to participate in the program
- ✓ You are able to attend appointments in either Tamworth or Newcastle

Register your interest at www.bit.ly/c0nnecT

Wondering if your family can participate? See next page or visit online form at above link!
For more information contact b2bfamily@newcastle.edu.au or 02 4921 5355

This project has been approved by the Hunter New England Human Research Ethics Committee, Approval No. 16/07/20/4.04 and the University of Newcastle Human Research Ethics Committee, Approval No. H-2016-0329.