INTEGRATIVE CONTEXT-PROCESS-OUTCOME EVALUATION OF SOUTH AUSTRALIA'S OBESITY PREVENTION AND LIFESTYLE (OPAL) PROGRAM

FINAL REPORT

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Overview

This Report summarises the findings of the integrative context-process-outcome evaluation of South Australia's Obesity Prevention and Lifestyle (OPAL) program. Findings are presented for all intervention and matched comparison communities across all five intervention years and for all OPAL Phases.

Introduction

Childhood overweight and obesity is a major public health issue in Australia with 25.8% of children aged 2 to 17 classified as overweight or obese. As a response to the high prevalence of overweight and obesity, the South Australian government launched the OPAL intervention program – a multi-site, multi-setting, multi-strategy community-based childhood obesity prevention initiative – in 20 metropolitan and regional communities. The aim of the OPAL program was "To improve eating and activity patterns of South Australian children, through families and communities in OPAL regions and thereby increase the proportion of 0 to18 year-olds in the healthy weight range." The State-Wide Evaluation Co-ordination Unit developed a comprehensive program logic model, incorporating quantitative and qualitative methods, to guide evaluation. This Report deals only with quantitative exposure and outcome data to evaluate the effectiveness of OPAL.

Methods

The OPAL program was implemented for approximately 5 years in 20 metropolitan and regional intervention communities as a state-wide initiative across South Australia. Its effectiveness was evaluated using a variation of the non-equivalent control (comparison) group, quasi-experimental evaluation research design with time series extension for 5 years pre-intervention and up to 2 years post-intervention. The evaluation frame thus covered 10-12 years. Intervention communities were matched on standard socio-demographic characteristics against 20 comparison communities. The primary outcome was the prevalence of overweight and obesity as a single category for 4 to 5 year-old pre-school children, using body mass index (BMI) calculated from objectively-measured height and weight drawn from the Women's and Children's Health Network (WCHN) of South Australia. Implementation across successive numbers of communities was staged over time in four phases all applying the same implementation principles but with minor differences in duration of intervention which in the later phases was shorter due to funding cutbacks. Pre-school children's addresses were geocoded using X, Y co-ordinates and assigned to state suburbs nested within communities assigned to intervention and comparison conditions. The community was the unit of exposure. Annual measures of weight and height from which BMI was calculated were analysed for suburbs nested in communities nested in intervention or comparison conditions. The independent variable was the presence or absence of conditions to enable and facilitate a community-based intervention program (i.e., the OPAL intervention). The null model was no difference in change over time across the evaluation periods for communities in the intervention relative to comparison condition. The outcomes analyses accounted for aspects of the social environment (i.e., income and education), built environment (i.e., fast-food outlet density, walkability, dwelling density) and program context and implementation (i.e., community leadership readiness and strength of weak partnership ties).

Key Outcomes

All results for the main effects analysis, social environment, and built environment, were statistically adjusted for median suburb income and median suburb education. The results are independent of, and not confounded by, suburb-level variations in socio-economic status (SES). Results reported here, further, are adjusted for multiple comparisons which has the effect of increasing *p*-values, making it more difficult to achieve statistical significance. These conservative procedures were applied to ensure the rigour of the evaluation and to safeguard the conclusions reached.

Overall Intervention Effect

Exposure to OPAL was associated overall with reductions in the prevalence of overweight and obesity for 4 to 5 year-old pre-school children in the intervention condition relative to the comparison condition. The impact of OPAL was modelled as a linear trend and statistically adjusted for any existing baseline differences in prevalence of overweight and obesity for suburbs within communities in the intervention and comparison conditions. The positive decline in overweight and obesity prevalence continued in the two years following cessation of funding, indicating that OPAL sustained its effect over time. The preventive fraction across the 5-year intervention and 2-year post-intervention periods combined was 12.2%, this figure representing the extent of overweight and obesity that would otherwise have arisen.

Context by Intervention Interaction

Social Environment

The prevalence of overweight and obesity decreased over time for suburbs within the highest education tertile in the intervention condition, but not the comparison condition. The OPAL intervention advantaged higher SES areas and suggests that these areas were best able to take up and respond to prevention messages.

The prevalence of overweight and obesity decreased over time for suburbs within the highest income tertile in the intervention condition, but not the comparison condition. Again, the OPAL intervention advantaged higher SES areas and suggests that these areas were best able to take up and respond to prevention messages.

Built Environment

Walk score was used as a measure of the built environment. A higher score indicates a more walkable suburb (e.g., daily errands are less reliant on a car). The prevalence of overweight and obesity decreased over time for suburbs with the highest walk scores category in the intervention condition, but not the comparison condition. This result indicates that high walk scores amplified the impact of the intervention; more specifically, it shows that the impact of OPAL varied according to walk score, that the built environment modified the impact of OPAL.

Density of fast-food outlets was used as a measure of the built environment. Greater density indicates a higher concentration of fast food. The prevalence of overweight and obesity slightly increased over time for suburbs within the highest fast-food tertile in the intervention condition, but there was no change in the comparison condition. A high concentration of fast-food outlets thus attenuated and reversed the otherwise positive effect of the OPAL intervention, being associated with a slight rise in overweight and obesity for areas in this category. This finding also shows that the impact of OPAL varied according to a given characteristic of the built environment. It highlights the need to account in the delivery of future interventions for key factors that can block the success of an otherwise positive program.

Dwelling density is a common measure of the built environment much used in urban planning. High dwelling density (relative to low) was associated with reduced overweight and obesity prevalence. The prevalence of overweight and obesity did not change over time for suburbs within the highest dwelling density tertile in the intervention condition; unexpectedly, it decreased, rather, for suburbs within the highest dwelling density tertile in the comparison condition.

Within the Intervention Condition

Partnership Strength

Within the intervention communities a greater proportion of weak ties in Year 1 of OPAL and ties averaged across all years was associated with a reduction in childhood overweight and obesity. These effects were apparent for both metropolitan and regional areas. These effects, however, varied by SES. For Year 1, the effect was observed only in the lower SES areas but persisted across SES when the proportion of weak ties was considered across all years. Across all years, 62 percent of OPAL's ties with community organisations were weak and the rest were strong. On the balance, OPAL maintained a network of weak ties with communities while fostering strong partnerships, possibly with organisations that were working with children.

Community Leadership

Within the intervention communities greater scores on baseline community leadership readiness were associated with a reduction in the prevalence of overweight and obesity. This effect was moderated by area SES and observed only in the lower SES condition. Similarly, a greater positive change in community leadership was associated with a reduction in the prevalence of overweight and obesity. This effect was observed only in the lower SES condition. These findings suggest that a reduction in overweight and obesity over the course of the OPAL program was associated with community leaders who, at baseline, were 'ready' to do something about the issue in their community and who demonstrated a commitment to supporting OPAL.

Conclusion

It was recently reported that in Australia, nationally, from 2007/8 to 2014/15 the prevalence of overweight and obesity in 5 to 12-year old children rose from 21.8 percent to 26.3 percent. This evaluation shows that for the same time frame, in South Australia, OPAL was associated with an overall reduction in the prevalence of overweight and obesity for 4-5-year-old pre-school children relative to the comparison condition. In absolute terms, the OPAL program achieved a reduction of 12.2% in the extent of overweight and obesity that would have otherwise arisen, a substantial effect of compelling public health significance given that most such behavioural population interventions with positive effects yield improvements of 5% on average. This evaluation of the OPAL initiative lends support to the continued use and potential scale-up of process-oriented and theory informed whole-of-community approaches to childhood obesity prevention.

1 INTRODUCTION

Childhood overweight and obesity is a major public health issue in Australia with one in four children classified as overweight or obese (Australian Institute of Health and Welfare 2017). From 2007/8 to 2014/15 the prevalence of overweight and obesity in 5 to 12-year old Australian children increased from 21.8 percent to 26.3 percent (Cancer Australia 2018). The development of childhood obesity is complex and reflects the exchange and interaction between multiple environments, individual beliefs and behaviours (Roberto, Swinburn et al. 2015). Limited physical activity, greater sedentariness and unhealthful eating habits are the primary drivers of weight gain in children (Gortmaker, Swinburn et al. 2011). Behavioural and lifestyle-related risk factors are shaped by the social and built environmental contexts in which children grow and mature (e.g., home, school and community). High-risk built environments that predispose children to gain excessive weight include residential areas with high densities of fast-food restaurants (Leonard, McKillop et al. 2014), poor quality parks (Singh, Siahpush et al. 2010, Elbel, Corcoran et al. 2016) unsafe walking corridors to school (Elbel, Corcoran et al. 2016), and unhealthful conditions within the home (Kalinowski, Krause et al. 2012, Borys, Richard et al. 2016). Poor quality built environments are strongly related to adverse socio-demographic and economic conditions (Daniel, Lekkas et al. 2011). Thus residing in a low socio-economic status (SES) area is a leading indicator of manifold social and built environmental influences conducive to childhood overweight and obesity (Kestens and Daniel 2010). Overweight is more pronounced in lower relative to higher SES environments, and the built environmental contexts of such areas are less supportive of healthful living (National Academies of Sciences 2018). Children attending schools in low-income neighbourhoods have more access to food outlets with ultra-processed foods than minimally processed foods (Leite, de Carvalho Cremm et al. 2018). Ongoing exposures to such 'obesogenic' influences across multiple settings (home, school and community) can make it difficult for children to engage in active travel and active leisure time activities, and to regularly consume healthful foods and beverages (Daniel, Kestens et al. 2009).

Studies on individual, school, home and community intervention approaches to obesity prevention have consistently demonstrated that individual-level programs, although showing improvements in anthropometric measures of adiposity, have effects that dissipate in the long term (Waters, de Silva-Sanigorski et al. 2011). Individual-level programs targeting changes in children's knowledge, attitudes and beliefs related to unhealthful lifestyles may be necessary, but alone are not sufficient to sustain short-term gains afforded by such programs. Children are largely dependent on their caregivers for such things as transportation, leisure time activities and food choices. A lack of sustainability in behavioural and health improvements is attributed to children's continued exposure to environmental risk conditions conducive to the development and maintenance of unhealthful lifestyles (Committee on Accelerating Progress in Obesity Prevention and Institute of Medicine 2012). So long as the social and built environments in which children grow and mature remain obesogenic, the effects of individual-level obesity prevention interventions will remain short-lived. Moreover, without an intentional focus on addressing the inequities in overweight and obesity in under-served or marginalised communities, programs aimed at improving health through changing the built environment may cause the disparity to widen (National Academies of Sciences 2018).

Many prevention programs follow a settings approach and are delivered in single settings, including schools, child care centres, or community centres (Poland, Krupa et al. 2009). Whilst such programs have shown effectiveness in improving children's behavioural and anthropometric outcomes, a combination of settings has been recommended as a best practice strategy for preventing or reducing weight gain in children, and for achieving longer-lasting individual and environmental benefits than any intervention implemented within a single setting (Bleich, Segal et al. 2013). Multilevel, multi-sector, and multi-setting community-based approaches are ideally suited to effecting positive improvements in actions on the individual and environmental determinants of childhood obesity (Green and Kreuter 2005). Underpinned by the principles of the Ottawa Charter for Health Promotion (World Health Organisation 1986) and social ecological systems theory, community-based approaches have been identified as holding the greatest promise for stemming the childhood obesity epidemic (Waters, de Silva-Sanigorski et al. 2011). A growing number of 'whole-of-community' childhood obesity prevention programs are generating evidence of effectiveness on children's measured body mass index. Some notable examples include *Shape-Up Sommerville* (USA), *APPLE* (New Zealand), and *Eat Well Be Active* and *Romp & Chomp* (Australia). Key to bringing about environmental and policy solutions to the structural inequities that shape childhood obesity is the mobilisation of communities to co-ordinate action across sectors and settings (Daniel and Green 1999). Whilst yielding smaller effects on average for any individual, the overall population impacts are sizeable and more sustainable (Rose 1985, Economos and Tovar 2012).

Community-based health promotion programs are complex, given their multifaceted interacting intervention components and implementation processes. A core consideration underpinning the capacity of community-based programs to impact childhood obesity is intervention context. Context pertains to aspects of children's social environments (e.g., area-level SES) and built environments (e.g., density of fast-food restaurants, or presence of walking paths), factors which influence the extent of uptake and/or exposure to intervention activities and messages. Context can be further distinguished by aspects of program context such as the *readiness* of communities to mobilise around childhood obesity, and the timing of program implementation in a community. Evaluating how context interacts with an intervention provides insight into differential levels of program effectiveness by specifying the environmental conditions under which programs are more, or less, likely to succeed (Hawe 2015). Whilst evidence exists that community-based childhood obesity prevention efforts successfully impact overweight and obesity, there is nevertheless limited evidence on the effects of intervention context on children's anthropometric outcomes. This is due to the absence of large-scale community-based intervention evaluations with sufficient units of analysis and statistical power to account for variations in context on children's overweight and obesity. The evaluation of context by intervention interactions has been identified as requiring urgent attention (Hawe 2015, Mayne, Auchincloss et al. 2015, National Academies of Sciences 2018). Formal examination of context-specific information on program effectiveness can inform public health policy and community planning for strategic investments in programs, allocating funding to environments where they are most likely to succeed, or needed.

As a response to the high prevalence of overweight and obesity, the South Australian government launched the OPAL intervention program - a multi-site, multi-setting, multi-strategy community-based childhood obesity prevention – in 20 metropolitan and regional communities. The aim of the OPAL program was "to improve eating and activity patterns of South Australian children, through families and communities in OPAL regions and thereby increase the proportion of 0 to 18 year-olds in the healthy weight range." The purpose of this project was to evaluate the effectiveness of the five-year OPAL program on pre-school children's Body Mass Index (BMI), and if successful, to identify the contextual circumstances by which OPAL was more, or less, successful.

1.1 THE OPAL PROGRAM

The Obesity Prevention and Lifestyle (OPAL) program was a multi-site, multi-setting and multi-sector community-based childhood obesity prevention program launched by the South Australian government in 2009. It was a state-wide initiative, implemented in four successive phases across 21 communities, 20 in South Australia and one in the Northern Territory. Initially, participating communities received five years of intervention funding from Commonwealth, State and Local governments. Phase 1 received the full five years of funding. Phases 2, 3 and 4, due to funding cutbacks, received less funding and for some communities within these phases the intervention period was reduced by two to three months.

The specific aim of the OPAL program was "to improve eating and activity patterns of South Australian children, through families and communities in OPAL regions and thereby increase the proportion of 0-18 year-olds in the healthy weight range." The following goals guided project implementation:

1. Increasing healthy eating (HE) through reducing energy dense nutrient poor food consumption and increasing nutritious food consumption through:
    a) Increasing healthy food available at outlets (e.g., schools, cafes, takeaways)
    b) Increasing healthy meals in and from homes (e.g., breakfast, lunchbox, breastfeeding)
    c) Improving local healthy food production, access and distribution (e.g., food gardens and co-operatives); and
2. Increasing physical activity (PA) and reducing sedentariness through:
    a) Increasing active travel (e.g., walking, riding, buses, trains)
    b) Increasing active leisure participation (e.g., play, limiting recreation screen time)
    c) Increasing the use of parks and placed (e.g., play spaces, trails)

and ensuring that OPAL activities conformed with state, national and international HE and PA principles, standards or guidelines.

OPAL was modelled on the successful French program 'Ensemble, prévenons l'obésité des enfants' (EPODE) (i.e. Together, let's prevent childhood obesity), which mobilised the community to plan, implement and evaluate obesity prevention interventions (Romon, Lommez et al. 2008). EPODE was based on the four pillars of: political commitment, social marketing, evidence-based action; and partnerships (Borys, Valdeyron et al. 2010, Borys, Le Bodo et al. 2011).

Over 500 communities around the world have adopted the EPODE approach (Van Koperen, Jebb et al. 2012). Australia became part of the EPODE International Network (EIN) with the launch of OPAL in South Australia in 2009. OPAL applied the four EPODE pillars and the following nine principles derived from the South Australia Department of Health's 'eat well be active Community Programs' (ewbaCP) stipulating that a program:

1. Is consistent with the EPODE methodology and State & National Healthy Eating and Physical Activity guidelines.

2. Is positive and non-stigmatising – OPAL is sensitive to body image concerns and does not demonise food, behaviours or factors connected with healthy weight.
3. Adopts a multi-strategy portfolio approach which is evidence-based with room for innovation.
4. Addresses community-development principles.
5. Is equity-focussed – OPAL reaches all parts of the community with a focus on the disadvantaged.
6. Is inclusive and respectful of diversity – working with Aboriginal and culturally and linguistically diverse communities.
7. Works in partnership with others across sectors, sites and settings.
8. Values the local community and responds to local needs and opportunities.
9. Uses sustainable processes and approaches.

The OPAL program was guided by three overarching theories. The social marketing theory of behaviour change applied traditional social marketing benchmark criteria to shift the social norms around physical activity and eating practices. These criteria range from customer orientation, behaviour change goals, segmentation, insight, exchange and competition, and each project implemented by OPAL was assessed against them. Through the community development theory of action and change, OPAL sought to engage stakeholders across all sectors within a community. Ecological systems theory relates to the various systems that comprise the social environment, from the individual-level environment (microsystem), the interaction of individuals in different settings (mesosystem), the social pillars that form structure within a society (e.g., neighbourhood or current political powers in place; exosystem), and last, the higher-level patterns that shape culture, personal beliefs, and values (macrosystem). Together, these theories outlined how OPAL aimed to achieve its outcomes (Jones, Verity et al. 2016).

OPAL had a comprehensive governance structure. It was supported by a Scientific Advisory Committee (SAC) comprised of a senior group of ministerially-appointed academic researchers. The committee's mandate was to provide scientific oversight to the evaluation and advice on the health messages for OPAL's annual themes. An OPAL Local Government Mayor's Club comprised of leaders from the 21 communities had a mandate to provide local political leaders with opportunities to share achievements. A Strategic Advisory Committee was the third committee to provide guidance to OPAL communities; it was formally dissolved as a committee in 2012. OPAL staff members were guided by the State-wide Co-ordination Unit, comprised of the Program Manager, the Evaluation Manager, Social marketing Manager, and administration staff. The State-wide Co-ordination Unit provided strategic direction (OPAL Collective 2016).

At the community level, each OPAL intervention site was staffed with two practitioners, the senior OPAL Managers and OPAL project support officers (OPSO). Most staff members were employed at full-time equivalent (FTE) positions; however, staff members in smaller rural communities were employed at reduced FTE, which reflected the smaller community population. The senior OPAL Manager was primarily responsible for planning and strategically guiding local program implementation, whereas the OPSO was primarily responsible for program delivery and on-the-ground contact with local stakeholders.

The program logic model that guided the planning, implementation and evaluation of OPAL is given in Figure 1 (Jones, Verity et al. 2016). The model highlights the resources, inputs and activities which result in intervention outputs, impacts and outcomes. It is a visual representation of the OPAL program theory, making explicit how the central components of the OPAL intervention were intended to bring about changes in the prevalence of overweight and obesity through a set of intermediate processes (i.e., behavioural and environmental changes). The logic model served as a road map for OPAL staff, making explicit what needed to happen to change the environment, children's behaviours and weight status (Jones, Verity et al. 2016). Briefly, guided by the community development, social marketing and ecological systems theories described above, local implementation was guided by specific principles (e.g., equity, non-stigmatising, values local community), six goals (home meals, healthy outlets, local food, active travel, active leisure, parks, and places) and seven action areas (policy, planning, awareness, education, training, infrastructure, and environments), complemented by annual social marketing themes focussing on a particular behaviour target (e.g., 'Water. The original cool drink.').

OPAL staff spent their first six months getting to know the local community and engaging with organisations. They developed a five-year plan, updated annually. Each year, staff attended three, four-day staff training sessions that included (i) council sharing (time for staff to share their learnings from local implementation), (ii) externally facilitated staff reflection sessions (opportunity for staff to engage in reflexive practice), and (iii) road maps of evidence-based interventions and capacity-building activities. Staff drew on program theories, action areas and principles, and synthesised evidence with local knowledge to mount locally responsive evidence-informed projects.

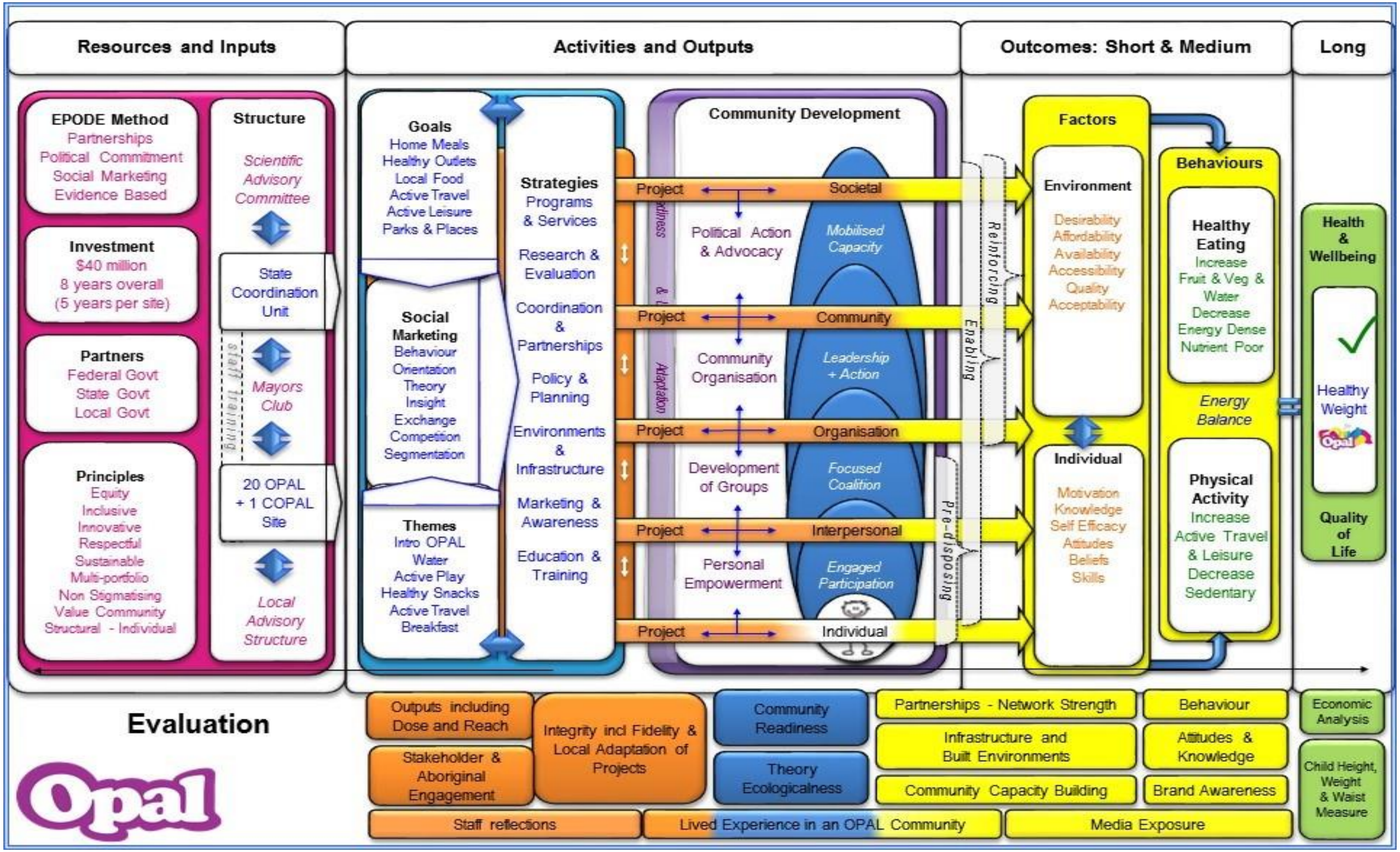

Figure 1. The OPAL Program Logic Model

2 EVALUATION

An intervention program is a representation of (i) a theoretical link between the known or perceived determinants of a problem, (ii) the problem itself and (iii) predicted changes in the problem situation (Cronbach 1982). This quantitative evaluation sought to determine in a rigorous manner the effectiveness of the OPAL intervention program at the population level, to assess whether OPAL was successful and, if so, why, and to establish the contextual circumstances by which OPAL was more, or less, successful. The null hypothesis was there would be no difference in change over time across the duration of the evaluation periods for communities in the intervention condition relative to those in the comparison condition.

The research design for the OPAL evaluation was developed by the Department for Health and Ageing with advice from the OPAL Scientific Advisory Committee (SAC). The SAC provided ongoing guidance to the OPAL State-wide Evaluation Co-ordination Unit on the evaluation methodology.

OPAL effectiveness was evaluated using a variation of the non-equivalent control (i.e., comparison) group quasi-experimental evaluation research design with time series extension for pre-intervention and post-intervention periods (Campbell and Stanley 1966). Each year, 4 to 5 year-old children were measured for height and weight and BMI calculated. BMI data were analysed for suburbs nested within communities nested in intervention or comparison conditions (Figure 2). The independent variable was the presence or absence of conditions (OPAL) to enable and facilitate a community-based intervention program.

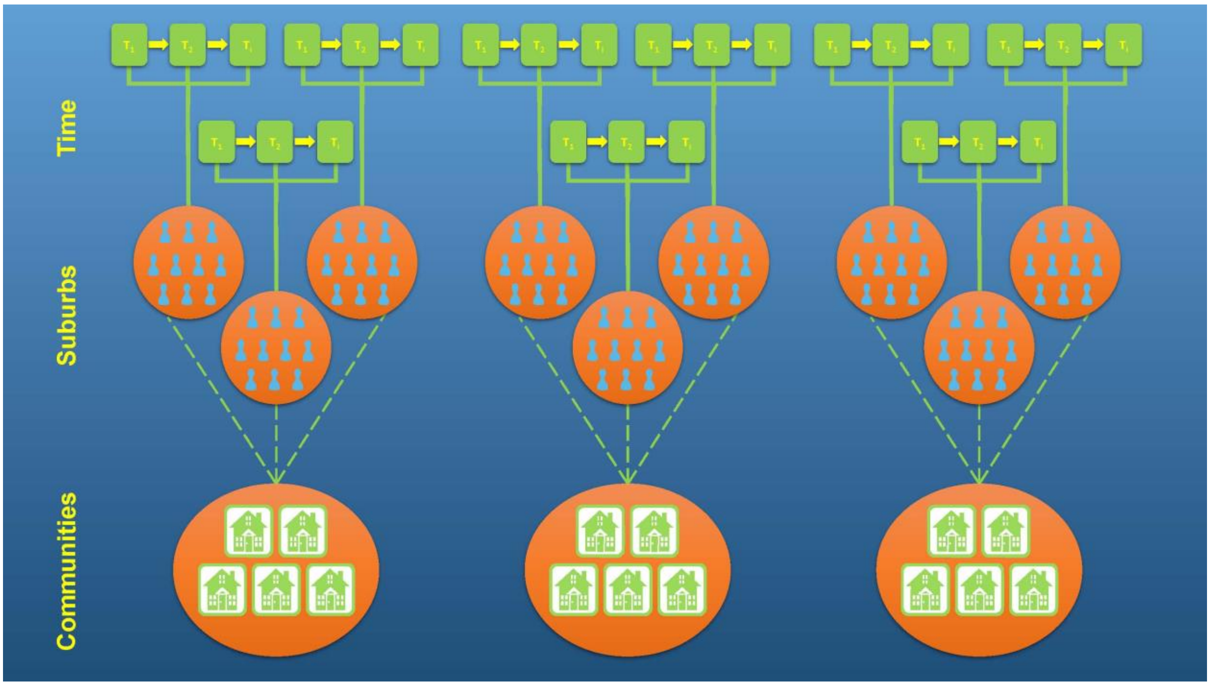

Figure 2. Repeated annual measures of children's height and weight nested within suburbs nested in communities. Twenty communities received OPAL and 20 did not (*n*=40 communities overall)

OPAL was implemented as noted for some five years in 20 metropolitan and regional intervention communities across South Australia. Intervention communities were matched on standard socio-demographic characteristics against 20 comparison communities.

The outcome was the prevalence of overweight and obesity as a single category for 4 to 5 year-old pre-school children, using BMI calculated from objectively-measured height and weight, drawn from the Women's and Children's Health Network of SA. Implementation across successive numbers of communities was staged over time in four phases each applying the same implementation principles but with minor differences in duration of intervention which was shorter due to funding cutbacks in later phases.

2.1 RESEARCH QUESTIONS

RQ1. What is the impact of OPAL on weight change over time in 4 to 5 year-old children, for intervention relative to comparison communities? (Main effect.)

RQ2. Does the impact of OPAL on weight change over time in 4 to 5 year-old children vary between intervention and comparison communities according to baseline social environmental factors? (Moderation by social environment.)

RQ3. Does the impact of OPAL on weight change over time in 4 to 5 year-old children vary between intervention and comparison communities according to baseline built environmental factors, accounting for social environmental factors? (Moderation by built environment.)

RQ4. (i) For intervention communities alone, what is the impact of baseline community leadership readiness, and change in leadership readiness, on weight change over time in 4-5 year-old children? (Main effect, intervention sub-analysis.) (ii) Does the impact of community leadership readiness on weight change over time in 4-5 year-old children vary according to baseline social environmental factors? (Moderation by social environment, intervention sub-analysis.)

RQ5. (i) For intervention communities alone, what is the impact of weak partnership ties (Year 1, and averaged across all years) on weight change over time in 4-5 year-old children? (Main effect, intervention sub-analysis.) (ii) Does the impact of weak partnership ties on weight change over time in 4-5 year-old children vary according to metropolitan versus non-metropolitan area and baseline social environmental factors? (Moderation by setting and social environment, intervention sub-analysis.)

2.2 COMMUNITY SELECTION AND MATCHING

There were 20 OPAL intervention communities in South Australia. Communities were defined as contiguous groups of suburbs for the Adelaide metropolitan area, and local government areas for the non-metropolitan area. Six OPAL communities were purposively chosen for intervention in mid-to-late 2009 (Phase 1), four in 2010 (Phase 2), five in 2011 (Phase 3), and five in 2012 (Phase 4). The selected communities had higher populations of children, higher populations of Aboriginal people, higher levels of disadvantage and higher levels of childhood overweight and obesity. They were also selected based on their local council's articulated commitment to health and well-being and financial commitment to the OPAL program.

This evaluation involves intervention and comparison communities for all phases over all years for which outcomes data were provided. The reach of the outcomes extraction allowed the evaluation to cover the four years prior to each Phase, whilst the timing of the extraction against OPAL Phases enabled covering an additional 0-2 years post-intervention. Hence, for Phases 1 and 2, 12 years of observations were available: four years pre-intervention, baseline year + five years intervention, and two years post-intervention. For Phase 3, 11 years of observations were available: four years pre-intervention, baseline year + five years intervention, and one year post-intervention. For Phase 4, 10 years of observations were available: four years pre-intervention, baseline year + five years intervention, and no year post-intervention.

Each intervention community (n=20) was matched to a comparison community (n=20) for a total of 40 communities evaluated under the quasi-experimental design. The following matching criteria were applied (±10% as a guide):

- Total population size;
- Youth population (persons aged 0 to 18 years);
- Maternal education (females 15 to 54 years with education > Year 12);
- Socio Economic Indexes For Areas (SEIFA) Index of Relative Social Disadvantage.

The arrangement of annual observations and intervention years for matched communities across the full 12 years of evaluation can be depicted as:

$M_{Intervention}$	0_1	0_2	0_3	0_4	X_0	X_1	X_2	X_3	X_4	X_5	0_1	0_2
$M_{Comparison}$	0_1	0_2	0_3	0_4	0_0	0_1	0_2	0_3	0_4	0_5	0_6	0_7

Within each community were nested smaller spatial units for which annual prevalence rates of overweight and obesity were calculated for 4 to 5 year-old children; these were the State Suburb (SSC), urban centre/rural locality (UC/RL) and local government area (LGA). The SSC is a close match to the official South Australian Geographic Names Board suburbs in the metropolitan area. The UC/RL is designed by the Australian Bureau of Statistics (ABS) to enable the identification of towns in non-metropolitan areas where the population is more dispersed; for the purposes of this evaluation it is treated as equivalent to the SSC. There were 471 SSC-UR/RLs considered for analyses (216 SSC-UC/RLs within intervention communities [median 9, IQR 6-16.5] and 255 SSC-UC/RLs within comparison communities [median 11, IQR 7-15]). For ease of readership, SSC's and UC/RL's are referred to collectively as 'suburbs' in Section 2.3 and beyond.

2.3 DATA SOURCES AND MEASURES

OUTCOME MEASURE

The primary outcome was overweight and obesity prevalence amongst 4 to 5 year-old children, modelled as change in prevalence across the evaluation period. This outcome was used as all children ages 4 through 5 years in SA are offered a free health check where height and weight (among other data) are measured and entered into a database held by the Women's and Children's Health Network of SA. The proportion of South Australian children participating in this scheme, until recently, was between 60-65%, but has dropped to the mid-50% range. Overweight and obesity was determined using age- and sex-specific international standards (Cole, Bellizzi et al. 2000) from BMI (kg/m^2) computed from measured weight and height records extracted from the Women's and Children's Health Network for children aged ≥ 3.5 year to < 5.5 years for the period covered by the evaluation: 1 September 2004 through 30 August 2017. Height and weight data were cleaned with records outside the following inclusion criteria removed:

- Child age 3.5 to 5.5 years (≥42 months and <66 months) at time of health check
- Weight above 8kg and below 65kg
- Height above 0.75m and below 1.45m
- BMI >10kg/m^2
- The most recent record for a given child (based on ID, checked against birthdate and sex)

Yearly (1st September to the next 31st August) proportions of overweight and obese pre-school children were calculated for suburbs within OPAL communities (child weight status data aggregated to yearly prevalence rates for suburbs within OPAL communities within intervention or comparison conditions). As each of the OPAL phases began at a different year, data were coded so that "Year 1" for each suburb represents the beginning of whichever Phase the suburb was assigned to.

SOCIAL AND BUILT ENVIRONMENTAL MEASURES

Social and built environmental measures were derived using a Geographic Information System (GIS) from secondary geo-referenced spatial databases (Matthews, Vernez-Moudon et al. 2009).

Social environmental measures included the socio-demographic features of suburbs within OPAL intervention or comparison communities. Social environmental data were sourced from the 2011 ABS Population and Housing Census (Australian Bureau of Statistics 2011), including: proportion of residents with a Bachelor's Degree or higher ("education"); and median household income ("income").

Built environment measures included: availability of fast food (outlet density); dwelling density; and Walk Score®. These measures were selected due to their potential to enable active living and healthful eating.

A count of fast-food outlets was constructed from a 2013 retail food environment database derived from the Sensis™ Yellow Pages™ and validated using NearMap©, Google StreetView™, and field ground-truthing (Google Earth© 2013, Nearmap© 2013, Coffee, Kennedy et al. 2016). Fast food was defined as major fast food franchises as well as independent takeaway food outlets such as pizza bars and fish or chicken and chips shops. Fast food density was calculated as the count per square kilometre ($n_{\text{fast food}}$/[suburb] area in km^2).

Dwelling density (dwellings/km^2) was calculated as the total dwellings within a suburb divided by suburb area in km^2 using data extracted from the South Australian Property Cadastre (Department of Planning Transport and Infrastructure: Land Service Group 2011).

Walk Score® is a composite walkability index incorporating population density, intersection density, and distances to amenities (Score© 2018). Walk Score® values for suburbs were obtained from the Walk Score® website during May 2018 (Walk Score© 2018).

STRENGTH OF WEAK PARTNERSHIP TIES

Partnership strength was operationalised on a scale with 7 response options and administered to OPAL practitioners who provided ratings on the strength of partnerships with organisations. A proportion of stakeholder organisations were sampled using a stratified random sampling procedure (Teddlie and Yu 2007). For each community, a maximum of four stakeholders were randomly selected from each of the following 13 OPAL sectors: Arts & Culture, Business & Commercial, Community Development, Education & Training, Environment & Conservation, Health & Fitness, Justice & Welfare, Kids, Youth & Families, Media, Planning & Design, Sports & Recreation, Transport, and Tourism. Four organisations per sector (n=52 organisations overall) was deemed a reasonable number for staff to rate their partnerships, without imposing a significant response burden. Partnerships were rated on a single-item, 7-point ordinal scale for the current intervention year and prior intervention years.

The single-item 7-point ordinal strength of partnership ties scale was the basis for the partnership survey which consisted of a one-page matrix listing, as rows, the organisations to be rated, and intervention years as columns. The scale was adapted from Harris (Harris, Luke et al. 2008) and guided by Granovetter's Strength of Weak Ties Theory (Granovetter 1973). The ratings were dichotomised to reflect weak (0) or strong (1) tie categories. Weak ties reflected the categories of 'not linked or integrated', 'communication' and 'co-operation'. Strong ties reflected the categories of 'co-ordination', 'collaboration', 'partnership'. and 'fully linked or integrated'. Thirty-eight OPAL managers and OPSOs completed the survey.

To assess the change in proportion of weak ties over time, the 7-point ordinal scale rating responses were dichotomised into weak (0) or strong (1) tie categories. Ratings for partnerships were summed and averaged to establish the proportion of weak ties for each year for each community. OPAL staff were involved in the adaptation of the scale to the OPAL context, establishing its face validity. Intra-rater reliability was established by inviting six OPAL staff to complete the survey at two time-points. Ratings across these participants yielded Kappa values of 0.80 (95% CI: 0.5 to 1.0) for the dichotomised scale. For more information on the scale please refer to Gancia (Gancia 2017).

COMMUNITY LEADERSHIP READINESS

The degree to which leaders are prepared to take action on any given issue can be assessed through the leadership dimension of the multidimensional community readiness tool (CRT) developed by the Tri-Ethnic Centre for Prevention Research at Colorado State University (Oetting, Donnermeyer et al. 1995, Plested, Edwards et al. 2006).

The leadership dimension of the CRT was assessed for each suburb within each OPAL intervention community. Four to six key respondents per community were recruited to rate each suburb within their community; if fewer than the minimum requirement of four respondents were recruited, then additional respondents were contacted until four respondents could be achieved. Key respondents from each community were selected based on the following criteria: (1) basic knowledge of obesity prevention activities implemented within community suburbs for the year before commencement of OPAL until the time of the survey; (2) tenure in their organisational position (for the duration of the OPAL program and the year before OPAL initiation); and (3) residency within or active involvement in the community. Participants were excluded if they did not meet residency or organisation tenure requirements. OPAL staff, local government employees, teachers and community members were targeted, however other respondents were considered where they met the inclusion criteria. School principals were excluded to reduce their response burden.

Respondents were asked to rate each suburb within their community for the perceived current level of leadership readiness and the baseline level of leadership readiness before the commencement of OPAL. Anchored statements were provided at each step of the scale (from 1 to 9) and respondents could score each suburb at 0.25-intervals. The survey was administered to all stakeholders in 2015. Given the staggered rollout of the OPAL intervention sites, the interval between the retrospective baseline assessment and the 2015 assessment varied between each site.

Seventy-nine of the possible 98 respondents contacted completed the online survey, yielding an overall response rate of 81%. Respondents provided leadership ratings for 168 suburbs in the 20 intervention communities. Seventeen communities had the required four respondents; however, one community had more than the required respondents (six respondents), and two communities had less than the required respondents (three respondents and two respondents). A majority of respondents were women (72%). Respondent occupations included local government (44%) and OPAL intervention (30%) roles; however, other local organisation staff (13%), elected councillors (6%), and school staff (6%) were also represented.

For more information on the leadership readiness measure please see Kostadinov (Kostadinov, Daniel et al. 2015, Kostadinov, Daniel et al. 2016)

2.4 ETHICS

Ethics approvals covering this evaluation were provided by the Human Research Ethics Committees of the South Australian Department for Health and Ageing, the Women's and Children's Hospital and the University of South Australia.

2.5 STATISTICAL ANALYSIS

Given the nested structure of the data with measurement occasions (level 1 units) nested within suburbs (level 2 units), and suburbs nested within OPAL communities (level 3 units) themselves nested within intervention conditions, all analyses were conducted using a multilevel modelling approach. There were 20 intervention communities and 20 comparison communities, overall, 40 level 3 units of analysis. The prevalence of overweight and obesity was modelled using a multilevel binomial regression model with yearly counts of children classified as overweight and obese as the outcome variable and the yearly total number of children per spatial unit (suburb) set as the denominator (offset). Level 1 statistical analysis considered the primary outcome, prevalence of overweight and obesity, within suburbs as a function of time, to assess change over time. Level 2 statistical analysis modelled the change in the prevalence of overweight and obesity within suburbs as a function of social and built environmental characteristics and, for intervention condition sub-analyses, suburb-level leadership readiness. Level 3 analyses modelled change over time in the prevalence of overweight and obesity within suburbs nested within communities for the 20 intervention communities relative to the 20 comparison communities and assessed the effect of the community-level intervention. Statistical models were adjusted for region (urban versus rural), intervention phase (4 phases of the project) and suburb-level SES characteristics (namely, education and income). Moderation (i.e., effect modification) models assessed the extent by which intervention effects varied according to environmental features and were tested using interaction terms between time, environmental and intervention condition measures.

Analyses were mainly performed with SAS software using the GLIMMIX (for Generalised Linear Mixed Models) procedure as it is well suited to the inclusion of both fixed and random effects in models. To handle the hierarchical data structure, random effects were used to account for the various nesting effects. Statistical significance was set at 0.05 and 95% confidence intervals (CI) calculated. A range of model fitting and comparison indices for choosing the most parsimonious model for fitting the data were used, especially, the Akaike Information Criterion (AIC) and the Bayesian Information Criterion (BIC) indices.

Data measurement occasions expressed as "phase years" consisted of 5 years of time points prior to the start of the intervention (coded as phase year time=-4 to time=0), and 7 time points accounting for 5 intervention years and up to 2 years post-intervention (phase year time=1 to time=7). The numbers of intervention and post-intervention annual time points were 7 for Phases 1 and 2, 6 for Phase 3 and 5 for Phase 4. Modelling of change in the annual prevalence of overweight and obesity used all data points (annual rates for 10-12 years) to support statistical power for inference on parameter estimates and their associated confidence intervals. The effect of time was tested both as a simple linear function (linear trend) and as a function of B-Splines (piecewise functions of time, joined at specified numbers of knots). Based on AIC and BIC indices, and to support clarity in the interpretation of the models (especially in cases of effect modification), time was modelled as a linear trend. *Additional procedures considered and further details on analyses undertaken are provided in Appendix 1*.

The first model to examine the intervention effect on change over time in prevalence rates of overweight and obesity considered only "time, intervention, and time*intervention", and included required random effects for clustering. Model-based differences in rates of overweight and obesity were estimated at each of the time points and tested for significance, *with p-values adjusted for multiplicity of comparisons* (Holm-Simulated approach). Given the number of suburbs within each community and the number of communities in each intervention condition, only two random effects were included, capturing variance components for initial status of overweight and obesity for suburbs nested within OPAL community and OPAL communities nested within intervention conditions. As suburb-level and community-level features enter in the models, these variance components stood to change in magnitude with the possibility of some becoming too small to be accounted for (e.g., no more variability at the community-level to be explained).

For analyses modelling change in the prevalence of overweight and obesity accounting for suburb-level social (SES) and built environmental features, all models were adjusted for region, OPAL phase and the pre-intervention prevalence of overweight and obesity. This baseline prevalence rate was computed as the prevalence at the baseline of the phase, one year prior to intervention (time=0) or at two years prior to intervention (time=-1) if missing at time=0. For sub-analyses modelling change in the prevalence of overweight and obesity within intervention communities only and the effect of suburb-level leadership readiness measures, models were adjusted for region, OPAL phase and SES education.

For second-order moderation effects requiring three-way interaction terms of numeric measures, at least one of the covariates involved in the interaction was dichotomised to simplify the interpretation of results. Categorisation was based mostly on tertile groups, with the dummy variable defined according to the question being assessed as either the upper third tertile (high) or the lower first tertile (low). All level 2 (suburbs) and level 3 (community) characteristics were time-invariant. As the full information maximum likelihood method was used for handling missing data, no other form of imputation approach was required.

To provide an indication of the absolute magnitude of the impact of OPAL in reducing the prevalence of overweight and obesity in preschool children the preventive fraction (a version of the attributable fraction) was calculated using the incidence of overweight and obesity in the comparison condition (the "exposed" group) and the incidence of overweight and obesity in the intervention condition (the "unexposed" group). The nature of this calculation is given in the Results section 3.3 (inferential modelling results) (pp. 25-26) using data from the main effects analysis. The resultant calculation for the 5-year intervention and 2-year post-intervention periods combine (7 years, overall) provides the proportion by which the prevalence of overweight and obesity that would otherwise have occurred was reduced by actions undertaken by OPAL through its implementation.

3 RESULTS

3.1 CHILD BMI DATA

SA Health provided a total of 139,082 records of children who had been measured for height and weight. Not all records were able to be geocoded, were within OPAL communities or met the inclusion criteria (loss recorded in Table 1). Records remaining in the resultant sample (n=68,763) were then aggregated by year and suburb within OPAL intervention and comparison communities.

Table 1. Unit-record sample loss

	Reason	loss	remaining
Received data	-	-	139082
Geocoding	not able to geocode	13015	126067
OPAL region	not in an OPAL intervention or comparison community	46262	79805
Age (3.5-5.5yrs) (42-66 months)	outside of age range	507	79298
BMI data	missing height/weight data or out of range (height/weight/BMI)[1]	1736	77629
Unique record	removal of duplicates (based on ID, sex, and date of birth)	67	77562
Within OPAL time-frame (baseline)	Prior to baseline time-range for each phase	6619	70943
intervention	outside of time-range for phases (>7 years post start of intervention)	2180	68763
OPAL sample	**available OPAL sample**	**-**	**68763**

[1] height inclusion range: 0.75 – 1.45m inclusive; weight inclusion range: 8 – 65kg inclusive; BMI inclusion: 10kg/m^2.

3.2 COMMUNITY-LEVEL DATA

Of the 471 suburbs initially included in the OPAL dataset, 37 suburbs did not have sufficient child BMI records at any timepoint. "Sufficient" was defined as suburbs having BMI data for at least five 4 to 5 year-old children per year (5 is the cut-off used for analysis by Australian Bureau of Statistics). Suburbs having records for four or fewer 4 to 5 year-old children per year were removed, yielding an analytic sample of 434 suburbs with a median of 9 suburbs per intervention community (IQR 5-13) and 10 suburbs per comparison community (IQR 7-14). Table 2 reports the distribution of suburbs for intervention condition, region and phase. There were slightly more suburbs in the comparison condition (n=235) than intervention condition (n=199) and 6 more communities were rural (n=220) than urban (n=214). More communities were included in later phases than in initial OPAL phases.

Table 2. Numbers of suburbs included, according to condition, region and phase

		Suburbs (n)
Condition	Intervention	199
	Comparison	235
Region	Urban	214
	Rural	220
Phase	Phase 1	79
	Phase 2	105
	Phase 3	125
	Phase 4	125

OVERWEIGHT AND OBESITY RATES

Table 3 presents for each OPAL phase year for OPAL intervention and comparison communities the number of children analysed, the mean and standard deviation for the *raw aggregated suburb-level prevalence rates* of overweight and obesity (what was modelled) and mean number of children per suburb. Raw overweight and obesity rates for 4 to 5 year-old children were greater for intervention than comparison communities during the baseline time-period (years -4 to 0). Figure 3 graphically characterises trends over time for aggregated raw data by phase year, with 95 % confidence limits showing the distribution of the raw rates. These aggregated rates are unadjusted for pre-existing residual socioeconomic characteristics of suburbs nested in communities (income and education), nor adjusted for regional status (urban versus rural) or OPAL phase.

Corresponding estimated rates of overweight and obesity adjusted for covariates (i.e., modelled) are presented in Table 4 and Figure 4, respectively. Covariate adjustment noticeably stabilised patterns of raw rates of overweight/ obesity.

SOCIAL AND BUILT ENVIRONMENT MEASURES

Summary statistics are given for social and built environment measures according to intervention condition in Table 5. Slight differences were observed between intervention and comparison communities with comparison communities being higher in area-level SES (both education and income). Regarding the built environment, intervention communities had greater dwelling density, fast food density and Walk Score®.

Table 3. Aggregated suburb-level *raw* overweight/obesity (OW/OB) prevalence rates and sample sizes according to phase year

	Intervention Communities (*n* = 20)						Comparison Communities (*n* = 20)					
Phase Year	*n* children	*n* suburb	Mean OW/OB rate /suburb	SD	Mean *n* children /suburb	Max *n* children /suburb	*n* children	*n* suburb	Mean OW/OB rate /suburb	SD	Mean *n* children /suburb	Max *n* children /suburb
-4	3346	68	20.25	8.15	41	323	2604	57	17.65	8.98	34	130
-3	2803	56	23.36	8.02	39	156	2323	51	17.12	8.15	31	151
-2	3459	68	20.92	9.53	42	337	2759	59	17.96	8.26	35	132
-1	3374	68	20.25	8.15	41	323	2636	57	17.65	8.98	34	130
0	3495	68	20.34	7.05	42	236	2819	62	17.07	7.40	34	158
1	3508	65	21.59	7.61	44	303	2654	58	17.79	8.08	33	152
2	3739	72	21.21	7.16	44	283	2776	61	19.31	8.66	34	183
3	3919	72	21.17	7.36	46	336	2903	63	18.22	8.39	34	162
4	3378	69	21.62	8.05	41	279	2503	55	18.86	9.10	32	132
5	3488	70	21.44	8.38	42	226	2507	52	18.68	6.97	32	185
6	2720	60	19.48	7.15	38	247	1789	41	19.57	7.87	30	137
7	2248	48	18.13	8.42	42	297	1303	34	22.71	9.97	30	63

Table 4. *Covariate-adjusted* (modelled) aggregated suburb-level overweight/obesity (OW/OB) prevalence rates and sample sizes according to phase year

	Intervention Communities (*n* = 20)						Comparison Communities (*n* = 20)					
Phase Year	*n* children	*n* suburb	Mean rate /suburb	95% confidence interval	Mean *n* children /suburb	Max *n* children /suburb	*n* children	*n* suburb	Mean rate /suburb	95% confidence interval	Mean *n* children /suburb	Max *n* children /suburb
-4	3346	68	20.50	18.91-22.22	41	323	2604	57	17.52	15.95-19.25	34	130
-3	2803	56	20.68	19.28-22.18	39	156	2323	51	17.44	16.12-18.87	31	151
-2	3459	68	20.86	19.56-22.24	42	337	2759	59	17.36	16.19-18.62	35	132
-1	3374	68	21.04	19.73-22.42	41	323	2636	57	17.28	16.12-18.53	34	130
0	3495	68	21.22	19.80-22.74	42	236	2819	62	17.21	15.90-18.62	34	158
1	3508	65	21.11	19.79-22.53	44	303	2654	58	17.60	16.38-18.91	33	152
2	3739	72	21.01	19.75-22.36	44	283	2776	61	18.01	16.84-19.27	34	183
3	3919	72	20.91	19.67-22.23	46	336	2903	63	18.43	17.25-19.69	34	162
4	3378	69	20.80	19.55-22.14	41	279	2503	55	18.85	17.61-20.18	32	132
5	3488	70	20.70	19.39-22.10	42	226	2507	52	19.29	17.93-20.76	32	185
6	2720	60	20.60	19.21-22.09	38	247	1789	41	19.74	18.22-21.40	30	137
7	2248	48	20.50	19.00-22.11	42	297	1303	34	20.19	18.45-22.10	30	63

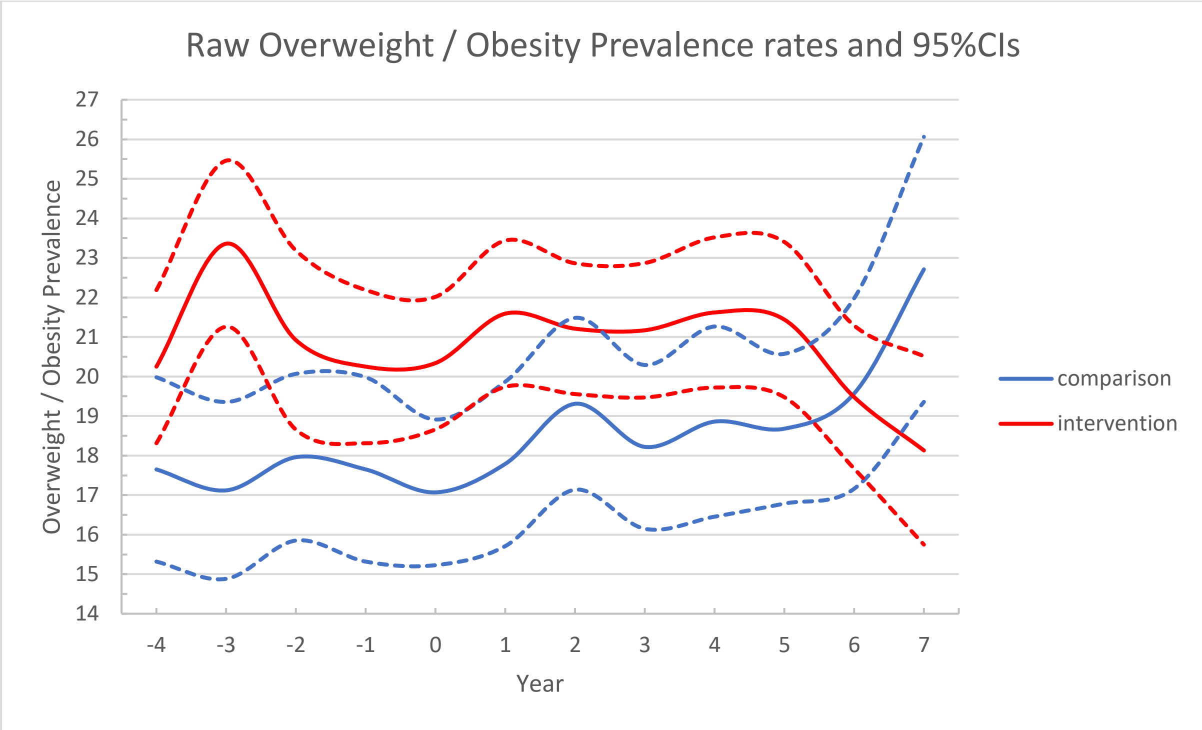

Figure 3. Aggregated *raw* mean overweight/ obesity prevalence rates, by phase year, for intervention and comparison conditions

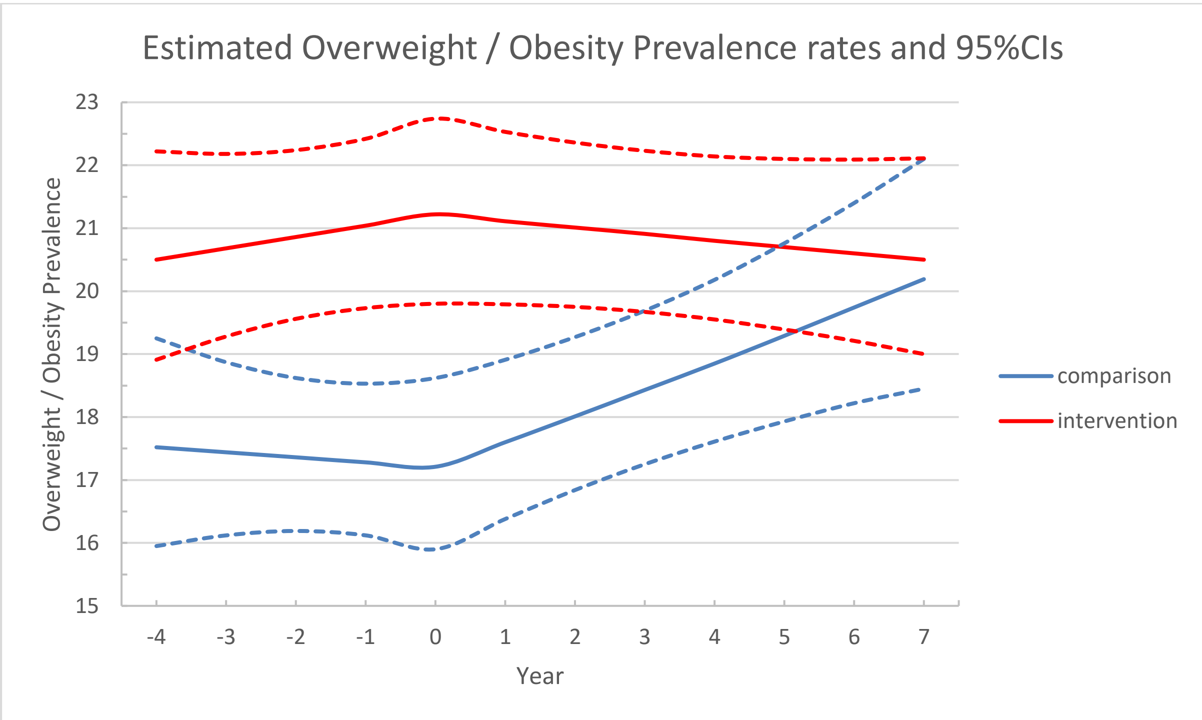

Figure 4. Covariate-adjusted (modelled estimates) mean overweight/ obesity prevalence rates by phase year, showing 95% confidence limits, for intervention and comparison conditions

Table 5. Descriptive features of communities, according to intervention condition (accounting for clustering of suburbs within communities)

	Intervention (n=20)				Comparison (n=20)			
	mean	SD	min	max	mean	SD	min	max
Social environment: Area-level SES								
Education (Bachelor's Degree or higher, %)	21.64	4.65	7.28	39.69	25.02	5.00	13.49	52.98
Income (median household, $/week)	1194.25	34.56	901.38	1433.63	1357.67	36.85	929.06	2060.50
Built environment								
Dwelling Density (per km-square)	501.96	22.40	13.55	1133.39	406.30	20.16	14.71	1332.52
Fast Food Density (per km-square)	1.65	1.28	0.06	4.05	1.25	1.12	0.01	4.63
Walk Score (0-100)	36.59	6.05	5.08	65.83	33.66	5.80	12	70.63
Categorised environmental exposures (High: upper tertile)	**%**	**SD**			**%**	**SD**		
Education	29.39	54.22	-	-	31.45	56.08	-	-
Income	25.88	50.87	-	-	44.04	66.36	-	-
Dwelling Density	42.60	65.27	-	-	29.25	54.08	-	-
Fast Food Density	46.26	68.02	-	-	29.76	54.55	-	-
Walk Score [1]	5.01	22.38	-	-	7.35	27.11	-	-

[1] Walk Score >69 classified as 'high' (i.e., not based on tertiles).

INTERVENTION-SPECIFIC COMMUNITY FEATURES (SUB-ANALYSES MEASURES)

Summary statistics for the community leadership readiness and partnership strength variables are summarised in Table 6. Community leadership readiness data were available for 20 communities. For partnership strength, baseline data were missing for one community. All 20 communities contributed ratings to the assessment of partnership ties across the program. Phases 3 and 4 contributed data for the first three years of the OPAL program only while Phases 1 and 2 contributed data across all years.

Community Leadership

Community leadership readiness was measured on a 9-point ordinal scale. The average score at baseline across all communities was 3.34 which is indicative of vague awareness (i.e., 'leadership believing that childhood obesity is a concern and that something *may* have to be done to address it'). Scores ranged from a minimum value of 1.50 which reflects leaders denying that childhood obesity is a problem (i.e., 'believing that obesity is a concern in general but not in their community' or 'obesity is a local concern but nothing needs to be done about it in their community') to a maximum value of 6.75 indicative of 'leadership being involved in or actively supporting continuing current childhood obesity prevention efforts AND providing or finding resources for efforts to become self-sufficient.'

The average score for community leadership in 2015, which reached communities at different stages of program maturation, was 5.19. This is indicative of preparation (i.e., 'leadership being involved in or actively supportive of planning of childhood obesity prevention efforts (possibly as part of a committee or group that addresses this issue)).' The minimum value of 1.88 reflects denial by leadership, as described above. The maximum value of 7.50 reflects confirmation and expansion, that 'leadership is actively participating in expanding or improving childhood obesity prevention efforts.' The average change in community leadership was 1.85 points on the nine-point scale, with a minimum increase of ~0.50 points and a maximum increase of ~ 4 points on the scale.

Partnership Ties

The average proportion of weak ties during Year 1 of OPAL was 0.70; hence, on average, 70% of OPAL's ties with organisations were weak (i.e., not linked, communication or collaboration), whilst 30% of ties were strong ('co-ordination', 'collaboration', 'partnership' and 'fully linked or integrated'). From the minimum and maximum values at baseline it is evident that communities' starting points differed quite significantly. Across all time points and communities, the average proportion of weak ties was 0.62 meaning that most of OPAL's organisational ties were in the communication/ collaboration realm. Again, there is significant variation across communities.

Table 6. Intervention-specific community process descriptors (not adjusted for clustering)

Measure	n	Mean	SD	Minimum	Maximum
Community leadership readiness at baseline (pre-OPAL	20	3.34	0.81	1.50	6.75
Community leadership readiness in 2015	20	5.19	1.23	1.88	7.50
Change in community leadership readiness	20	1.85	0.89	0.00	3.81
Proportion of weak partnership ties (baseline)	19	0.70	0.17	0.47	1.00
Proportion of weak partnership ties (mean across time)	20	0.62	0.17	0.27	0.88

3.3 INFERENTIAL MODELLING RESULTS

Results of the inferential models pertaining to RQ1 (Model I, main effect) and RQ2 (Models II and III, moderation by social environment) are presented in Table 7 (RQ1-2). Results of Models IV to VII, assessing RQ3, are presented in Tables 8 and 9. Tables 10 and 11 (Models VIII through XI) relate to RQ4 and Tables 12 and 13 present the results of Models XII through XVII for RQ5.

RQ1: What is the impact of OPAL on weight change over time in 4 to 5 year-old children, for intervention relative to comparison communities? (main effect) (refer to Table 7)

Model I assessed the main effect of OPAL on weight change for intervention relative to comparison communities. At baseline, intervention communities were more likely to have a greater prevalence of overweight and obesity amongst 4-5 year-old children (Beta = 0.154 [95%CI 0.087 to 0.222], $p<0.0001$). Overall, overweight and obesity prevalence increased over time (Beta = 0.009 [95%CI 0.001 to 0.017], $p=0.020$). However, for intervention communities, the overweight and obesity rate statistically significantly declined over time relative to the comparison communities (Beta = -0.013 [95%CI -0.023 to 0.003], $p=0.008$). This intervention effect was robust to the inclusion of social and built environment measures and their interactions within subsequent analytic models (Models II through VI, Tables 7 through 9).

Exposure to OPAL was associated overall with reductions in the prevalence of overweight and obesity for 4-5 year-old pre-school children in the intervention condition relative to the comparison condition.

Preventive Fraction. The preventive fraction was derived drawing on Rothman (1986) and Miettinen (1974). According to the fitted models adjusted for region, OPAL phase, education and income (see Table 7, Model II), estimated rates of change (RC) for overweight/ obesity were 0.0093 and -0.0093 per year for comparison (CC) and intervention (IC) communities, respectively. Assuming the same rates of change across both a 5-year period and a 7-year period, rates of changes for these periods were calculated as:

$RC_{CC}(5yr) = 0.0465$ and $RC_{IC}(5yr) = -0.0465$, respectively.

$RC_{CC}(7yr) = 0.0651$ and $RC_{IC}(7yr) = -0.0651$, respectively.

Taking the overall OW/OB prevalence rate (at baseline) across communities for both the comparison and intervention conditions combined, corresponding to the population-level prevalence (estimated from the unadjusted, or null model) as $P_0 = 0.1925$ then, by the end of the 7-year period, prevalence rates in both groups would be:

$P_{CC} = P_0 + (RC_{CC} * P_0) = P_0 * (1 + RC_{CC})$, and $P_{IC} = P_0 + (RC_{IC} * P_0) = P_0 * (1 + RC_{IC})$.

Therefore, the preventive fraction can be calculated as: $100 * (P_{CC} - P_{IC})/P_{CC}$.

This approach to calculating the preventive fraction accounts for differing rates of change over time in the incidence of OW/OB within communities (increase in CC and decrease in IC) and applies these rates to a hypothetical population baseline equivalent to both community conditions.

The preventive fraction for a 5-year period is thus:

$P_{CC} = 0.1925* 1.0465 = 0.20145$ (20.15%); $P_{IC} = 0.1925 * 0.9535 = 0.18355$ (18.36%)

$100 * (P_{CC} - P_{IC})/P_{CC} = 0.0888 = 8.9\%$

The preventive fraction for a 7-year period is thus:

$P_{CC} = 0.1925 * 1.0651 = 0.20503$ (20.50%); $P_{IC} = 0.1925 * 0.9349 = 0.17997$ (18.0%)

$100 * (P_{CC} - P_{IC})/P_{CC} = 0.1220 = 12.2\%$.

Notice that the preventive fraction for a single, 1-year period is:

$P_{CC} = 0.1925 * 1.0093 = 0.19429$ (19.43%); $P_{IC} = 0.1925 * 0.9907 = 0.19071$ (19.07%)

$100 * (P_{CC} - P_{IC})/P_{CC} = 0.0185 = 1.85\%$

Based on the fitted models estimating the main effect of OPAL the preventive fraction varied from 1.85% (for a single year) to 8.9% (for the 5-year intervention period) to 12.2% (for the 7-year period reflecting the overall intervention and post-intervention periods combined). These figures indicate the proportion by which the prevalence of overweight and obesity that would otherwise have occurred was reduced by actions undertaken by OPAL through its implementation.

RQ2: How does the impact of OPAL on weight change over time in 4 to 5 year-old children vary between intervention and comparison communities according to baseline social environmental factors? (moderation by environment) (refer to Table 7)

Models II and III estimated modification of the effect of OPAL according to the social environment, that is, area education and income (RQ2). There was no statistically significant association between area education and overweight and obesity prevalence, and no interaction effect between education and intervention in relation to baseline overweight and obesity prevalence (Model II). Area education was not associated with change in overweight and obesity prevalence. However, for intervention communities, education was associated with a reduction in overweight and obesity prevalence over time (Beta = -0.014 [95%CI -0.022 to -0.007], p<0.003). There was no association between area education and change in overweight and obesity prevalence amongst comparison communities.

Regarding Model III, area income was inversely associated with baseline overweight and obesity prevalence (-0.087 [95%CI -0.129 to -0.044), p<0.0001), though amongst intervention communities this baseline association was opposite (0.070 [95%CI 0.016 to 0.124], p=0.011). Overall, area income was not associated with change in overweight and obesity rate though area income was inversely associated with change in overweight and obesity prevalence for intervention communities (Beta = -0.009 [95%CI -0.017 to -0.001], p=0.026). There was no statistically significant association between area income and change in overweight and obesity rate for comparison communities.

Amongst intervention communities, but not comparison communities, both income and education were associated with decreasing overweight and obesity prevalence for 4 to 5 year-old children. Higher area education and income amplified the reduction in overweight and obesity amongst intervention communities.

Table 7. Results of inferential models for RQ1 and RQ2 (intervention effect and moderation by social environment, respectively)

Effects [1]	Model I [2] (AIC 9640.46)			Model II [3] (AIC 9602.02)			Model III [4] (AIC 9606.20)		
	estimate	**95% CI**	**p value**	**estimate**	**95% CI**	**p value**	**estimate**	**95% CI**	**p value**
Intervention	0.1541	0.0866; 0.2217	<0.0001	0.1174	0.0610; 0.1739	<0.001	0.1194	0.0656; 0.1732	<0.0001
Time	0.0093	0.0014; 0.0171	0.020	0.0093	0.0011; 0.0176	0.026	0.0086	0.0007; 0.0164	0.032
Time*intervention	-0.0133	-0.0233; -0.0034	0.008	-0.0186	-0.0292; -0.0080	<0.001	-0.0153	-0.0256; -0.0051	0.003
Education	-	-	-	-0.0481	-0.1033; 0.0071	0.087	-	-	-
Education*intervention	-	-	-	0.0278	-0.0318; 0.0874	0.360	-	-	-
Education*time	-	-	-	0.0019	-0.0083; 0.0121	0.713	-	-	-
Education*time*intervention (IC)	-	-	-	-0.0142	-0.0219; -0.0066	<0.001	-	-	-
Education*time*comparison (CC)	-	-	-	0.0019	-0.0083; 0.0121	0.715	-	-	-
Income	-	-	-	-	-	-	-0.0869	-0.1294; -0.0443	<0.0001
Income*intervention	-	-	-	-	-	-	0.0698	0.0160; 0.1235	0.011
Income*time	-	-	-	-	-	-	0.0021	-0.0059; 0.0101	0.611
Income*time*intervention (IC)	-	-	-	-	-	-	-0.0092	-0.0174; -0.0011	0.026
Income*time*comparison (CC)	-	-	-	-	-	-	0.0021	-0.0059; 0.0101	0.611

[1] All models adjusted for region, OPAL phase and pre-intervention prevalence rate of overweight and obesity (at time=0); [2] Model I included only time, intervention and the interaction time*intervention; [3] Model II: Model I and area education, adjusted for area income; [4] Model III: Model I and area income, adjusted for area education; NB: SES variables (education and income) are continuous and were standardised for analyses.

RQ3. How does the impact of OPAL on weight change over time in 4 to 5 year-old children vary between intervention and comparison communities according to baseline built environmental factors, accounting for social environmental factors? (moderation by environment) (refer to Tables 8 and 9)

Models IV through VI assessed RQ3. Dwelling density (Table 8, Model IV), and its interaction term with intervention, were not associated with baseline overweight and obesity rates. High dwelling density (compared to low) was associated with reductions in overweight and obesity prevalence (Beta = -0.021 [95% CI -0.037 to -0.005], p=0.009). There was no association between high dwelling density and change in overweight and obesity prevalence amongst intervention communities, though amongst comparison communities, high dwelling density was associated with a decrease in overweight and obesity prevalence (Beta = -0.021 [95%CI -0.037 to -0.005], p=0.009).

Walk Score® (Table 8, Model V) was not associated with baseline overweight/obesity rates, nor was there a statistically significant interaction between Walk Score® and intervention in relation to baseline overweight and obesity rate. Walk Score® was not associated with change in prevalence rates over time. However, amongst intervention communities, high Walk Score® (compared to low) was inversely associated with change in overweight and obesity prevalence (Beta = -0.038 [95%CI -0.068 to -0.009], p=0.012). This association was not statistically significant in comparison communities.

Neither fast food availability (density; Table 9, Model VI) nor its interaction term with intervention, were associated with baseline overweight and obesity rate. Fast food density was not associated with change in overweight and obesity prevalence. Amongst intervention communities, but not comparison communities, high fast food density was statistically significantly associated with an increasing prevalence of overweight and obesity (Beta = 0.014 [95%CI 0.0006 to 0.0270], p=0.041).

The findings of Models IV through VI indicate that the impact of OPAL varied according to baseline measures of the built environment.

Table 8. Results of inferential models for RQ3 (moderation by built environment: dwelling density and walk score)

Effects [1]	Model IV [2] (AIC 9609.17)			Model V [3] (AIC 9605.10)		
	estimate	95% CI	p value	estimate	95% CI	p value
Time	0.0172	0.0072; 0.0270	<0.001	0.0093	0.0013; 0.0173	0.023
Intervention	0.1408	0.0701; 0.2115	<0.0001	0.1089	0.0548; 0.1629	<0.0001
Time*intervention	-0.0183	-0.0320; -0.0046	0.009	-0.0115	-0.0216; -0.0014	0.026
Dwelling Density (High)	0.0492	-0.0322; 0.1306	0.236	-	-	-
Dwelling Density*time	-0.0213	-0.0373; -0.0053	0.009	-	-	-
Dwelling Density*intervention	-0.0715	-0.1740; 0.0312	0.172	-	-	-
Dwelling Density*time*intervention (IC)	-0.0049	-0.0172; 0.0075	0.440	-	-	-
Dwelling Density*time*comparison (CC)	-0.0213	-0.0373; -0.0053	0.009	-	-	-
Walk Score (High)	-	-	-	0.1351	-0.0134; 0.2836	0.075
Walk Score*time	-	-	-	-0.0050	-0.0413; 0.0314	0.790
Walk Score*intervention	-	-	-	0.0164	-0.1662; 0.1991	0.860
Walk Score*time*intervention (IC)	-	-	-	-0.0381	-0.0678; -0.0085	0.012
Walk Score*time*comparison (CC)	-	-	-	-0.0047	-0.0412; 0.0317	0.801

[1] All models adjusted for region, OPAL phase and pre-intervention prevalence rate of overweight and obesity (at time=0); [2] Model IV: Model I and Dwelling density, adjusted for are education and are income; [3] Model V: Model I and Walk Score, adjusted for area education and area income.

Table 9. Results of inferential models for RQ3 (moderation by built environment: fast food density)

Effects [1]	Model VI [2] (AIC 9612.13)		
	estimate	**95% CI**	**p value**
Time	0.0121	0.0021; 0.0222	0.018
Intervention	0.1403	0.0692; 0.2114	<0.001
Time*intervention	-0.0257	-0.0406; -0.0108	<0.001
Fast Food Density (High)	0.0172	-0.0592; 0.0937	0.659
Fast Food Density*time	-0.0081	-0.0240; 0.0079	0.321
Fast Food Density*intervention	-0.0517	-0.1492; 0.0458	0.298
Fast Food Density*time*intervention (IC)	0.0138	0.0006; 0.0270	0.041
Fast Food Density*time*comparison (CC)	-0.0081	-0.0240; 0.0079	0.321

[1] All models adjusted for region, OPAL phase and pre-intervention prevalence rate of overweight and obesity (at time=0); [2] Model VI: Model I and Fast Food Density, adjusted for area education and area income.

RQ4. (i) For intervention communities alone, what is the impact of baseline Community Leadership Readiness, and change in Leadership Readiness, on weight change over time in 4 to 5 year-old children? (Main effect, intervention sub-analysis.) (ii) Does the impact of baseline Community Leadership Readiness and Change in Leadership Readiness on weight change in 4 to 5 year-old children vary according to baseline social environmental factors? (moderation by social environment, intervention sub-analysis) (refer to Tables 10 and 11)

Models VII and VIII (Table 10) assessed RQ4. Baseline Leadership Readiness was related to baseline overweight and obesity rates (Beta = 0.0444 [95% CI 0.0158 to 0.0729], p=0.002) but, over time, Leadership Readiness predicted reductions in overweight/obesity prevalence (Beta = -0.0087 [95% CI -0.0150 to -0.0025], p=0.006). For moderation by the social environment (i.e. Education, RQ4[ii]), there was no association between Baseline Leadership Readiness and change in overweight and obesity prevalence in the high area education condition (Beta= -0.0045 [95% CI -0.0206 to 0.0116], p=0.580). There was, however, an association in the Low Education condition (Beta = -0.0092 [95% CI -0.01588 to -0.00242], p=0.008. It thus appears that the effect of Baseline Leadership Readiness on reduction in overweight and obesity prevalence was driven by the low education condition.

Change in Leadership Readiness (Table 11) was not associated with baseline overweight and obesity rates but was associated with reductions in overweight/obesity rates over time (Beta = -0.0128 [95%CI -0.0182 to -0.0074], p<0.0001). This association varied by the social environment (Model XI) being statistically significantly associated with reductions in overweight and obesity only amongst communities with low education at baseline, but not high education communities.

In intervention communities, both Baseline Leadership Readiness and Change in Leadership Readiness were associated with reductions in overweight and obesity prevalence over time. These effects were primarily driven by associations within low education communities.

Table 10. Results of inferential models for RQ4 (Baseline Leadership Readiness)

Effects [1]	Model VII [2] (AIC 5241.73)			Model VIII [3] (AIC 5247.18)		
	estimate	95% CI	p value	estimate	95% CI	p value
Time	-0.0031	-0.0093; 0.0030	0.317	0.0031	-0.0093; 0.0032	0.334
Leadership Readiness	0.0444	0.0158; 0.0729	0.002	0.0436	0.0168; 0.0704	0.001
Time*Leadership Readiness	-0.0087	-0.0150; -0.0025	0.006	-0.0091	-0.0159; -0.0024	0.008
Time*Leadership Readiness Base*Education [4] (High: upper tertile)	-	-	-	-0.0045	-0.0206; 0.0116	0.580
Time*Leadership Readiness Base*Education [4] (Low: lower 2 tertiles)	-	-	-	-0.0092	-0.0159; -0.0024	0.008

[1] All models adjusted for region, OPAL phase and area education; [2] Model VII included only time, Leadership Readiness and the interaction time*Leadership Readiness; [3] Model VIII: Model VII with moderation by social environment (Education); [4] Education defined as High: in the upper tertile; Low: lower 2 tertiles.

Table 11. Inferential results for RQ4 (Change in Leadership Readiness)

Effects [1]	Model IX [2] (AIC 5231.90)			Model X [3] (AIC 5237.13)		
	estimate	95% CI	p value	estimate	95% CI	p value
Time	-0.0064	-0.0127; -0.0001	0.046	-0.0064	-0.0128; -0.0000	0.047
Leadership Readiness Change	0.0117	-0.0164; 0.0399	0.414	0.0113	-0.0178; 0.04045	0.446
Time*Leadership Readiness Change	-0.0128	-0.0182; -0.0075	<0.0001	-0.0133	-0.0190; -0.0076	<0.0001
Time*Leadership Readiness Change*Education [4] (High: upper tertile)	-	-	-	-0.0084	-0.0235; 0.0068	0.977
Time*Leadership Readiness Change*Education [4] (Low: lower 2 tertiles)	-	-	-	-0.0133	-0.0190; -0.0076	<0.0001

[1] All models adjusted for region, OPAL phase and area education; [2] Model IX included only time, change in partnership ties and the interaction time*change in partnership ties.; [3] Model X: Model IX with moderation by social environment (Education); [4] Education defined as High: in the upper tertile; Low: lower 2 tertiles.

RQ5. (i) For intervention communities alone, what is the impact of weak Partnership Ties (Year 1, and averaged across all years) on weight change over time in 4 to 5 year-old children? (Main effect, intervention sub-analysis.) (ii) Does the impact of weak Partnership Ties (Year 1, and averaged across all years) on weight change over time in 4 to 5 year-old children vary according to metropolitan versus non-metropolitan area and baseline social environmental factors? (moderation by setting and social environment, intervention sub-analysis) (refer to Tables 12 and 13)

Models XI through XVI assessed RQ5. Year 1 Partnership Ties (Table 12) was not associated with baseline overweight and obesity prevalence (Beta = 0.0305 [95% CI -0.0150 to 0.0759], p=0.188). Regarding change over time, Year 1 Partnership Ties was associated with reductions in overweight and obesity prevalence (Beta = -0.0168 [95% CI -0.0233 to -0.0103], p<0.0001). This association did not vary by region but did vary by area education. Year 1 Partnership Ties were associated with decreasing overweight and obesity rates only amongst low education areas.

Mean Partnership Ties (Table 13) was positively associated with baseline overweight and obesity prevalence (Beta = 0.0527 [95% CI 0.0280 to 0.0775], p<0.0001) but over time was associated with reductions in overweight and obesity rates (Beta = -0.0198 [95% CI -0.0254 to -0.0142], p<0.0001). The effect of Mean Partnership Ties on change in overweight and obesity did not vary according to region or education and remained statistically significantly associated with reductions in overweight and obesity prevalence in all sub-groups.

For intervention communities, Partnership Ties (Year 1 and mean) were associated with decreasing overweight and obesity rates. The impact of Year 1 Partnership Ties on change overweight and obesity rates varied according to the social environment (education) but not region. The impact of mean Partnership Ties on change in overweight and obesity did not vary according to region or the social environment but remained linked to decreasing overweight and obesity rates in all sub-groups.

Table 12. Results of inferential models for RQ5 (Year 1 Partnership Ties)

Effects [1]	**Model XI** [2] **(AIC 4646.66)**			**Model XII** [3] **(AIC 4648.08)**			**Model XIII**[4] **(AIC 4652.44)**		
	estimate	**95% CI**	**p value**	**estimate**	**95% CI**	**p value**	**estimate**	**95% CI**	**p value**
Time	-0.0007	-0.0075; 0.0060	0.831	-0.0016	-0.0086; 0.0055	0.666	0.0032	-0.0110; 0.0046	0.427
Partnership ties	0.0305	-0.0150; 0.0760	0.188	0.0292	-0.0164; 0.0748	0.210	0.0063	-0.0399; 0.0524	0.789
Time*Partnership ties	-0.0168	-0.0233; -0.0103	<0.0001	-0.0204	-0.0318; -0.0091	<0.001	-0.0199	-0.0280; -0.0118	<0.0001
Time*Partnership*Region (Urban)	-	-	-	-0.0152	-0.0229; -0.0074	<0.001	-	-	-
Time*Partnership*Region (Rural)	-	-	-	-0.0204	-0.0317; -0.0091	<0.001	-	-	-
Time*Partnership*Education (High: upper tertile)	-	-	-	-	-	-	-0.0088	-0.0227; 0.0051	0.215
Time*Partnership*Education (Low: bottom 2 tertiles)	-	-	-	-	-	-	-0.0199	-0.0280; -0.0118	<0.0001

[1] All models adjusted for region, OPAL phase and area education [2] Model XI included only time, baseline partnership ties and the interaction time*baseline partnership ties [3] Model XII: Model XI with moderation by region (Urban vs. Rural) [4] Model XIII: Model XI with moderation by education defined as: High upper tertile; Low lower 2 tertiles.

Table 13. Results of inferential models for RQ5 (Mean Partnership Ties over 5 years)

Effects [1]	Model XIV [2] (AIC 4426.64)			Model XV [3] (AIC 4426.44)			Model XVI [4] (AIC 4441.34)		
	estimate	95% CI	p value	estimate	95% CI	p value	estimate	95% CI	p value
Time	-0.0020	-0.0087; 0.0047	0.559	-0.0009	-0.0078; 0.0059	0.786	-0.0021	-0.0092; 0.0050	0.566
Mean Partnership Ties	0.0527	0.0280; 0.0775	<0.0001	0.0532	0.0285; 0.0778	<0.0001	0.0425	0.0137; 0.0713	0.004
Time*Mean Partnership Ties	-0.0198	-0.0254; -0.0142	<0.0001	-0.0163	-0.0236; -0.0091	<0.0001	-0.0196	0.0258; -0.0135	<0.0001
Time*Mean Partnership Ties*Region (Urban)	-	-	-	-0.0240	-0.0319; -0.0161	<0.0001	-	-	-
Time*Mean Partnership Ties*Region (Rural)	-	-	-	-0.0163	-0.0236; -0.0091	<0.0001	-	-	-
Time*Partnership Ties*Education (High: upper tertile)	-	-	-	-	-	-	-0.0179	-0.0322; -0.0036	0.014
Time*Partnership Ties*Education (Low: lower 2 tertiles)	-	-	-	-	-	-	-0.0196	-0.0258; -0.0134	<0.001

[1] All models adjusted for region, OPAL phase and SES education [2] Model XIV included only time, partnership ties mean value over 5 years and the interaction time*partnership ties mean value [3] Model XV: Model XIV with moderation by region (Urban vs. Rural) [4] Model XVI: Model XIV with moderation by education defined as: High in the upper tertile group; and Low in lower 2 tertiles.

4 DISCUSSION

4.1 OVERALL EVALUATION

This is one of the first large-scale multisite quasi-experimental evaluations of a community-based childhood obesity prevention program to demonstrate effectiveness in reduced levels of children's overweight and obesity using BMI derived from objectively measured height and weight. The OPAL evaluation indicates that for communities in the intervention condition relative to communities in the comparison condition there was a clear overall decrease in the prevalence of overweight and obesity. This intervention effect remained statistically significant even accounting simultaneously for area-level income and education which eliminates confounding by these variables as a potential explanation for the observed effect. The decline in overweight and obesity extended across the two years following the cessation of funding, indicating that OPAL sustained its effect in the short term, possibly longer. The intervention test of effect signifying a decrease over time in the prevalence of overweight and obesity persisted across all statistical models not just that testing the main effect of the program. It extended also to models that tested the moderating impacts of built environmental variables, whilst accounting for area-level education and income as covariates. The consistency of the result across all models indicating that OPAL was effective in reducing overweight and obesity amongst preschool children in South Australia is clear evidence of its overall population impact and benefit. OPAL's impact is all the more remarkable given that across Australia, during the same time period over which OPAL was effected in South Australia, the national prevalence of overweight and obesity in children and youth rose by 4.5 percent, from 21.8 to 26.3 percent (Cancer Australia 2018).

The OPAL evaluation included 20 intervention and 20 comparison communities with implementation data collected from all 20 intervention communities, across multiple time points. Evaluations of this scope are rare for community-based interventions. Within the EPODE International Network, where the *EPODE* model has been adopted by 500 communities, the South Australia OPAL intervention is extolled as an exemplar, for the rigour and thoroughness of the state co-ordinated comprehensive evaluation. In absolute terms, as given by the preventive fraction, the actions implemented by OPAL achieved a reduction of 12.2% in the extent of overweight and obesity that would otherwise have arisen across the 5-year intervention period and 2-year post-intervention periods combined. This intervention effect is of clear public health significance insofar as OPAL intervention results should be interpreted by their compelling practical and population health significance (Baguley, 2009). To have prevented 12.2% of cases of OW/OB is a considerably better achievement than the 5% mean gain seen by Rooney & Murray (1996) in their meta-analysis of social health intervention programs (mean effect size = 0.10). *OPAL, therefore, surpasses by a factor of 2.5 the average effects of similar types of social interventions*.

This large-scale, multi-site evaluation lends strong support to growing the evidence base regarding the effectiveness of 'whole-of-community' childhood obesity prevention programs currently embodied by single site or smaller scale multi-site evaluations such as *Shape-Up Sommerville* (USA) (Economos, Hyatt et al. 2013), *APPLE* (New Zealand)(Taylor, McAuley et al. 2008), *Eat Well Be Active* (Pettman, Magarey et al. 2014) and *Romp & Chomp* (de Silva-Sanigorski, Bell et al. 2010) (Australia).

4.2 CONTEXT BY INTERVENTION INTERACTIONS

Our evaluation findings provide new evidence on 'context by intervention' interactions; specifically, that the impact of OPAL on children's weight gain was modified by features of children's social and built environments. This is an important area for consideration when planning population strategies for health promotion initiatives: the need to anticipate whether contextual variations in both living conditions and opportunities for healthful living stand to: (i) complement or increase the benefit of a well-conceived policy or health promotion strategy, (ii) inhibit or attenuate any otherwise positive benefits of a given strategy, or (iii) implicitly perpetuate social health differentials through gains to those population segments most able to take up positive benefits, rather than population segments least able to receive or act on otherwise healthful incentives or prospects for health improvement. The findings outlined here suggest that population health initiatives should consider differential forms of program delivery, for example, more intensified efforts for direct outreach, use of different incentives or enabling strategies dependent on (i) variations in the values, attitudes and beliefs that predispose community members to take up and act on health improvement opportunities, and (ii) conditions of living (i.e., SES) and contextual factors (e.g., fast food density, walkability) present or absent that can support or compromise general supports.

For the social environment, the prevalence of overweight and obesity decreased over time for suburbs within the highest income tertile in the intervention condition, but not the comparison condition. That OPAL advantaged children living in higher SES neighbourhoods suggests children and families in these areas were best able to actively engage in OPAL intervention activities such as "Healthy Brekky Promotion" with their local grocer or 'Plant Your Own Fresh Snack." Further, they may have been better placed to take advantage of environmental changes effected by OPAL such as using one of the communities' "Water Bottle Refilling Stations."

For the built environment, the prevalence of overweight and obesity decreased over time for suburbs within the highest walk score tertile in the intervention condition, but not the comparison condition. Here, OPAL privileged children living in neighbourhoods that were more walkable. Using a distance decay algorithm, the walk score is an index which awards points based on distances to amenities, population density, and intersection density. Amenities within a 5-minute walk are given maximum points; no points are given after a 30-minute walk. It may be that a more walkable environment, with a lower intersection density, allowed parents to engage with their children in safe active travel. Safe walking corridors to school, and having children develop their own active travel maps to school, were initiatives mounted in multiple OPAL communities that would have been enabled by more walkable areas.

The prevalence of overweight and obesity slightly increased over time for suburbs within the highest fast-food tertile in the intervention condition, but there was no change in the comparison condition. A high concentration of fast-food outlets attenuated and reversed the otherwise positive effect of the OPAL intervention and was associated with a slight rise in overweight and obesity. For children and families living in an environment with McDonald's, Red Rooster and other fast food restaurants at their door-step, OPAL's healthy eating messages and activities such as 'Plant Your Own Fresh Snack" may have been less appealing. Although OPAL staff had financial resources, an annual budget of $75000 (while considered generous by health promotion standards) could have been insufficient to compete with the lucrative marketing strategies of commercial fast-food corporations that specifically target children.

Research on obesogenic environments has often been criticised for inadequately accounting for (i.e., “controlling”) confounding influences, since many built and social environmental characteristics vary together (UK Government's Foresight Program 2007, Daniel, Kestens et al. 2009). Not controlling for these influences can lead to residual confounding where apparent associations with aspects of the built environment simultaneously reflect features of the social environment that have not been controlled through design or analysis. Our analyses of the built environment, which included fast-food density, dwelling density and walkability accounted for both area- level education *and* area-level income. A strength of our analyses is that the measures of built environment which modified OPAL reductions of overweight and obesity were independent of and not confounded by these two key expressions of area-level SES, income and education.

That the impact of OPAL varied according to characteristics of the built environment highlights the need for future programs to account for such features in the planning and delivery of interventions. Despite the higher prevalence of childhood overweight/obesity in low SES areas, OPAL was more effective in higher SES areas. The implications of this reality imbue a sense of urgency to address structural inequities underlying this discrepancy in OPAL benefit (National Academies of Sciences 2018). At a programmatic level, drawing on a qualitative study on OPAL implementation, staff may require more resourcing and time to build up community ownership to overcome the barriers faced working in low SES areas: persistence alone may not be enough, and can lead to burnout (Richards, Kostadinov et al. 2014). The resources and supports required to reach under-served populations will vary by project. As an example, more streamlined local council approval, in one case, would have facilitated OPAL staff efforts to install a traffic signal on a busy road near a school in a disadvantaged neighbourhood; instead, a meridian was installed which was deemed less than ideal for promoting children’s safe active travel to school (Richards, Kostadinov et al. 2014). From a broad viewpoint, community-based health promotion programs may need to be enacted alongside policy to change the environmental moderators of individual health behaviours and for population-wide health benefits to be realised (Swinburn 2008, Baum 2014).

4.3 MERIT OF OPAL APPROACH

The positive effect of OPAL lends support to the continued use and potential scale-up of childhood obesity initiatives founded on community development and health promotion principles where new interventions are tailored to the local context using process-oriented and theory-informed program planning models. Such community-based interventions are considered ‘complex’ (Hawe, Shiell et al. 2004) and require staff with high-level strategic thinking and program planning skills. In OPAL, senior council managers with this high-level expertise were hired and worked, as a team, with junior staff. The OPAL program integrated staff training to enable ongoing learning and capacity-building related to the planning and implementation of OPAL goals, principles, and strategies (see Figure 1). The commitment to high quality staff training was a major strength of the OPAL program. Each year staff benefitted from three 4-day staff training sessions that included: council sharing; an externally facilitated staff reflection session; road maps of evidence-based interventions and capacity-building activities. The training enabled staff to plan and implement ecological programs and learn from each other's experiences as the program matured. The recruitment of high-level staff supported by junior team members and provision of ongoing training is likely to have buttressed the OPAL approach.

Relatedly, the positive intervention effect of OPAL supports the four pillars that comprise the *EPODE* model: political commitment, social marketing, evidence-based action, and partnerships (Borys, Valdeyron et al. 2010). Local government councils from each of the 20 intervention communities committed to supporting OPAL, financially, politically, as well as in co-locating OPAL staff within council. In this regard, while preceding it, the aim of OPAL aligned exceptionally well with the SA Public Health Act (2011) which reflects the state's approach to public health. With this Act, councils were required to include public health strategies in their local planning processes with the goal of creating healthful social and built environments to improve population health outcomes. Through the partnership principle and a call to engage 'Public Health Partner Authorities', the Act reinforced the need for establishing multi-sector partnerships. Support for programs like OPAL were a vehicle for establishing partnerships to improve population-level health outcomes.

4.4 STRENGTH OF WEAK PARTNERSHIP TIES

The sub-analysis of 20 intervention communities, found that a larger proportion of weak partnership ties between OPAL and community organisations was associated with reductions in the prevalence of childhood overweight and obesity. This relationship was consistent for metropolitan and regional areas for ties in Year 1, and across all years. A greater proportion of weak ties in Year 1, however, was associated with a reduced prevalence of overweight and obesity only in the lower SES areas.

The partnership measure was developed based on Granovetter's Strength of Weak Ties theory (Granovetter 1973). Adapted from Harris(Harris, Luke et al. 2008), it is the first time that a partnership measure has been applied across 20 intervention communities in a community-based intervention with data from more than two timepoints.

The theory posits that weak ties have the most potential to strengthen and develop into strong partnerships, increase network size and act as a bridge by connecting actors who may not otherwise work together. Granovetter's theory is relevant to the OPAL program, as implemented intervention strategies were aimed to reach target populations through the formation of partnerships in a range of settings (e.g., school, children's centres, grocery stores) and sectors (e.g., Education & Training, Transportation, Community Development, Sports & Recreation, Environment & Conservation). Weak ties, often represented as acquaintances or infrequent contacts, are integral to the growth of an inter-organisational network as they provide a mechanism through which new links are built (Jack 2005). Although partnerships can be productive at any level of strength (i.e., strong or weak) (Klak and Mullaney 2013), weak ties at the initial stages of a partnership can be most influential on partnership development – more so than the frequency of contact or strong ties at the beginning of the partnership (Uhlik 2011). On average, 70% of OPAL's partnership ties in the first year were 'weak'. Our data suggest that the strength of weak ties early on in a program is critical to lower SES areas where there is a greater need to mobilise resources and support across the whole-of-community for childhood obesity prevention.

Gancia's PhD thesis (Gancia 2017) on the evolution of partnership strength within OPAL found that communities largely started with a benchmark of 'weak ties' which then strengthened over time, but, as OPAL staff planned to 'exit the community' and transferred the responsibility for projects to partner organisations, the proportion of weak ties then rose again, this summary highlighting that the trajectory of the proportion of weak ties was curvilinear. Gancia's study also found that OPAL staff developed stronger partnerships with the 'four big sectors' already working with and invested in children – Education, Sports & Recreation, Community Development and Kids, Youth & Families. Stronger ties from these four sectors considered against the weaker ties associated with the remaining nine sectors suggests a tipping point in favour of 'the strength of weak ties' which this evaluation found to be associated with a reduction in the prevalence of overweight and obesity in children. These weak ties allowed OPAL to be visible, break down silos, and collaborate in a community-wide network. Hence, the apparent sustainability of the positive OPAL intervention effect on the prevalence of children's BMI two years following the termination of state funding may be due to the strength of weak ties owing, in part, to the transfer of responsibility and ownership to community organisations so an "OPAL sized whole" wasn't left in the community (Gancia 2017). This interpretation aligns with the literature which suggests that weak ties are especially conducive to program sustainability, as they can often develop into strong partnerships (Evashwick and Ory 2003).

4.5 COMMUNITY LEADERSHIP

Findings from the sub-analysis of intervention communities provide new and important empirical evidence on the importance of community leadership in community-based health promotion efforts focussing on children's weight change over time. Higher scores at baseline and greater change in leadership readiness both aligned with reductions in the prevalence of overweight and obesity over time. However, these effects were modified by area-level SES and restricted to low SES areas only, even within an overall OPAL context that principally benefitted higher SES areas.

Findings on leadership readiness underscore the importance of the commitment and buy-in of community leaders to childhood obesity prevention. Communities where, at baseline, leaders either 'denied that obesity was a local problem or acknowledged that it was an issue, but nothing needed to be done' were less likely to reap the benefits of OPAL (in terms of reducing the prevalence of child overweight and obesity). During the program, OPAL staff used a multitude of strategies to raise awareness and secure support from community leaders. There was an average change, from baseline to 2015, in community leadership support of almost two points on the nine-point scale, on par with other studies (Kostadinov, Daniel et al. 2015). Some communities gained, however, strong support from community leadership from baseline, moving up three to four points on the leadership readiness scale. These higher levels of support attained are indicative of, "leadership involvement in or active support of continuing current childhood obesity prevention efforts AND providing or finding resources for efforts to become self-sufficient" or "leadership actively participating in expanding or improving childhood obesity prevention efforts." These higher levels of community leadership are reflective of program sustainability, supported by the continued decline in the prevalence of overweight and obesity in the intervention communities two years following the cessation of state funding.

The observation of no relationship found for baseline readiness, or change in readiness, in higher SES areas suggests that leadership may be more important in lower SES areas, potentially for leveraging resources to reach and engage children and families living in more impoverished conditions in active travel, active recreation and healthy eating activities and messaging.

The assessment of leadership readiness has been streamlined by the work of Kostadinov, who has developed an online survey tool (easily adapted to a paper-based format) that can be completed in less than 10 minutes (Kostadinov, Daniel et al. 2015, Kostadinov, Daniel et al. 2016). Future community-based interventions should assess baseline leadership readiness and, where leadership levels are indicative of resistance or vague awareness, strategies can be employed to raise awareness that a problem exists locally and that the community can do *something* (Plested, Edwards et al. 2007).

4.6 LIMITATIONS

The evaluation findings reported here are subject to limitations.

1. The quasi-experimental non-equivalent control (comparison) group design explicitly recognises in its very name non-equivalence between intervention conditions. True equivalence is the aim of true experimental interventions involving randomisation and in proportion to sample size will increase the likelihood that inherent differences between experimental groups (people) will be equalised between conditions. Without randomisation there are always differentials in certain characteristics that may or may not bias or confound the inferred impact of an intervention. In the case of this evaluation various procedures were used to reduce the likelihood of competing influences accounting for the inferred intervention effects: matching of communities, stringent statistical procedures controlling for both area-level education and income, and rigorous analytic strategies that statistically accounted for the clustering of observations at three levels which had the effect of increasing variance estimates and reducing the statistical significance of estimated parameters. Statistical tests also accounted for chance effects related to multiple comparisons. These conservative strategies reduce but do not exclude the possibility of bias or confounding that could present alternate explanations for the effects inferred. Residual confounding due to unmeasured influences is an additional potential threat to the validity of the results.

2. The intervention effect reported may be underestimated given potential contamination by OPAL activities spreading from intervention to comparison suburbs. Especially for the metropolitan area, communities are collections of contiguous suburbs and any group distinction can be only artificial, relevant to administrative purposes, but not defining any meaningful break in living conditions or built environmental circumstances. Some intervention suburbs were adjacent to comparison suburbs and it is highly likely that intervention activities intended for children and residents of intervention suburbs ‘spilled-over’ into adjacent comparison suburbs.

3. Until 2010 approximately 65 percent of 4-year-olds attended the child health check in South Australia. Attendance since has declined into the mid-50 percent range; however, there is no evidence to suggest that children receiving a health check differ from those who do not.

4.7 CONCLUSION

This large-scale multisite quasi-experimental evaluation of a state-wide community-based childhood obesity prevention program provides compelling evidence in favour of effectiveness in the reduction of childhood overweight and obesity due to the program. For the 20 communities in the intervention condition relative to the 20 matched communities in the comparison condition there was an overall decrease in the prevalence of overweight and obesity. In absolute terms, the impact of OPAL due to actions implemented was a reduction of 12.2% in the extent of overweight and obesity that would otherwise have arisen. OPAL effects were independent of area-level income and education which eliminates confounding by these socio-economic status variables as competing explanations. Positive reduction in overweight and obesity continued across the two years following the cessation of funding, indicating that OPAL sustained a positive effect for at least the short term.

This evaluation provides new and valuable empirical evidence documenting 'context by intervention' interactions; specifically, that the impacts of OPAL on children's weight was modified by features of children's social and built environments. This is an important area for consideration when planning population health promotion actions: the need to anticipate whether contextual variations in living conditions and opportunities for healthful living stand to (i) complement or increase the benefit of a well-conceived policy or health promotion strategy, (ii) inhibit or attenuate any otherwise positive benefits of a given strategy, or (iii) implicitly perpetuate social health differentials through gains to those population segments most able to take up positive benefits, rather than population segments least able to receive or act on otherwise healthful incentives or prospects for health improvement. The findings outlined here also suggest that population health initiatives should consider differential forms of program delivery, for example, more intensified efforts for direct outreach, use of different incentives, or enabling strategies dependent on (i) variations in the values, attitudes and beliefs that predispose a capacity to take up and act on health improvement opportunities, and (ii) conditions of living and contextual factors present or absent that can support or compromise general supports.

This evaluation also provides a number innovative and novel insights into mechanisms of program action. The sub-analysis of the 20 intervention communities found that a larger proportion of weak partnership ties between OPAL and community organisations was associated with reductions in the prevalence of childhood overweight and obesity. This relationship was consistent for metropolitan and regional areas and across high and low SES areas. This finding indicates that the nature of the relationship between OPAL and the 13 OPAL sectors was important. This evaluation is the first time ever that a partnership measure has been applied in a community-based intervention across more than two timepoints in a longer-term, large-scale initiative involving 20 intervention communities. In addition, the sub-analysis of the 20 intervention communities also provides new and important *empirical* evidence on the vital role of community leadership in community-based health promotion efforts focussing on childhood obesity and overweight. The data-based inference that leadership is most important for low relative to high SES areas has clear application for public health practice: it delivers an imperative for committed engagement for planning with such population segments.

The positive intervention effect of OPAL affords support to the *EPODE* model and the continued use and potential scale-up of childhood obesity initiatives based on community development and health promotion principles where interventions are tailored to the local context through process-oriented and theory-informed program planning models. The OPAL evaluation supports the four pillars which comprise the *EPODE* model: political commitment, social marketing, evidence-based action, and partnerships. The finding that the built and social environmental contexts of the OPAL communities served to modify the OPAL program gives credence to the SA Public Health Act (2011) which draws attention to the innate link between local health matters and the local environment by requiring public health strategies to be accounted for in urban planning processes with the goal of creating healthful social and built environments to support positive population health.

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6 APPENDICES

6.1 APPENDIX 1: DETAILED STATISTICAL METHODOLOGY

This material supplements the statistical description given in Section 2.5. The primary outcome was the prevalence of 4 to 5 year-old children either overweight or obese, observed at the suburb level. Thus, the unit of analysis with repeated measures was the suburb, nested within OPAL communities nested within intervention conditions. The hierarchical data structure stipulated "time" in years as the first level of clustering as suburb-level prevalence rates were tracked over time for 12 years: 5 years pre-intervention + 7 years intervention period. The second level of clustering was the suburb within community, and the third level the community within intervention conditions. Multi-level modelling was used.

Initial exercises assessed time effects as a (i) simple linear function (linear trend), (ii) non-parametric function of B-Splines (piecewise functions of time joined according to a given number of knots); and (iii) interrupted time series approach, dividing the study period into two segments, before and after intervention periods (Wagner et al., 2002; Wang et al., 2013). Several key considerations precluded using a time series approach: (i) the numbers of the time points pre-intervention (5 years) and post-intervention (0-2 years, depending on OPAL Phase) were not equally distributed as is a fundamental requirement (Bernal et al, 2017); (ii) the low number of total time points – 10 to 12 points depending on OPAL Phase, it being well established that analyses involving fewer than 18 time points are highly underpowered, thus suspect (Zhang et al. 2011); (iii) the low anticipated OPAL effect size where it is known that the interrupted time series analysis is best suited to interventions where the effect size can be anticipated to be at least 0.50 (Zhang et al. 2011) (unlikely for OPAL as a program aimed at changing behaviour to reduce OW/OB); (iv) the assumption that the outcome would be unchanged in the absence of the intervention – not the case for OPAL, as prevalence rates of OW/OB had risen over time and were rising when OPAL was initiated (Penfold & Zhang, 2013); (v) the assumption that the comparison group be as similar as possible to the intervention group (i.e., exchangeability in the outcome between groups in the absence of the intervention) (Zhang et al., 2011) – not the case with OPAL as intervention communities were chosen based on prior knowledge of need, given rising rates of OW/OB; and (vi) the requirement to have hypothesised ***a priori*** how the intervention would affect the outcome, in terms of change in level only (mean), change in slope only (secular trend), or both (Bernal et al., 2017) – not pre-anticipated. Therefore, for these reasons, an interrupted time series approach was not used; rather, best judgement was applied to account for pre-intervention trends in OW/OB across the intervention and comparison communities, to best conserve statistical power.

A non-parametric analysis with three knots was seriously debated. However, based on model fit (AIC and BIC indices) and, importantly, to support clarity in the interpretation of models (especially for effect modification analyses), time was ultimately modelled as a linear trend.

Change in suburb-level prevalence rates of OW/OB over time (i.e., combined pre-intervention and intervention periods) was assessed using binomial regression models, using a binomial distribution for count data with the total number of children per suburb per year as the offset or denominator, given that the prevalence rates of OW/OB exceeded ~10% (Sanford Weisberg, 2005; Deddens JA &

Petersen MR, 2008). Random effects for suburbs and OPAL communities were imposed to capture further (unknown) suburb-level and community-level sources of variability. We used the variance-component as the variance-covariance structure and source of autocorrelation, leading to suburb-level and community-level intra-class correlations.

There were 217 suburbs in the intervention condition and 254 suburbs in the comparison condition, totalling 471 suburbs within 40 OPAL communities (20 per each of the intervention and comparison conditions). There was a total of 4,356 observation-years across the 5-year pre-intervention period (-4 to 0 phase years) and 7-year intervention period (1 to 7 phase years). Suburbs with fewer than 5 children per suburb per year were excluded ("5" is the cut-off used by Australian Bureau of Statistics for analysis and reporting). This exclusion yielded 199 suburbs for the intervention condition and 235 suburbs for the comparison condition.

Patterns of observations over 12 years were smoothed and modelled as linear trends (overall secular trend, *time* in the inferential models), with intervention condition and a time*intervention condition interaction term added to the model to assess the effects over time of exposure versus no exposure to OPAL (basic model adjusted for region, OPAL phase, and pre-intervention OW/OB prevalence, i.e., Model I, main effect, Table 7, this report). Further models included area-level socioeconomic status indicators (income, education) and built environmental characteristics.

We accounted for secular trends using two strategies. First, we accounted for the pre-intervention baseline (Year "0") prevalence of overweight and obesity. The baseline rate was computed as the prevalence at baseline for each respective Phase, at one year prior to intervention (time=0) or at two years prior to intervention (time=-1) if missing at time=0. The results of this analysis are summarised below, in Table 1a, Model **I**. The "time" and "time*intervention condition" terms are statistically significant, and the parameter estimates indicate that the success of the OPAL intervention reflects no increase in OW/OB in the intervention condition, whereas OW/OB rates increased over time in the comparison condition. This is a classic indication of a positive effect for a quasi-experiment.

The second strategy to account for secular trends was to adjust for the weighted average of the pre-intervention rates of OW/OB for phase years -4 to 0. These results are summarised below, in Table 1a, Model **II**. The results are consistent with Model I: the "time" and "time*intervention condition" terms are statistically significant, and the parameter estimates similarly indicate a positive effect of OPAL for change in the intervention condition relative to the comparison condition.

Table **1b** Models **III** and **IV**, below, align to Table 1**a** Models I and II, respectively, differing only in adjustment for OPAL phases, region, and socio-economic status.

The first, rather than second, approach for accounting for pre-intervention differences in OW/OB prevalence was selected, given its greater statistical power. Thus, Model I, Table 1a and Model III, Table 1b are as reported in this report, Section 3.

Table 1a. Results of inferential models for Research Question #1 (intervention effect), specifically, two approaches to account for pre-existing differences in rates of OW/OB prior to the initiation of the intervention, *unadjusted* for covariates

Effects	**Model I [1] baseline prevalence = Phase Year 0**			**Model II [2] Baseline prevalence = Phase Year -4 to 0**		
	estimate	**95% CI**	**p value**	**estimate**	**95% CI**	**p value**
Baseline Prevalence	0.0341	0.0074; 0.0608	0.012	0.8930	0.5465; 1.2394	<0.001
Intervention	0.1541	0.0866; 0.2217	<0.0001	0.1395	0.0616; 0.2175	<0.001
Time	0.0093	0.0014; 0.0171	0.020	0.0158	0.0014; 0.0301	0.031
Time*interv.[3]	-0.0133	-0.0233; -0.0034	0.008	-0.0224	-0.0406; -0.0043	0.016
Time (IC)	-0.0037	-0.0098; 0.0024	0.232	-0.0067	-0.0178; 0.0045	0.241
Time (CC)	0.0095	0.0016; 0.0173	0.018	0.0158	0.0014; 0.0301	0.031

[1] Model I uses all 12 years of data: 4 years pre-intervention, baseline year "0", 5 years intervention and 2 years post-intervention; it adjusts for baseline prevalence as pre-intervention rate of overweight/obesity at time = 0;

[2] Model II uses all 12 years of data and adjusts intervention and post-intervention effects for weighted mean pre-intervention rates of overweight/obesity for Phase Years -4 to 0;

[3] Coefficient is the difference between group slopes; coefficients for Time (IC) (intervention condition) and Time (CC) (comparison condition) are the within group slopes.

Table 1b. Results of inferential models for Research Question #1 (intervention effect), specifically, two approaches to account for pre-existing differences in rates of OW/OB prior to the initiation of the intervention, *adjusted* for covariates

Effects [4]	**Model III [1] baseline prevalence = Year 0**			**Model IV [2] Baseline prevalence = Year -4 to 0**		
	estimate	**95% CI**	**p value**	**estimate**	**95% CI**	**p value**
Baseline Prevalence	0.0216	-0.0043; 0.0475	0.102	0.5231	0.1792; 0.8670	0.003
Intervention	0.1194	0.0656; 0.1732	<0.0001	0.1251	0.0515; 0.1988	0.001
Time	0.0086	0.0007; 0.0164	0.032	0.0150	0.0006; 0.0293	0.041
Time*interv.[5]	-0.0153	-0.0256; -0.0051	0.003	-0.0217	-0.0398; -0.0036	0.019
Time (IC)	-0.0039	-0.010; 0.0022	0.212	-0.0068	-0.0180; 0.0043	0.230
Time (CC)	0.0089	0.0011; 0.0168	0.025	0.0150	0.0006; 0.0293	0.041

[4] Models III and IV are as specified for Models I and II, respectively, but adjusted for OPAL phase, region (urban versus rural) and both area education and income;

[5] Coefficient is the difference between group slopes; coefficients for Time (IC) (intervention condition) and Time (CC) (comparison condition) are the within group slopes.

References for Appendix 1

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