Assessing Cost-effectiveness *of* Obesity Prevention Policies *in Australia*

ACE-OBESITY POLICY 2018

DEAKIN UNIVERSITY

DEAKIN HEALTH ECONOMICS

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Where to find the report and associated publications

An electronic version of this report and other outputs from this program of work are available at: www.aceobesitypolicy.com.au

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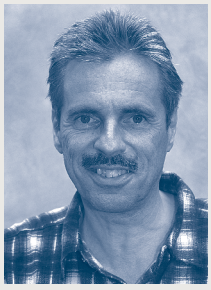

Dedication to Associate Professor Jan Barendregt

For Jan Barendregt, without whose technical expertise in epidemiological modelling this project would not have been possible. Jan's life ended too soon, and he will be sorely missed. His work will continue to inform and influence health decision-making, and this will add healthy years to the lives of countless anonymous others around the world for many decades to come.

Assessing **Cost-effectiveness** *of* **Obesity Prevention Policies** *in Australia*

ACE-OBESITY POLICY 2018

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Foreword

Chronic diseases are a major and growing health problem for Australia and similar economy countries. Rates of chronic disease are also growing in emerging economy countries. In Australia, the single biggest uncontrolled risk factor for chronic disease is overweight and obesity. The impact of obesity is not confined to increasing the risk of chronic disease with, for example, impacts on the costs of all hospitalisations, poorer outcomes post-elective surgery, and increased risk of pregnancy-related complications. It is also a concern that the obesity in one generation may impact on the next, with maternal obesity or excess weight gain associated with higher risk of obesity in offspring.

The reasons why a large proportion of our community are now living with overweight or obesity clearly lie beyond individual behaviour alone. When being overweight or obese affects more than 60% of our population, we have to look to the broader determinants to better understand the pattern of disease, and why some population groups have higher rates of obesity than others.

The most successful public health interventions, based on sound population health science, have almost always involved measures beyond individual behaviour change. We now have a growing evidence-base about interventions that can impact on the incidence and prevalence of overweight and obesity in our community. The prioritisation of the implementation of these interventions will need to take into account both the variations within our communities and be based on the assessment of the best return on investment. The successes in tobacco control and HIV also show us the importance of considering the potential for adoption given the social, political and cultural environment at the time - it requires a progressive building of strategy.

The NHMRC Centre of Research Excellence in Obesity Policy and Food Systems, led by Alfred Deakin Professor Rob Carter, has made a unique and substantial contribution to developing and prioritising the evidence-base for intervening in relation to obesity. It has brought together public health scientists, health economists and policy researchers to address this complex issue. It has produced informative reports, backed by peer-reviewed scientific publications, to drive discussion of the interventions that result in the best return on investment. Importantly it has substantially built capacity in the field, through its fellows and PhD students. This report provides a summary of obesity prevention interventions from the perspective of best investment and beyond the specifics of obesity; it can serve as a model for comprehensive assessment of public health interventions. The evidence generated from this report will be an important tool to assist the public health community and decision-makers in policy and practice understand the priorities for addressing this major public health problem.

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Executive summary

The current obesity epidemic in Australia and around the globe has significant negative health and economic consequences. Addressing this problem will require a comprehensive societal response, including implementation of a suite of multi-sectoral government policies. Informed government action requires reliable comparative evidence on the costs and benefits of various policy options.

ACE-Obesity Policy is a priority-setting study that aimed to evaluate the economic credentials of a range of obesity prevention policies (including both regulatory and program-based interventions), across multiple sectors and multiple areas of governance (local, state and federal governments, and the private sector). The study formed part of the broader body of work of the National Health and Medical Research Council funded Centre of Research Excellence in Obesity Policy and Food Systems (APP1041020: 2012-2018), and answered the research question: "*What are the most effective, cost-effective, affordable and implementable policy options to prevent obesity across a range of settings?*"

The Assessing Cost-Effectiveness (ACE) approach was adopted – characterised by the use of consistent, rigorous methods for the technical cost-effectiveness analyses (including extensive uncertainty analyses), alongside qualitative analyses of key implementation considerations relevant to policy decisions (strength of evidence, equity, acceptability, feasibility, and sustainability). The modelling of expected health benefits and related costs in response to an intervention was based on a previously developed proportional, multi-state, life table Markov model.

Key advancements made to the model as part of the ACE-Obesity Policy study included:

- the integration of physical activity and fruit and vegetables intake as risk factors (in addition to body mass index);
- the development of an equity-focused version of the model that allowed the quantification of the differential cost, health and cost-effectiveness outcomes across different socio-economic position (SEP) groups; and
- modifications to allow better quantification of interventions targeted at children.

ACE-Obesity Policy is a priority-setting study that aimed to evaluate the economic credentials of a range of obesity prevention policies across multiple sectors and multiple areas of governance.

Intervention selection was based on a deliberative process that included consideration of:

1. the potential impact on addressing obesity in Australia;
2. the relevance to current policy decision-making; and
3. the availability of evidence for intervention effectiveness.

Full economic evaluations were conducted for 16 interventions, with 50 different scenarios explored. Evidence reviews were completed for a further 12 interventions, but full economic modelling was not conducted due to the lack of evidence for effectiveness required to complete a robust evaluation.

All 16 interventions were found to be cost-effective approaches to addressing obesity in the Australian population. Eleven of these interventions were estimated to produce health benefits and save costs in the long term (classified as 'dominant'). The five remaining interventions were estimated to produce health benefits at a cost well below the common decision threshold used in Australia (classified as 'cost-effective'). Extensive uncertainty, threshold and scenario analyses showed that results were robust to changes in intervention-specific key input variables and assumptions.

An intervention to increase the price of alcohol through a uniform volumetric tax performed best in terms of its cost-effectiveness credentials and health benefits. This intervention has not previously been evaluated as an obesity prevention measure. Regulations to tax sugar-sweetened beverages and restrict television advertising of unhealthy foods ranked second and third on the cost-effectiveness league table, and have both been recommended by authoritative obesity prevention reports and health promotion bodies as key components of an obesity prevention strategy. This study is the first to evaluate the cost-effectiveness of several other promising obesity prevention interventions such as: restrictions on price promotions of unhealthy foods; supermarket shelf-tags on healthier products; and workplace interventions to reduce sedentary behaviour.

The vast majority (seven out of nine) regulatory interventions evaluated were dominant, compared to around half (four out of seven) of the program-based interventions. These differences were largely driven by the increased implementation costs of program-based interventions. However, the modelling of program-based interventions was generally based on stronger evidence for intervention effectiveness. Due to limitations in the current state of the evidence, the modelling of many of the regulatory interventions was based on their demonstrated impact on dietary and physical activity outcomes; their likely impact on body weight was generally based on the assumption that diet and physical activity outcomes are sustained without compensatory behaviour.

Effective action to prevent obesity will not be possible without strong governmental leadership and commitment.

Two interventions (related to taxing sugar-sweetened beverages, and restricting television advertising of unhealthy foods) were quantitatively evaluated for their impact on equity. Both evaluations found a positive impact on equity of health outcomes, with higher health gains in the lower SEP groups. The qualitative assessment that included a judgement on both process and outcome dimensions of equity, found that many of the most cost-effective interventions also resulted in higher out-of-pocket costs relative to income for lower SEP groups. Governments need to consider the design of obesity prevention interventions to ensure inequities are not exacerbated (e.g., hypothecation of taxes to benefit those in special need and from lower SEP groups).

Effective action to prevent obesity will not be possible without strong governmental leadership and commitment. Challenges will arise from the following:

1. Several interventions evaluated in this study may reduce specific company profits resulting in low levels of industry acceptability.
2. Many of the health benefits and cost-savings may only materialise in the longer term (i.e., beyond any single political cycle).
3. Many of the recommended interventions are cross-sectoral in nature, and successful implementation will require a whole-of-government approach with inter-departmental co-operation and co-ordination.
4. Broad-based societal support for obesity prevention needs to be mobilised.

Despite these challenges, the great potential for substantial health benefits stemming from the obesity prevention interventions evaluated in this study can be used to garner a coalition of support for these policies.

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Abbreviations

ACE	An abbreviation given to the methodology developed by Carter & Vos in leading economic evaluations involving multiple interventions (priority-setting). ACE is short-hand for Assessing Cost-Effectiveness and is commonly used in study titles (e.g. ACE-Obesity; ACE-Prevention) or in reference to ACE methods.
AIHW	Australian Institute of Health and Welfare
AUD	Australian Dollar
B	Billion
BMI	Body Mass Index (measured in kilograms per metre squared, kg/m^2)
CHEERS	Consolidated Health Economic Evaluation Reporting Standards
CHOICES	Childhood Obesity Interventions Cost-Effectiveness Study
CRE	Centre of Research Excellence
DALY	Disability Adjusted Life Year
GDP	Gross Domestic Product
GLOBE	Global Obesity Centre
HALY	Health Adjusted Life Year
HRQoL	Health Related Quality of Life
ICER	Incremental Cost-Effectiveness Ratio
IRSD	Index of Relative Socio-economic Disadvantage
kg	Kilogram
kJ	Kilojoule
LY	Life Year
M	Million
MET	Metabolic Equivalent Task
NCD	Non-Communicable Disease
NE	North east quadrant of the cost-effectiveness plane
NHMRC	National Health and Medical Research Council
NUTTAB	Food Standards Australia New Zealand nutrient tables
NW	North west quadrant of the cost-effectiveness plane
OECD	Organisation for Economic Co-operation and Development
OPIC	Pacific Obesity Prevention In Communities study
PA	Physical Activity
PIF	Population Impact Fraction
PSC	Project Steering Committee
pYLD	Prevalent Years Lived with Disability
RCT	Randomised Controlled Trial
RR	Relative Risks
SE	South east quadrant of the cost-effectiveness plane
SEIFA	Socio-Economic Indexes for Areas
SEP	Socio-Economic Position
SW	South west quadrant of the cost-effectiveness plane
UI	Uncertainty Interval
USA	United States of America
WHO	World Health Organization

One Introduction

1.1 The problem of obesity

Over the last three decades, the prevalence of overweight and obesity[1] has increased substantially. Globally, approximately 1.9 billion adults are overweight or obese. Furthermore, an estimated 380 million children are estimated to be overweight or obese (1). Australia has the 5th highest prevalence of obesity among countries in the Organisation for Economic Co-operation and Development (OECD) (2). In Australia, approximately 63% of the adult population and 27% of children are either overweight or obese (3). Obesity prevalence is disproportionate across population groups, with Indigenous Australians and individuals from lower socio-economic position (SEP) groups more likely to have an elevated body mass index (BMI) (3).

Obesity has serious health consequences. Raised BMI is a major risk factor for diseases such as cardiovascular disease, type 2 diabetes, musculoskeletal conditions and many cancers (4). These diseases, often referred to as non-communicable diseases (NCDs), not only cause premature mortality but also long-term morbidity (3). In 2016, overweight and obesity were the greatest contributors to Australia's burden of disease (5). In addition to the health impact, obesity also has a substantial economic impact on Australia with the most recent estimates indicating that the direct (medical) costs of obesity are approximately $3.8 billion (2014-2015 values) per year, with indirect costs (related to reduced productivity) of an additional $8.6 billion dollars each year (6).

The aetiology of overweight and obesity is relatively simple. It results from sustained energy imbalance where energy consumed, through food and beverage intake, is higher than the energy expended, through bodily functions and physical activity. The causes of this imbalance are highly complex, with many individual, social and environmental factors contributing to the epidemic (7). Nevertheless, there is global recognition that the increased supply of relatively cheap, tasty, energy-dense food, improved food distribution and marketing, alongside strong economic forces driving consumption and growth are key drivers of the obesity epidemic (8). The changes to the food environment have been accompanied by a shift to more sedentary lifestyles, through increased urbanisation, greater use of cars, and more office-based occupations (9).

In Australia, approximately 63% of the adult population and 27% of children are either overweight or obese.

1 Overweight and obesity are defined by the World Health Organization (WHO) as "abnormal or excessive fat accumulation that presents a risk to health". (WHO, 2013. Available from: https://www.who.int/nmh/events/ncd_action_plan/en/) For adults, overweight and obesity are most commonly measured by Body Mass Index (BMI): body weight in kilograms divided by the square of height in metres (kg/m^2). A BMI over 25 is considered overweight, and a BMI over 30 is considered obese. In children (aged less than 18 years), overweight is defined as a BMI at or above the 85th percentile and below the 95th percentile for children of the same age and sex, whereas obesity is defined as a BMI at or above the 95th percentile for children of the same age and sex. (WHO, 2003. Available from: http://www.who.int/dietphysicalactivity/publications/trs916/en/)

1.2 Policy response to obesity[2]

There is global consensus that efforts to address obesity require a comprehensive societal response (10). This includes government policies (potentially including regulations, taxation/subsidies, programs and infrastructure), across a wide range of sectors, such as health, education, agriculture, transport, trade and finance, as well as wide-scale action from the private sector and community groups (11).

To date, much of the obesity prevention effort has focussed on individual treatments or health promotion programs. The development and implementation of recommended government policies that target the environmental and systemic drivers of obesity have generally been slow and inadequate globally (12). A recent assessment of the Australian government's efforts to address obesity found that while Australia is meeting best practice in the implementation of some policies (e.g., in the area of food labelling), there are a number of areas where Australia is lagging significantly behind other countries in their efforts to address obesity (13).

Some important reasons for the lack of implementation of recommended policies in Australia include:

- limited evidence of the economic impact of recommended interventions;
- strong pressure from the food industry to minimise regulations that may reduce its profitability;
- government limitations, including difficulties in implementing policies that have an impact on multiple sectors and a lack of political leadership in the area; and
- lack of strong, broad-based public support for change (14-16).

1.3 Priority-setting for obesity prevention

Despite the growing burden of preventable diseases, the health budget for prevention efforts is only 1.34% of Australia's health expenditure (17). This is considerably less than prevention expenditure in comparable countries such as Canada, the United Kingdom and New Zealand (17). Within this limited budget, governments need to prioritise what interventions to fund. Economics is a useful discipline for priority-setting, as its core purpose is to address the question of how to allocate scarce resources to maximise societal welfare (18, 19). Economic evaluations enable decision-makers to make informed judgements based on the value-for-money of potential policy actions.

Economic evaluations enable decision-makers to make informed judgements based on the value-for-money of potential policy actions.

Over the last 15 years, there has been an increase in economic evidence to guide decision-making on obesity-related policy, with most evaluations focused on medical treatments for obesity, such as pharmaceuticals and bariatric surgery, and fewer on obesity prevention policies (20). Despite the growing number of economic evaluations related to obesity, single intervention evaluations are limited in their ability to inform priority-setting decisions. Policy makers require comparative evidence on multiple policy-relevant interventions that are appropriate for their local population and decision context (20, 21).

The Assessing Cost-Effectiveness (ACE) methodology was developed in Australia, and has been utilised in two Australian obesity-related priority-setting studies: 'ACE-Obesity' and 'ACE-Prevention' (22, 23). ACE-Obesity (2004-2006) evaluated the cost-effectiveness of 13 obesity prevention and treatment interventions targeted at children and adolescents (24). The ACE-Prevention study (2006-2010) evaluated 150 interventions, primarily targeting the prevention of NCDs, with nine interventions related to obesity (23). These ACE studies have made major contributions to the application of population modelling as part of priority-setting exercises related to prevention, and have influenced successive international priority-setting studies (25-27).

2 For the remainder of this report, the term obesity is used to mean "overweight and obesity", unless specifically mentioned.

The international experience of priority-setting studies related to obesity are summarised below:

- The economics component of the Pacific Obesity Prevention in Communities (OPIC) study (27) aimed to facilitate evidence-based food policy decision-making in the Fijian and Tongan contexts. The most cost-effective interventions were policies related to import duties on food products, and policies related to food prices and food availability.
- The OECD and World Health Organization (WHO) microsimulation chronic disease prevention modelling (28) assessed the cost-effectiveness of seven obesity prevention interventions for six developing countries. The most cost-effective interventions were those that had large population coverage and had low implementation costs (i.e., restricting marketing of unhealthy foods to children and interventions affecting the price of foods).
- The Childhood Obesity Interventions Cost-Effectiveness Study (CHOICES), USA (26) used the ACE approach to evaluate a range of childhood obesity prevention policies related to nutrition and physical activity.

Further analyses showed that primary prevention interventions were more likely to be cost–saving compared to treatment interventions.

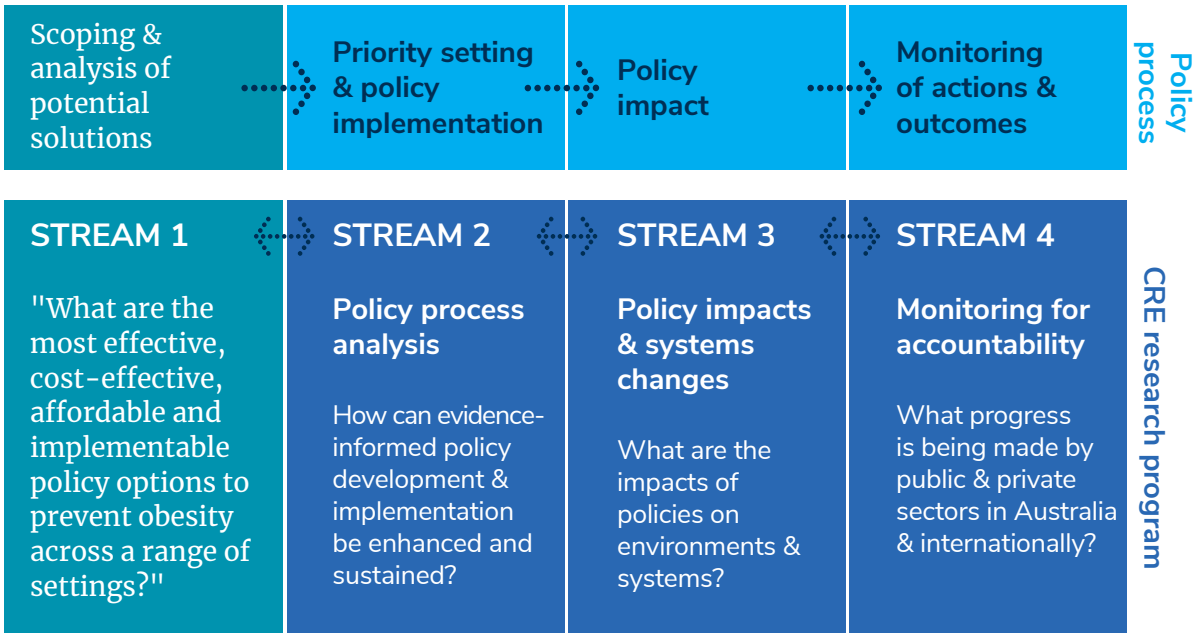
A review of the economic credentials of the 22 obesity-related interventions from the Australian ACE studies showed that the majority of the interventions addressed the downstream causes of and treatments for obesity, including medical interventions and interventions targeted at individual behaviour change. Only three interventions targeted the upstream determinants of obesity (i.e., 'reduction of advertising of unhealthy food and beverages to children', 'front-of-pack traffic light labelling', and 'unhealthy food and beverage tax'); all three of these interventions were found to be cost-saving. However, these interventions also rated high on the scale of political difficulty for implementation. Further analyses showed that primary prevention interventions were more likely to be cost-saving compared to treatment interventions. Interventions involving regulations and taxes were all cost-effective; whereas, only some of the program-based interventions, which usually required additional skills, services and funding for ongoing implementation, were cost-effective (20). The previous ACE studies were undertaken using a health sector viewpoint (or study perspective), where all costs and benefits relevant to government departments of health, and healthcare-related costs and benefits to the individual are incorporated. This perspective has limitations in capturing the costs and benefits that accrue to sectors other than health, and is therefore particularly limiting when considering broad-based obesity prevention interventions. Despite obesity being more prevalent amongst the most disadvantaged groups in our community, previous assessments of the impact of interventions on equity have been limited to qualitative analyses.

This study - the ACE-Obesity Policy study - focused on the current gaps in the economic evidence by evaluating a range of obesity prevention policies (including both regulatory and program-based interventions) across multiple sectors and multiple areas of governance (local, state and federal governments, and the private sector). It evaluated interventions that targeted the upstream determinants of obesity, and considered the impacts of interventions beyond the health sector perspective that was the focus of previous analyses. In addition, the ACE-Obesity Policy study aimed to quantify the equity impacts of several interventions and incorporate them into the technical cost-effectiveness results.

1.4 NHMRC Centre of Research Excellence in Obesity Policy and Food Systems

The ACE-Obesity Policy study formed part of the National Health and Medical Research Council (NHMRC) funded Centre of Research Excellence (CRE) in Obesity Policy and Food Systems (APP1041020; 2012-2018). The overarching aim of the research program was to '*reduce the burden of obesity and nutrition-related disease through methods development, training and knowledge exchange on policy actions for creating healthy, sustainable, equitable food systems and reversing obesogenic environments*'. The research program was structured around the policy-making process and was organised into four streams. Although it is recognised that the policy-making process is rarely linear, the program aimed to provide policy relevant research evidence at each step of the policy process (29) (Figure 1).

Figure 1 ***Overview of the NHMRC Centre of Research Excellence program of work***



ACE-Obesity Policy aimed to identify promising solutions to the obesity epidemic, and to provide economic and implementation evidence required by decision-makers (Stream 1 in Figure 1). Research in Stream 2 involved analyses of examples of obesity prevention policy development and implementation processes to answer the question: 'How can evidence-informed policy development and implementation be enhanced?' In recognition that obesity is a result of complex interactions between individuals and the environment they live in, Stream 3 aimed to take a more sophisticated systems approach to the analysis of the impact of policies on local environments. Stream 4 aimed to monitor the progress of governments and the private sector in improving food environments as a means of motivating the major influencers of the food environment.

Key findings from Streams 2, 3 and 4 are available electronically at:
www.aceobesitypolicy.com.au

> The overarching aim of the research program was to *'reduce the burden of obesity and nutrition-related disease through methods development, training and knowledge exchange on policy actions for creating healthy, sustainable, equitable food systems and reversing obesogenic environments'.*

two Methods

2.1 Research question

The research question for this priority-setting study was:

"What are the most effective, cost-effective, affordable and implementable policy options to prevent obesity across a range of settings?"

This study aimed to inform decision-making at various levels about the package of obesity prevention interventions offering the greatest 'value-for-money' by conducting high quality, collaborative research.

2.2 The ACE approach

Although there is no 'gold standard' for priority-setting methodology, it is generally agreed that the process should be systematic, explicit, fair and evidence-based (30). The ACE approach to priority-setting is characterised by the use of consistent, rigorous methods for the technical cost-effectiveness analysis that provides decision-makers with quantitative data on the costs and outcomes of interest. In addition to technical cost-effectiveness analyses, effective priority-setting methods require a process that addresses the broader concerns of decision-makers and the range of issues that impinge on policy decisions (22). The ACE approach features a second stage in the analysis where important policy considerations (referred to as 'implementation considerations' hereafter) are analysed qualitatively and presented alongside the cost-effectiveness results.

Another key feature of the ACE approach is the consideration of 'due process', where legitimacy is achieved through discussion and debate at each stage of the process (21).

The key features of the ACE-Obesity Policy study were:

- The application of economic concepts of 'opportunity cost' (i.e., benefit versus benefit forgone, and all resources valued based on the alternative use of resources), 'marginal analysis' (incremental analysis of interventions compared to a common comparator and relationship between intervention design and resource use) and a clear 'concept of benefit' (to underlie 'value-for-money' considerations).
- Clearly specified rationale for intervention selection to underscore the opportunity cost principle. Intervention selection was undertaken initially by the ACE–Obesity Policy team and then presented and discussed with the Project Steering Committee (PSC) (see Section 2.3 and Figure 2).
- Standardised evaluation methods. Regular ACE-Obesity Policy team meetings ensured consistency in the application of methods and input values. Methodological decisions were documented and saved in a repository accessible by all members across institutions.

- A common setting, decision context (implementation across Australia) and comparator (i.e., current practice) across all evaluations.
- The use of Australia-specific data wherever possible, adjusted to reflect 2010 values.
- The use of the best available evidence in all analyses.
- Extensive uncertainty incorporated into parameter inputs, to ensure key outcomes reflected potential uncertainty in the costs, epidemiological assumptions, and process/effectiveness estimates.
- The cost-effectiveness results were placed within a broader decision-making framework where qualitative information on the 'strength of evidence', 'acceptability of the intervention to multiple stakeholders', 'feasibility of implementation', 'sustainability of implementation' and other relevant considerations were documented and assessed as 'high', 'medium' or 'low' (see Section 2.6).
- The development and application of a framework to ensure consistency in the assessment of the strength of evidence for interventions (see Figure 3).
- Technical cost-effectiveness results by SEP were presented for two interventions. The remaining interventions considered equity impacts qualitatively.
- Previous ACE studies involved a PSC consisting of stakeholders including experts, clinicians, community representatives and policy makers. For this study, the PSC consisted of the chief investigators and associate investigators of the CRE. This group included national and international experts with a breadth of knowledge, skills and expertise in economic and epidemiological modelling; policy making in prevention; obesity advocacy; and obesity and nutrition research. The PSC convened annually over the five years of the project, and provided guidance on the selection of interventions and the framework for the assessment of strength of evidence. The PSC also provided guidance on the logic pathway and the application of the implementation considerations for a selection of interventions.
- The ACE-Obesity Policy research team, consisting of epidemiologists, health economists, modellers and obesity experts, discussed all logic pathways and reviewed the application of the implementation considerations to ensure consistency across the interventions evaluated. For individual interventions, additional relevant policy makers and content area experts were engaged to ensure policy relevance, and use of the best available evidence for intervention evaluation.

Although there is no 'gold standard' for priority-setting methodology, it is generally agreed that the process should be systematic, explicit, fair and evidence based.

2.3 Intervention selection process

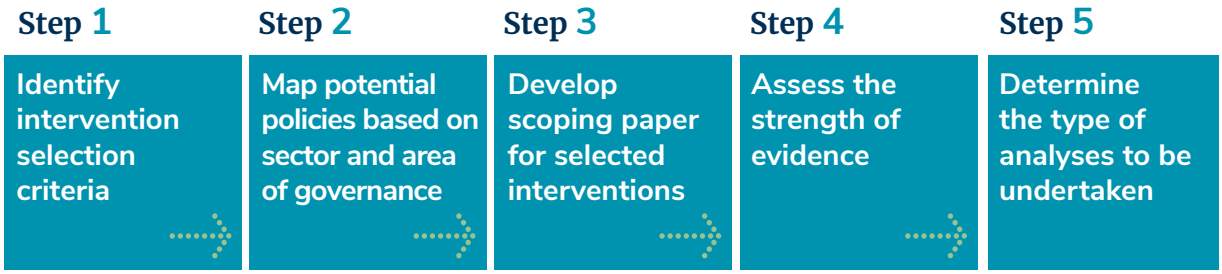
An important step in a priority-setting study involves the systematic selection of interventions for evaluation – the options for change. When addressing a single disease area within the healthcare sector, there is usually a limited choice of alternative interventions. However, when the aim is to inform priority-setting of obesity prevention interventions across a range of sectors, there are a large number of heterogeneous policy/intervention options that could be considered.

The following overarching principles were applied for the selection of interventions for evaluation:

- Include interventions aimed at primary prevention rather than treatment;
- Focus on population-wide interventions;
- Focus on options of a policy nature, with program-based interventions limited to those that could be rolled out to the target population across Australia; and
- Include options for change across a range of sectors.

A five-step process (Figure 2) was used to select the interventions for evaluation. The final step also considered the type of analysis (full economic evaluation, threshold analyses, or 'what if' scenario analyses)[3], that would be suitable for application to the intervention and associated evidence base.

Figure 2 ***Intervention selection process***



Step 1 Identify intervention selection criteria

The ACE-Obesity Policy team and the PSC agreed on the following three intervention selection criteria:

1. Potential impact on addressing the problem of obesity in Australia.
2. Relevance to current policy decision-making for national, state and/or local governments, and/or relevant private sector organisations (e.g., private health insurers). Interventions were required to be transferable to a range of settings and, therefore, interventions that were highly context specific and difficult to scale-up were excluded.
3. Availability of evidence of efficacy/effectiveness to support the analyses, using a broad definition of evidence.

3 Threshold analyses show the threshold value for a key variable where the analysis tips from being cost-effective to no longer cost-effective. 'What if' analyses are based on plausible assumptions of the effect size.

Step 2 Map potential policies based on sector and area of governance

The ACE–Obesity Policy study aimed to consider a range of interventions across different sectors that impacted different levels of government and non-government decision-makers. Potential policies were identified by reviewing key policy documents by the WHO (9, 10), the Australian National Preventive Health Agency (31) and the Institute of Medicine (32). Potential interventions were mapped to a matrix based on the 'Obesity Policy Action' framework (11). The matrix classified interventions according to whether policy adoption was the responsibility of local governments, state governments, the federal government or the private/non-government sector.

The matrix also classified potential interventions based on the following policy areas:

- Policies targeting food environments
  - Food production; food composition; food promotion; food labelling; food prices; food provision; and food retail
- Policies targeting physical activity environments
  - Transport; Infrastructure and Planning; Education; Employment; and Sports and Recreation
- Policies in sectors not routinely involved in obesity prevention
  - Finance; Commerce and Trade; Social Services; Environment; and Transport
- Settings-based policies
  - Early childcare; education; workplaces; and local communities
- Supporting infrastructure for obesity prevention
  - Leadership and governance; monitoring; platforms for interaction; workforce development

The matrix was presented to the PSC annually, and additional relevant interventions based on emerging evidence, policy activity globally, and expert views were added throughout the course of the project. The matrix is available at www.aceobesitypolicy.com.au

Step 3 Develop scoping paper for selected interventions

In conjunction with the PSC, a range of interventions were selected for preliminary evaluation. For each of these interventions, a scoping paper was completed outlining:

- the intended impact of the intervention;
- the policy status of the intervention both in Australia and internationally;
- the relevant stakeholders;
- the evidence of effectiveness for the intervention; and
- the potential issues related to the modelling of the intervention.

Scoping papers were informed by systematic-like searches of the literature (grey and academic). Evidence from the literature related to the effectiveness of the intervention was assessed for quality using appropriate tools based on the study design (33, 34).

Step 4 Assess the strength of evidence

Unlike medical interventions for the *treatment* of disease, in the context of obesity prevention there are many cases where the evidence of effectiveness of *preventive* measures may only be seen indirectly (e.g., through changes in the food environment) or gradually (through small incremental changes in population behaviour or health) (35). Furthermore, there are a range of relevant outcomes for studies that investigate intervention effectiveness in the area of obesity prevention. The most proximal evidence comes from interventions reporting changes in weight or BMI. Some studies focus on less proximal outcomes, such as those related to change in diet and physical activity outcomes. In these cases, sustained changes without compensation are required to result in longer term changes to BMI.

Given that the obesity epidemic calls for immediate action, decision-makers are required to make decisions based on the *best available* evidence rather than waiting for the *best possible* evidence. The traditional hierarchy of evidence used in evidence-based medicine, where randomised controlled trials (RCTs) with clinical outcomes provide the highest quality of evidence, is likely to be too narrow a framework to assess the quality of the evidence base for obesity prevention interventions. It has therefore been recommended that a broader perspective be taken on the admissible evidence considered for obesity prevention strategies (35, 36).

Given that the obesity epidemic calls for immediate action, decision-makers are required to make decisions based on the best available evidence rather than waiting for the best possible evidence.

The strength of evidence assessment developed for this study (Figure 3) considered the balance of evidence, and was based on the study type, the consistency of findings and the quality of studies. After deliberation by the ACE-Obesity Policy team, each intervention was classified as having 'high', 'medium' or 'low' certainty of effect on BMI outcomes and on dietary/physical activity outcomes. This assessment fed into the implementation considerations.

Step 5 Determine the type of analyses to be undertaken

The final step in the intervention selection process was to determine the type of analysis suitable for the policy intervention. Full economic evaluations were undertaken for interventions determined to have high or medium certainty of effect. For interventions with low strength of evidence, but where the necessary data inputs were available, full cost-effectiveness analyses were undertaken incorporating appropriately large uncertainty in the inputs. For interventions determined to have a low certainty of effect and a lack of available input data, 'what if' and threshold analyses were considered. Interventions were prioritised for these analyses based on the likely importance of the intervention as part of a comprehensive obesity prevention strategy, and the likelihood of generating better evidence in the future, particularly considering the characteristics of the intervention.

Figure 3 *Criteria for classifying the degree of certainty of effectiveness of each intervention*

Body Mass Index (BMI) / weight outcomes	Diet / physical activity outcomes
HIGH certainty of effect **The balance of evidence was judged to provide high certainty of effect based on:** • One or more Level I or Level II studies,[#] with accurately measured outcomes,[%] that show results consistent with other studies (where they exist) AND/OR • Multiple Level III studies,[#] with accurately measured outcomes,[%] that show consistent results	**HIGH certainty of effect**
MEDIUM certainty of effect **The balance of evidence was judged to provide medium certainty of effect based on:** • Multiple studies (including Level III, Level IV, relevant indirect / parallel / modelled evidence)[#] that show consistent results OR • The intervention effect is based on a single Level II study,[#] specified in the same way and conducted in the same context as the selected intervention. The single study needed to be assessed as superior to other studies if results were not consistent with previous studies.	**MEDIUM certainty of effect**
LOW certainty of effect **The balance of evidence was judged to be inconclusive regarding effectiveness based on:** • Level I, II, III or IV studies[#] and/or relevant indirect / parallel / modelled evidence that show inconsistent results AND/OR • No clear evidence of effect, but strong program logic coupled with evidence of effect on relevant distal outcomes	**LOW certainty of effect**

Notes:

\# *Level I study: a systematic review of Level II studies; Level II study: a randomised controlled trial; Level III study: a comparative study with controls; Level IV: a cross sectional study or case series. Classification based on NHMRC Evidence Hierarchy (37).*

% *As an example, measured BMI is considered more accurate than self-reported BMI.*

2.4 Key features of the economic analyses

Key methods of the economic evaluations, as recommended for reporting by the Consolidated Health Economic Evaluation Reporting Standards (CHEERS) statement (38), are detailed in Table 1.

Table 1 ***Key reporting items for methods utilised in the ACE–Obesity Policy economic evaluations***

Target population and subgroups	Australian 2010 population aged 2-100 years (39). Subgroups of this population based on age, sex and BMI profile were used for targeted interventions. Subgroup analyses by SEP were undertaken for a limited number of evaluations.
Setting and location	Interventions requiring implementation by local, state, federal governments and private organisations across a range of settings (e.g., communities, schools, workplaces) were included. All analyses reflected implementation across Australia.
Study perspective	Limited societal. All evaluations attempted to collect the opportunity costs and benefits to individuals, governments and the private sector[4]. Productivity impacts were not included.
Comparator	Australian 2010 population aged 2-100 years, not exposed to the intervention.
Time horizon	Time horizon for the modelled implementation of an intervention varied according to the intervention's application in real life. The costs, cost-offsets and health impacts were tracked over the lifetime of the target population or 100 years.
Discount rate	3% was applied uniformly to costs and benefits to remain consistent with previous ACE studies related to obesity (22, 23).
Choice of health outcomes	Short term health outcomes were reported as change in BMI, weight (in kg), physical activity (in metabolic equivalent task (MET) minutes per week) and fruit and vegetable intake (in grams per day). The primary long term health outcome resulting from the change in the short term outcomes was reported in Health Adjusted Life Years (HALYs).
Measurement of effectiveness	Intervention effect assessed using strength of evidence framework (see Figure 3).
Measurement and valuation of preference-based health outcomes	Health related quality of life (HRQoL) impacts related to BMI status during childhood were included using published data (40).

4 When using a societal perspective, the costs and benefits to all members of society should be captured. All interventions are likely to have spill-over effects on members of society not primarily targeted for an intervention. In order to ensure the evaluation was tractable and due to the availability of data, the capturing of downstream spill-over effects was beyond the scope of the evaluations. For example, a school-based intervention encouraging fruit and vegetable consumption may also increase the consumption of fruits and vegetables of other family members and may also have an impact on the family food budget. Our evaluation was limited to include the cost of the school-based intervention and the benefits to the school children. The spill-over effects on the whole family were excluded. The potential downstream spill-over effects are reported qualitatively for relevant interventions (see Section 5).

Estimating resources and costs	Event pathways for the implementation of the intervention were used to identify costs at each step in the process. The opportunity cost principle (41) was used to identify cost categories. Resource use was collected using primary and secondary data sources. Valuation was based largely on administrative databases using real prices for the reference year 2010. Details of the costing methodology are provided in Section 2.5.1.1.
Currency, price date, and conversion	2010 Australian dollars. When costs were not available for the 2010 reference year, the Australian Institute of Health and Welfare price indexes were used to adjust prices to 2010 values (42). For health related costs, the total health price index was used, whilst for non-health related costs, the gross domestic product index was used. International costs were not used in the evaluations.
Choice of model	A proportional, multi-state, life table Markov model simulating the BMI, physical activity and fruit and vegetable consumption profile of the 2010 Australian population (hereafter referred to as the ACE-Obesity Policy model). The impact of changing the BMI, physical activity and/or fruit and vegetable consumption profile of the population as a result of the intervention was captured in the reduced rates of obesity-related diseases. Details of the methods and key sources are provided in Section 2.5.
Assumptions	An outline of the structural assumptions is provided in Section 2.5. Key assumptions related to individual interventions are provided in the intervention reports section (Section 5) and details can be found in the individual intervention publication list available in Appendix 4
Analytic methods	An outline of the analytical methods used for the ACE-Obesity Policy model is presented in Section 2.5. The key methods used for individual interventions are provided in the intervention reports section (Section 5) and details can be found in the individual intervention publications (publication list available in Appendix 4).

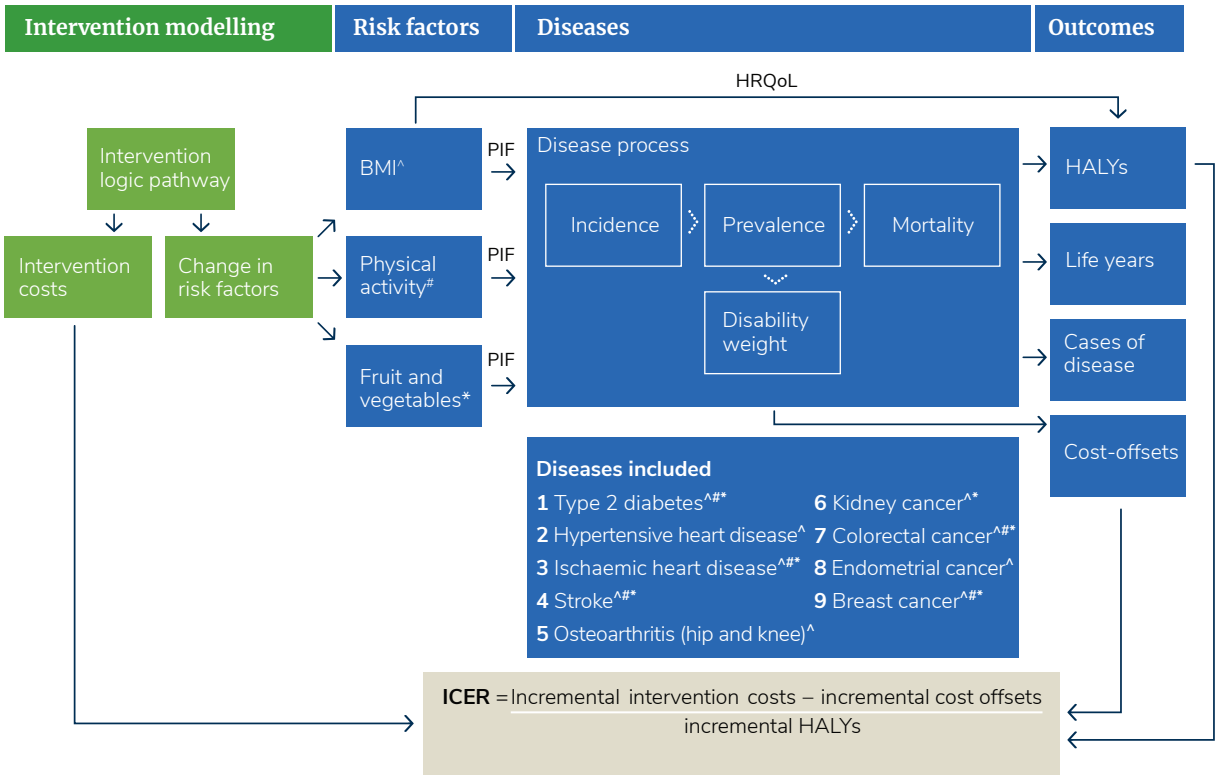
Notes: *ACE: Assessing Cost-Effectiveness; BMI: body mass index; HALYs: health adjusted life years; HRQoL: health related quality of life; kg: kilogram; MET: metabolic equivalent task; SEP: socio-economic position*

2.5 Modelling the cost-effectiveness of obesity prevention interventions

The modelling process consisted of three steps. The first involved modelling the intervention costs and impact on each of the risk factors of interest: BMI, physical activity, and fruit and vegetable intake. The second step involved modelling the short term changes in risk factor profile to long term changes in health and health related cost-savings using the ACE-Obesity Policy model. The final stage involved aggregating the incremental costs and the incremental health outcomes of the intervention compared to the comparator to calculate the incremental cost-effectiveness ratio (ICER) (Figure 4).

An intervention was considered cost-effective if the ICER was less than or equal to $50,000 per health adjusted life year (HALY) gained. This willingness-to-pay threshold was used in previous ACE studies (22, 23), and is the commonly used threshold in Australia (43). ICER thresholds tend to be related to national income, and countries similar to Australia have similar thresholds (e.g., UK and Canada). A common rule-of-thumb is for the ICER threshold to be 1.5-2 times the Gross Domestic Product (GDP) per capita, with thresholds moving up or down based on factors such as capacity to spend, size of the disease burden and the severity of conditions addressed.

Figure 4 *Schematic of the ACE-Obesity Policy model*



Notes: *BMI: body mass index; HALYs: health adjusted life years; HRQoL: health related quality of life; ICER: incremental cost-effectiveness ratio; PIF: population impact fraction.*

2.5.1 Intervention modelling

2.5.1.1 Measurement of intervention costs

Using a limited societal perspective, the intervention costs accruing to a range of government sectors (as relevant to intervention implementation), private companies and individuals were included. Relevant intervention costs and outcomes were ascertained by using logic pathways to identify the steps required for the intervention to achieve a change in risk factors. The cost components varied by intervention type; however, the main cost elements included:

- recruitment for targeted interventions;
- the cost of legislation for mandatory policies; and
- key aspects of intervention delivery, implementation, administration, compliance and maintenance over the lifetime of the intervention.

The impact of an intervention on industry revenue was included in sensitivity analyses where appropriate data was available to support the analysis. In the primary analyses, the deadweight losses associated with taxation (decreased economic wellbeing as a result of the tax), and potential welfare losses to individuals were not included.

Individual out-of-pocket costs related to engagement with the intervention were included. Time and travel costs were included as part of this. Time costs for children, however, were not included. Productivity costs, costs associated with research and development, and intervention evaluation were also excluded.

2.5.1.2 Valuation of costs

Unit cost data were collected largely from administrative databases for the 2010 reference year. Wages included salary oncosts (i.e., superannuation, payroll tax, workers compensation, fringe benefits tax) and a 17.5% loading for four weeks of annual leave. Time costs were valued at the hourly average gender free wage rate (44). Volunteer time was valued at 33% of the average wage rate (45). Given that many of the policies would require legislative changes, a detailed costing study was undertaken to estimate the cost of passing legislation in the federal parliament (46).

2.5.1.3 Measurement of changes in risk factors

For interventions resulting in a change in food consumption, relevant food composition data were obtained from either the Food Standards Australia New Zealand NUTTAB 2010 database (47) or The George Institute Food Composition database, and used to estimate the difference in kilojoules (kJ) resulting from an intervention. Kilojoule change as a result of an intervention was converted into a corresponding change in weight in kilograms (kg) using validated energy balance equations for adults and children (48, 49), and then converted to a change in BMI using average height, by age and sex (50). Intervention effects in children measured in BMI z-score were converted to a change in BMI using WHO standardised growth charts for age and sex (51).

Changes in physical activity as a result of an intervention were assumed to have an impact on physical activity as well as a resultant change in BMI. Changes were modelled as the difference in metabolic equivalent task (MET) minutes per week using published values from the literature (52, 53). Changes in MET minutes per week were an input to the physical activity risk factor component of the model. MET minutes were also converted to change in kJ using the validated equation (52), and then to change in BMI. Changes in fruit and vegetable intake (in grams per day) resulting for an intervention were an input to the fruit and vegetable risk factor component of the model. Substitution and compensatory effects of an intervention (on diet and/or physical activity) were not included in the analyses unless there was evidence of such effects.

For comparability, it was assumed that the impact of regulatory interventions was maintained over the lifetime of the modelled population. However, when this assumption was deemed unreasonable, intervention scenarios were tested using plausible variations to the maintenance of effect. For program-based interventions, the duration of effect varied according to the characteristics of each intervention.

2.5.2 ACE-Obesity Policy model

Health economic models are analytical tools that help inform decision-making under uncertainty (54). These techniques are particularly important in the context of obesity prevention where longitudinal data on the impact of prevention initiatives are often not available. The ACE-Obesity Policy model uses mathematical relationships between the characteristics of the population, risk factors, and diseases to predict the longer term outcomes of obesity prevention initiatives. The structure of the ACE-Obesity Policy model is based on the previous ACE-Prevention model (55), with some important improvements and additional features. These included the ability to quantify costs and health impacts by SEP, an expanded analytic scope of health outcomes to include children and health-related quality of life (HRQoL) outcomes attributable to BMI status, and the inclusion of physical activity and fruit and vegetable intake as risk factors for disease.

The ACE-Obesity Policy model is a proportional, multi-state life table Markov model. A schematic of the model is shown in Figure 4. The model consists of three key components, namely risk factors, disease processes, and outcomes.

The model simulates the effects of intervention-related changes to the distribution of one or more risk factors (i.e., BMI, physical activity, and/or fruit and vegetable intake) in the population of interest (2010 Australian population aged 2 to 100 years (39)) on the incidence of diseases related to that risk factor. Reduced incidence of diseases results in reductions in prevalence and disease-related mortality and morbidity. This, in turn, results in improved long term health outcomes and healthcare cost-savings.

2.5.2.1 Risk factors

Population impact fractions (PIFs) were used to measure the proportional change in disease incidence as a result of changes in the population profile of the three risk factors of interest. Relative risks (RR) from the Global Burden of Disease 2010 study (56) were used to calculate the PIF for diseases related to BMI and physical activity. Various sources reporting the RR of diseases related to fruit and vegetable intake (57-62) were used to calculate the relevant PIFs. PIFs were calculated using the distribution shift method for BMI and fruit and vegetable intake (63) and the relative risk shift method for physical activity (64).

When interventions impacted both BMI and physical activity, the RRs and the PIFs for the diseases impacted by both risk factors were adjusted using a multiplicative function (65) to account for the joint effect of the two risk factors. It was assumed that fruit and vegetable intake had an independent effect on diseases, and no adjustment for joint effects was made.

BMI was modelled for individuals aged 18 to 100 years stratified by sex and 5-year age groups. Individuals aged 2 to 17 years were modelled by gender and 1-year age increments. The BMI distribution was modelled using data from the Australian Health Survey 2011-12 (50), assuming a lognormal distribution.

Physical activity was modelled for individuals aged 2 to 100 years by gender and 1-year age increments. Physical activity levels were classified using weekly energy expenditure measured in mean MET minutes per week (52). These were grouped into four categories according to risk, namely 'inactive', 'low active', 'moderately active', and 'highly active' (66).

Interventions that resulted in changes in sedentary behaviour were modelled based on the change in METs. The benefits of decreasing sedentary behaviour, independent of physical activity and BMI, were not included in the modelling. Fruit and vegetable intake distribution was modelled for individuals aged 2 to 100 years by gender and 5-year age groups. A lognormal distribution was modelled using mean intake of fruits and vegetables (in grams per day) from the Australian Health Survey 2011-12 (50).

2.5.2.2 Disease process

Nine diseases causally related to BMI (i.e., type 2 diabetes, hypertensive heart disease, ischaemic heart disease, stroke, osteoarthritis of the hip and knee, kidney cancer, colorectal cancer, endometrial cancer and breast cancer) were modelled. Of these, five diseases were also related to physical activity (i.e., type 2 diabetes, ischaemic heart disease, stroke, colorectal cancer and breast cancer) and six diseases were related to fruit and vegetable intake (i.e., type 2 diabetes, ischaemic heart disease, stroke, kidney cancer, colorectal cancer and breast cancer).

Disease-specific life tables were used to calculate the epidemiologic impact of a reduction in the average incidence of risk factor-related diseases. Incidence rates were used to calculate prevalence and mortality rates for each disease using DisMod2 software (67). These rates were used to simulate transitions between four health states (i.e., 'healthy', 'diseased', 'dead due to the disease' and 'dead due to other causes') for each disease (55). Morbidity impacts were quantified using prevalent years lived with disability (pYLDs), multiplied by disease-specific disability weights from the Global Burden of Disease 2010 study (68)[5]. As with previous ACE studies related to obesity, disability weights from the Global Burden of Disease were used rather than utility weights from the literature in order to use a uniform source with consistent methods for disease state disability/utility weighting across all the diseases included in the model.

5 Although the disability weights used are from the Global Burden of Disease study (68), the calculation of Global Burden of Disease DALYs varies from the calculation of HALYs in this study. The ACE-Obesity Policy study follows similar methods to previous ACE studies. See the ACE-Prevention report (23) for further details.

2.5.2.3 Outcomes

The primary long term health outcome in the ACE-Obesity Policy model was the incremental Health Adjusted Life Years (HALYs) saved as a result of the intervention. HALYs were calculated by aggregating the population level changes to overall mortality and morbidity for each disease (using Global Burden of Disease disability weights and the negative HRQoL impacts attributable to BMI in childhood (40)). Given that the average age of onset of diseases associated with the risk factors of interest is generally mid-life, the addition of HRQoL impacts allowed the quantification of short-term impacts of obesity interventions in children and adolescents.

Other health outcomes included total life years saved (LYs) as a result of the intervention, calculated from mortality effects of the intervention, and the number of cases of disease averted, calculated from the changes in the incidence of disease.

Total healthcare cost-savings (the treatment costs that are averted due to reductions in disease prevalence as a result of an intervention, also referred to as cost-offsets) were used to calculate the net costs of an intervention. Data on healthcare costs for incident cases (all cancers in the model) or prevalent cases (other diseases in the model) were taken from the Australian Institute of Health and Welfare (AIHW) (69). The 2001 costs available from AIHW were inflated to 2010 prices using the Health Price Index (42).

2.5.3 Adaptation of the model for interventions targeted at children

At ages less than 20 years, the RR of obesity-related diseases associated with elevated BMI is not significant and the intervention impact as estimated by the ACE-Obesity Policy population model is limited to the HRQoL benefits of lower BMI in childhood. Model adaptations (the child matrix model) were made to allow interventions targeted at children to accrue benefits in adult years by simulating the impacts on obesity-related diseases as the targeted population ages over time. Note that there is a significant time delay before childhood interventions show significant impacts on obesity-related diseases and therefore HALYs.

2.5.4 Socio-economic position model

The ACE-Obesity Policy SEP model was developed to estimate the differential costs, benefits and cost-effectiveness of interventions across different SEP groups measured using the Socio-Economic Indexes for Areas (SEIFA). SEIFA Index of Relative Socio-Economic Disadvantage (IRSD) quintile specific data for key parameters such as disease incidence, mortality rate, BMI distribution and population numbers were used to populate quintile specific sub models (46).

The differential effectiveness of obesity prevention interventions across SEP groups was modelled for two interventions (i.e., the 'Sugar sweetened beverage tax (20%)' and 'Restricting television advertising of unhealthy foods'), allowing for the quantification of their equity impacts.

2.5.5 Uncertainty and sensitivity analyses

All modelling was undertaken using Microsoft Excel 2013 software. Extensive parameter uncertainty analyses were undertaken using Monte Carlo simulation using the Excel add-in software, Ersatz (version 1.35) (70). Two thousand iterations of the model with varying parameter values defined by the most likely distribution of each variable were used to present all results with 95% uncertainty intervals (95% UI).

Key assumptions related to specific interventions were tested in univariate sensitivity analyses. Where there was large uncertainty related to specific values, threshold analyses were undertaken to present the threshold value for the intervention effect variable that resulted in a mean ICER that would be considered cost-effective. This was designed to enable readers to make informed judgements on the economic credentials of interventions.

2.6 Implementation considerations

As part of the ACE approach, results from cost-effectiveness analyses were placed within a broader framework that seeks to incorporate other factors (implementation considerations) that are important to decision-makers but difficult to quantify (21, 22). The implementation considerations used as part of this study were adapted by the ACE-Obesity Policy team from those used in previous ACE studies (23, 24), and were reviewed by the PSC.

The implementation considerations included for all modelled interventions were:

- **Equity** qualitatively considers whether the intervention is likely to have a positive, neutral or negative effect on equity, and is defined as 'the impact of the intervention on inequity in the distribution of disease and health status, and access to, or utilisation of, specific intervention(s)' (23). In assessing these equity impacts, consideration was also given to out-of-pocket costs relative to income that may occur as a result of the intervention. This definition of equity is a 'composite' definition in the sense that it included both process and outcome dimensions of equity. This approach was suitable for a qualitative approach to equity assessment that sought to flag key issues to inform intervention design and policy judgements. The qualitative analysis was informed by the literature and expert judgement. The two quantitative assessments of equity undertaken in this study used a definition based on SEP. Socio-economic position as an indicator of equity has relevance to both process and outcome dimensions, but is not comprehensive in its coverage, nor does it weight these individual components.
- **Strength of evidence** incorporates an analysis of the strength of evidence of effect for the intervention based on the framework presented in Section 2.3. Strength of evidence was categorised into:
  - Strength of evidence for BMI or body weight effects (high, medium and low certainty of effect);
  - Strength of evidence for dietary-related effects (high, medium and low certainty of effect);
  - Strength of evidence for physical activity effects (high, medium and low certainty of effect).
- **Acceptability** considers the likely acceptability of an intervention to various stakeholders, informed by the literature and based on program logic, 'real-world' experience, expert input and/or parallel evidence. Acceptability was categorised into:
  - Acceptability to government (high, medium, and low);
  - Acceptability to industry (high, medium, and low); and
  - Acceptability to the general public (high, medium, and low).
- **Feasibility** considers the likely feasibility of implementation for an intervention, based on local/national/international experience and/or parallel evidence (high, medium, low).
- **Sustainability** considers likely sustainability based on:
  - The mechanism of intervention (e.g., mandatory regulations, voluntary regulations/guidelines, national roll-out of programs);
  - The level of ongoing funding required; and

  The likelihood that the intervention will result in sustained behaviour change. By their very nature, legislative interventions were typically classified as highly sustainable, with voluntary and program-based interventions assessed based on the merits of each intervention (high, medium, and low).

- **Other considerations** summarises important considerations specific to each intervention, such as the potential for "spill-over" or side effects (positive or negative) resulting from the intervention but not included in the modelling.

Implementation considerations for each intervention were critically examined by the ACE-Obesity Policy team against the criteria for assessment, and relative to other interventions included as part of the study[6].

2.7 Presentation of results

In this report, we aimed to provide policy-relevant high-level results, with supporting evidence to allow decision-makers to assess the relevance and reliability of the findings. Detailed results for individual interventions are available in individual publications (see publications list in Appendix 4).

2.7.1 League table and implementation considerations

Results from the cost-effectiveness analyses are presented in a league table (Section 3.3, Table 5), ranked by their ICERs in order from the most cost-effective to the least cost-effective intervention. For dominant interventions (interventions that result in both health gains and net cost-savings), the interventions have been ranked by total health gains (HALYs). Table 5 also includes a description of the type of intervention and the target population. The estimated intervention costs over the first three years of the intervention are provided as an indication of the short term budget impact ('affordability') of each intervention. In addition to the key cost-effectiveness results, Table 5 also includes the assessment of the strength of evidence, as it is a key consideration when interpreting the quantitative results.

Although the league table is a concise way of displaying the results of this study, caution is recommended against simplistic interpretation of the league table (e.g., ordering of interventions from best to worst), as there is a risk of inappropriate comparisons due to the different size and nature of the target populations, risk factor targeted, and nature of each intervention.

Implementation considerations are presented in Table 6 (Section 3.4) for all the interventions evaluated. This provides a succinct overview of the other factors likely to be important to decision-makers. The table is ordered firstly on strength of evidence for BMI, then strength of evidence on dietary and physical activity outcomes, followed by equity, and finally by the number of 'positive' or 'high' ratings for the remaining categories. Table 2 shows the traffic light colour coding for the classification for each of the implementation considerations.

Table 2 ***Implementation considerations and categories for classification***

Implementation consideration	Categories for classification		
Equity	Positive	Neutral	Negative
Strength of evidence (BMI)	High	Medium	Low
Strength of evidence (physical activity/diet)			
Acceptability to government			
Acceptability to industry			
Acceptability to the public			
Feasibility			
Sustainability			

6 Given the qualitative nature of implementation considerations, the assessment of 'high', 'medium' and 'low' were based on judgement. The ACE-Obesity Policy team made the assessments for this report to ensure consistency between interventions, however these may differ to the assessments made by authors of the publications of specific interventions.

2.7.2 Intervention reports

The results from each intervention are also presented in four-page summary reports (Section 5). These reports are designed to provide an overview of each intervention. Details of the publication citation or publication status are provided to guide readers to more detailed information on specific interventions. The first table in each intervention report describes:

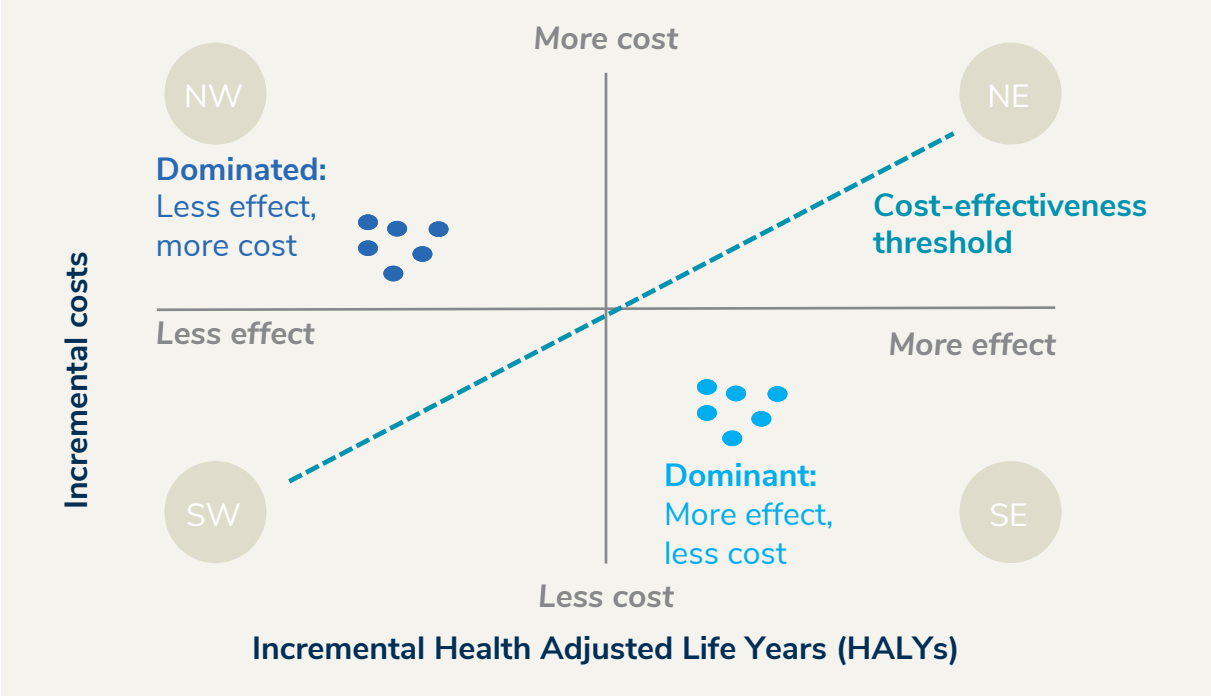
- the key intervention scenarios modelled, including the risk factors modelled;
- the type of model used in the evaluation (population model or the child matrix model);
- the population targeted;
- the weighted average change in body weight and BMI;
- assumptions related to the decay of intervention effect; and
- the categories of costs included in the analyses.

Results are also presented on a cost-effectiveness plane that plots the 2000 iterations of the incremental costs and health benefits (HALYs) of the intervention versus the comparator (i.e., no intervention) (Figure 5). This provides a visual representation of the range of cost-effectiveness results for the scenarios modelled. Iterations of the intervention falling in the north east (NE, Figure 5) quadrant represent runs of the model where the intervention produces more health benefits, but is more costly than the comparator. Iterations falling in the south east (SE, Figure 5) quadrant are 'dominant', as they result in more health benefits and less cost compared to the comparator. Interventions with the majority of interventions in the SE quadrant represent excellent opportunities for resource allocation. Iterations falling in the south west (SW, Figure 5) quadrant represent runs of the model that result in less health benefits but less cost compared to the comparator. Iterations falling in the north west (NW, Figure 5) quadrant are 'dominated' – representing runs of the model where the intervention results in less health benefits and more cost compared to the comparator. Interventions with the majority of interventions in the NW quadrant do not represent good value-for-money.

Results in the NE and SW quadrants are expressed as ICERs. For these quadrants, the 'cost-effectiveness' decision threshold line representing $50,000 per HALY gained is shown in Figure 5. All iterations below this threshold in the NE quadrant and above the threshold in the SW quadrant represent runs of the model that are considered value-for-money. The probability of the intervention being cost-effective was calculated as the proportion of these iterations out of the total number of iterations.

The results from each intervention are presented in four-page summary reports (Section 5). These reports are designed to provide an overview of each intervention.

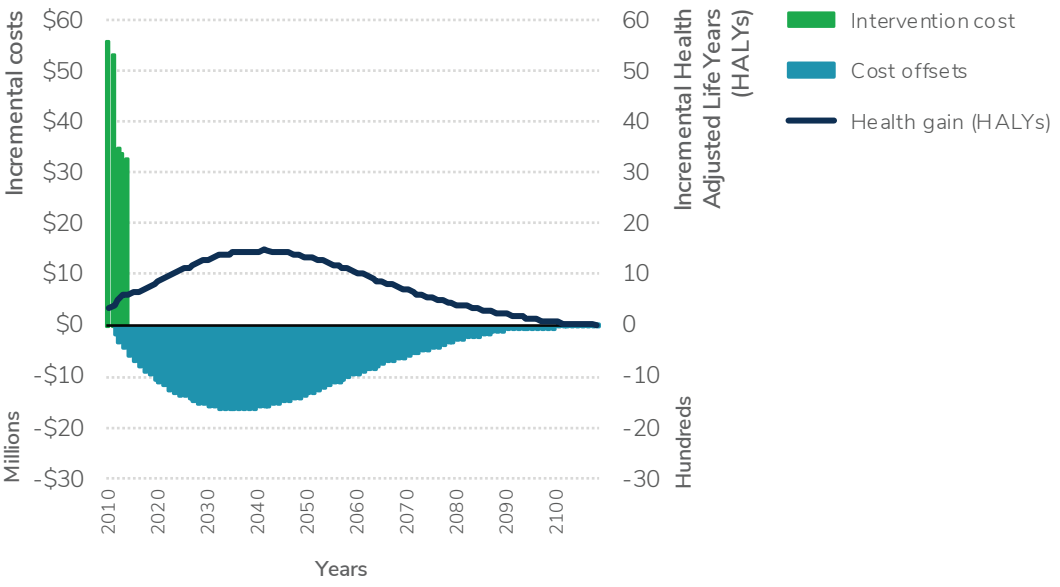
Figure 5 *The cost–effectiveness plane*



Notes: *HALYs: health adjusted life years; NE: north east; NW: north west; SE: south east; SW: south west*

The second figure in the intervention reports represents the accrual of costs, healthcare cost-savings and health gains (HALYs) over the model time horizon (example shown in Figure 6). This provides important information to decision-makers, visually summarising the initial and ongoing investment needed to implement an intervention (green bars), and the time horizon over which the modelled health benefits (dark blue line) and healthcare cost-savings (light blue bars) are likely to accrue.

Figure 6 *Costs, cost offsets and health gains over time*



Notes: *Results are presented over time to demonstrate the timing of investment (green bars) relative to the timing of the cost-savings (blue bars) and health gains (dark blue line). Incremental costs are expressed in 2010 Australian dollars. HALYs: health adjusted life years.*

The final section of the intervention reports provides a qualitative assessment and overall rating for the implementation considerations (see Section 2.6).

Three Results

A total of 28 interventions were evaluated. Of these, full economic evaluations were conducted for 16 different interventions, with 50 different intervention scenarios explored. Twelve interventions had scoping papers completed but did not progress to full economic evaluation.

3.1 Interventions selected for cost-effectiveness evaluation

Full cost-effectiveness analyses were undertaken for 16 obesity prevention interventions across several sectors (Table 3). For each intervention, the government departments that are likely to be most involved in the decision-making and implementation process have been identified (see Table 4). For the majority of the interventions (12 of 16), particularly those directed towards improving the nutrition environment, multiple sectors would likely need to be involved, with policy leadership required from state and federal Departments of Health. In these cases, the interventions were categorised as 'cross-sectoral' interventions. Two of the interventions were considered the primary responsibility of the Department of Health (both state and federal), and one intervention was primarily related to the transport sector. A mix of regulatory (9 interventions) and program-based interventions (7 interventions) were evaluated.

Nine interventions were nutrition-based interventions addressing BMI as the key risk factor. Four interventions aimed to primarily increase physical activity, and, therefore, impacted both BMI and physical activity risk factors. Two of these physical activity interventions targeted sedentary behaviour. Two interventions were multi-component interventions impacting both nutrition and physical activity, however outcomes for these interventions were limited to impacts on BMI due to the availability of evidence. Although fruit and vegetable intake was identified as an important risk factor for inclusion in the ACE-Obesity Policy model, no selected interventions targeted this risk factor.

For the majority of the interventions, particularly those directed towards improving the nutrition environment, multiple sectors would likely need to be involved, with policy leadership required from state and federal Departments of Health.

Table 3 *Interventions evaluated in the ACE-Obesity Policy study*

Intervention	Sector/Policy area	Level of governance
Alcohol price increase: uniform volumetric tax/ minimum floor price	Cross-sectoral (health, the alcohol industry)	Federal and state governments (Departments of Health; Department of Industry Innovation and Science; Treasury)
Community–based interventions	Cross-sectoral (across all local government sectors)	Local government
Financial incentives for weight loss by private health insurers	Cross-sectoral (health, the private health insurance industry)	Federal government (Department of Health; Australian Prudential Regulation Authority)
Fuel excise: 10c per litre increase	Transport	Federal government (Department of Infrastructure, Regional Development and Cities; Treasury)
Menu kilojoule labelling on fast food	Health	Federal and state governments (Departments of Health; Department of Industry Innovation and Science)
National mass media campaign related to sugar-sweetened beverages	Health	Federal government (Department of Health; Department of Communications and the Arts)
Reformulation in response to the Health Star Rating system	Cross-sectoral (health, the food and beverage industry)	Federal and state governments (Departments of Health; Department of Industry Innovation and Science)
Restricting television advertising of unhealthy foods	Cross-sectoral (health, communications)	Federal government (Department of Health; Department of Communications and the Arts; Australian Communications and Media Authority)
Restrictions on price promotions of sugar-sweetened beverages	Cross-sectoral (health, the food and beverage industry)	Federal and state governments (Departments of Health; Department of Industry Innovation and Science)
School-based intervention to reduce sedentary behaviour	Cross-sectoral (health and education)	Federal government (Department of Health; Department of Education and Training)
School-based intervention to increase physical activity	Cross-sectoral (health and education)	Federal government (Department of Health; Department of Education and Training)
Sugar-sweetened beverages tax	Cross-sectoral (health, the food and beverage industry)	Federal government (Department of Health; Department of Industry, Innovation and Science; Treasury)
Package size cap on sugar-sweetened beverages	Cross-sectoral (health, the food and beverage industry)	Federal government (Department of Health; Department of Industry, Innovation and Science)
Reformulation to reduce sugar content in sugar-sweetened beverages	Cross-sectoral (health, the food and beverage industry)	Federal and state governments (Departments of Health; Department of Industry Innovation and Science)
Supermarket shelf tags on healthier products	Cross-sectoral (health, the retail industry)	Federal government (Department of Health; Department of Industry, Innovation and Science)
Workplace intervention to reduce sedentary behaviour	Cross-sectoral (health, industries involving desk-based work)	Federal government (Department of Health; Department of Jobs and Small Business)

3.2 Interventions selected for intervention scoping only

Scoping papers were completed for 12 interventions, but analysis did not progress to full economic modelling. The main reason related to the lack of evidence of effectiveness to complete a robust evaluation. In prioritising interventions for evaluation, a judgement was made on the importance of including the evaluation as part of this priority-setting study (see Section 2.3). The scoping papers are available at www.aceobesitypolicy.com.au

Table 4 *Interventions with scoping papers that were not progressed to modelling*

Intervention	Sector	Reason for not evaluating
Active transport to school	Cross-sectoral (health, education, transport)	Not prioritised as other school based interventions included in the study.
Carbon pricing of food in Australia	Agriculture	Lack of robust evidence of likely impact on overall dietary patterns.
Changes to the built environment to increase walkability	Built environment	Modelling was limited by the need for detailed location specific data. Recent economic evaluation for a sidewalk intervention in Perth, Australia.
Congestion pricing	Transport	Limited evidence of effect. Difficulty in measuring intervention exposure and costing.
Cooking programs for children	Health	Lack of evidence of the intervention's impact on obesity outcomes.
Food provision – nutrition standards in government institutions	Cross-sectoral (health, government institutions)	Limited evidence of effect on whole diet. Evaluation postponed as there is likely to be more evidence available in the near future.
Interventions at a local government level to improve healthiness of fast food	Cross-sectoral (health, local government, the food retail industry)	Lack of evidence of effective interventions.
Limiting unhealthy food and drink marketing to children through sports sponsorship	Cross-sectoral (health, sports)	Limited evidence of effect on dietary and obesity outcomes.
Monitoring of population BMI	Health	Lack of evidence of the intervention's impact on obesity-related outcomes.
Regulation of types of fats used in fast food restaurants	Cross-sectoral (health, the food retail industry)	Lack of evidence of the intervention's impact on obesity-related outcomes.
Traffic calming and safety interventions	Transport	Limited evidence of effect. Difficulty in defining intervention exposure and costing.
Workplace wellness programs	Cross-sectoral (health, business community)	Limited evidence to support assumptions.

3.3 Cost-effectiveness results

Table 5 shows the results of the full economic evaluations completed for the ACE-Obesity Policy study. While Table 5 provides point estimates only (based on the means), uncertainty around the estimates (reported in the individual reports in Section 5) should be considered when interpreting the results.

All interventions were evaluated as being cost-effective. Eleven interventions were assessed as being 'dominant' (i.e., resulting in health gains and net cost-savings). The remaining five interventions had mean ICERs ranging from approximately $1,700 to $29,000 per HALY gained. All ICERs were well below the decision threshold of $50,000 per HALY gained.

The uncertainty analyses showed that across all interventions evaluated, the probability of the intervention being cost-effective was 95-100% for the base case analyses. The cost-effectiveness results of the different scenarios tested for individual interventions are reported in Section 5. In general, the intervention cost-effectiveness results were robust to variations to assumptions and input parameters.

In general, the overall cost-effectiveness results are sensitive to the following modelling assumptions:

- Duration of effect: Sensitivity analyses conducted for selected interventions revealed that modelled results are highly sensitive to the duration of effect. This is particularly relevant for interventions targeted at children.
- Population reach: The results reflect that even relatively small changes in BMI and physical activity can result in substantial health benefits when the change occurs in large numbers of the population. Interventions impacting middle aged adults result in immediate impacts on disease epidemiology and therefore resulted in more favourable results.

3.4 Implementation consideration results

A comparative assessment of how the interventions performed against the implementation considerations is provided in Table 6. Given that the technical cost-effectiveness results are only one consideration in the decision making process, it is important to consider the league table results (Table 5), along with the implementation considerations (Table 6). The table is ordered based on the strength of evidence criteria followed by the equity criteria.

All interventions were evaluated as being cost-effective. Eleven interventions were assessed as being 'dominant'.

Table 5 *League table of cost-effectiveness results*

Intervention	Intervention type	Intervention component	Target population	Risk factor addressed	Length of intervention/ effect maintenance	ICER (mean, $/HALY gained)	Total HALYs gained	Total intervention costs	Intervention costs in the first 3 years	Total healthcare cost offsets	Total net cost*	Strength of evidence - BMI
Alcohol price increase: uniform volumetric tax	Regulatory	Nutrition	14-100 year olds	BMI	Lifetime	Dominant	471,165	$31.9M	$24.7M	$4.8B	-$4.8B	Low
Sugar-sweetened beverages tax (20%)	Regulatory	Nutrition	2-100 year olds	BMI	Lifetime	Dominant	175,300	$120.5M	$11.8M	$1.7B	-$1.7B	Low
Restricting television advertising of unhealthy foods (mandatory)	Regulatory	Nutrition	5-15 year olds	BMI	Lifetime	Dominant	88,396	$5.9M	$1.5M	$783.8M	-$777.9M	Low
Package size cap on sugar-sweetened beverages (mandatory)	Regulatory	Nutrition	2-100 year olds	BMI	Lifetime	Dominant	73,883	$210.0M	$143.8M	$750.9M	-$540.9M	Low
Supermarket shelf tags on healthier products (voluntary)	Program	Nutrition	2-100 year olds	BMI	3 years/ 3 years	Dominant	72,532	$8.5M	$8.5M	$646.8M	-$638.1M	Low
Menu kilojoule labelling on fast food	Regulatory	Nutrition	2-100 year olds	BMI	Lifetime	Dominant	63,492	$170.4M	$36.9M	$672.0M	-$502.0M	Low
School-based intervention to reduce sedentary behaviour	Program	Sedentary behaviour	8-9 year olds	BMI/PA (SB)	Lifetime	Dominant	61,989	$15.3M	$14.4M	$660.8M	-$676.1M	Medium
School-based intervention to increase physical activity	Program	Physical activity	8-9 year olds	BMI/PA	Lifetime	Dominant	60,780	$10.0M	$9.5M	$640.6M	-$630.5M	Medium
Restrictions on price promotions of sugar-sweetened beverages (mandatory)	Regulatory	Nutrition	2-100 year olds	BMI	Lifetime	Dominant	48,336	$17.0M	$4.6M	$498.0M	-$481.0M	Low
Reformulation to reduce sugar in sugar-sweetened beverages (voluntary)	Regulatory	Nutrition	2-100 year olds	BMI	Lifetime	Dominant	28,981	$44.4M	$31.2M	$295.0M	-$250.6M	Low
National mass media campaign related to sugar-sweetened beverages	Program	Nutrition	18-100 year olds	BMI	3 years/ 3 years	Dominant	13,958	$31.0M	$30.5M	$157.0M	-$127.3M	Low
Reformulation in response to the Health Star Rating system (voluntary)	Regulatory	Nutrition	2-100 year olds	BMI	Lifetime	1,728	4,207	$46.1M	$31.2M	$41.6M	$4.5M	Low
Financial incentives for weight loss by private health insurers	Program	Multi-component	18-100 year olds	BMI	5 years / 11 years	7,376	140,110	$1.7B	$1.6B	$692.2M	$1.0B	High
Fuel excise: 10c per litre increase	Regulatory	Physical activity	18-64 year olds	BMI/PA/ Injury	Lifetime	7,684	237	$4.4M	$4.4M	$2.6M	$1.8M	Low
Community-based interventions	Program	Multi-component	5-18 year olds	BMI	Lifetime	8,155	51,792	$878.2M	$878.2M	$452.0M	$425.7M	High
Workplace intervention to reduce sedentary behaviour	Program	Sedentary behaviour	18-65 year olds	PA (SB)	1 year/ 5 years	28,703	7,492	$269.4M	$269.4M	$54.4M	$215.0M	Low

Notes: B: billion; BMI: body mass index; HALY: health adjusted life year; ICER: incremental cost-effectiveness ratio; M: million; PA: physical activity; SB: sedentary behaviour; $: Australian dollars 2010; * Negative numbers indicate total net cost-savings. The willingness-to-pay threshold for this analysis is $50,000 per health adjusted life year. Dominant: the intervention is both cost-saving and improves health.

Table 6 *Results of implementation considerations*

Intervention	Intervention type	Strength of evidence - BMI	Strength of evidence - PA/diet	Equity	Acceptability - Government	Acceptability - Industry	Acceptability - Public	Feasibility	Sustainability	ICER (mean, $/HALY gained)
Community-based interventions	Program	High	N/A	Neutral	High	High	High	Medium	Medium	8,155
Financial incentives for weight loss by private health insurers	Program	High	N/A	Negative	High	Medium	Medium	High	Medium	7,376
School-based intervention to reduce sedentary behaviour	Program	Medium	Medium	Positive	High	High	High	High	Medium	Dominant
School-based intervention to increase physical activity	Program	Medium	Medium	Positive	High	High	High	High	Medium	Dominant
Reformulation in response to the Health Star Rating system (voluntary)	Regulatory	Low	Medium	Positive	High	Medium	High	High	Medium	1,728
Restricting television advertising of unhealthy foods (mandatory)	Regulatory	Low	Medium	Positive	Medium	Low	High	High	High	Dominant
Reformulation to reduce sugar in sugar-sweetened beverages (voluntary)	Regulatory	Low	Medium	Positive	High	Medium	Medium	High	Medium	Dominant
Menu kilojoule labelling on fast food	Regulatory	Low	Medium	Neutral	High	Medium	High	High	High	Dominant
Supermarket shelf tags on healthier products (voluntary)	Program	Low	Medium	Neutral	High	Medium	High	High	Medium	Dominant
Workplace intervention to reduce sedentary behaviour	Program	Low	Medium	Neutral	High	Medium	High	Medium	Low	28,703
Sugar-sweetened beverages tax (20%)	Regulatory	Low	Medium	Neutral	Medium	Low	Medium	High	High	Dominant
Alcohol price increase: uniform volumetric tax	Regulatory	Low	Medium	Negative	Medium	Low	Low	High	High	Dominant
Package size cap on sugar-sweetened beverages (mandatory)	Regulatory	Low	Low	Positive	Low	Low	Low	Low	Medium	Dominant
National mass media campaign related to sugar-sweetened beverages	Program	Low	Low	Neutral	Medium	Medium	Medium	High	Medium	Dominant
Fuel excise: 10 cent per litre increase	Regulatory	Low	Low	Negative	Low	Medium	Low	High	High	7,684
Restrictions on price promotions of sugar-sweetened beverages (mandatory)	Regulatory	Low	Low	Negative	Low	Low	Low	Low	High	Dominant

Notes: BMI: body mass index; HALY: health adjusted life year; ICER: incremental cost-effectiveness ratio; PA: physical activity; The willingness-to-pay threshold for this analysis is $50,000 per health adjusted life year. Dominant: the intervention is both cost-saving and improves health.

Four Discussion

All interventions evaluated in this priority-setting study were assessed as being cost-effective approaches to addressing obesity in the Australian population. The majority of interventions were estimated to result in substantial downstream health benefits.

4.1 Dominant interventions[7]

Of the 11 dominant interventions (producing health gains and cost-savings), 'Alcohol price increase: uniform volumetric tax' was estimated to produce the largest health gains and appears at the top of the league table. The top three interventions on the league table ('Alcohol price increase: uniform volumetric tax', 'Sugar-sweetened beverages tax (20%)', and 'Restricting television advertising of unhealthy foods (mandatory)') are all regulatory interventions. Importantly, however, there is currently limited empirical evidence of the impact of these interventions on BMI outcomes, with all scoring 'low' on the strength of evidence criteria. This is despite these interventions having strong program logic. There was variation in how these top three interventions on the league table performed in terms of acceptability and feasibility. However, once implemented, they were all assessed as being sustainable, particularly taking into account their regulatory nature. An important consideration is the exclusion of impacts on industry profits for the two interventions at the top of the league table ('Alcohol price increase: uniform volumetric tax' and 'Sugar-sweetened beverages tax (20%)' interventions), due to the lack of available data. When industry revenue losses were incorporated into a scenario for the 'Restricting television advertising of unhealthy foods' intervention, it remained dominant.

It is imperative that future research further explores the sustainability of obesity prevention intervention effects over time.

The majority of dominant interventions impacted the whole population (or the whole adult population). Three of the dominant interventions targeted children, but incorporated the assumption that the estimated BMI changes were maintained over the lifetime. Given that the ACE-Obesity Policy model is sensitive to this assumption, it is imperative that future research further explores the sustainability of obesity prevention intervention effects over time.

Total intervention costs for dominant interventions varied from $6 million (M) to $210M. In the majority of cases, these costs were borne by government, with most of the costs incurred in the first year of implementation, and relatively small costs (e.g., related to monitoring and/or compliance) in subsequent years. The variation in intervention costs reflects differences in the nature of the interventions evaluated and in the way that the different interventions are implemented.

7 Over-emphasis on dominant interventions is cautioned against, as the purpose of preventive health interventions is not to save money, but to improve health outcomes. All 16 interventions evaluated produce health gains at a reasonable cost.

4.2 Cost-effective interventions

Of the five interventions assessed as cost-effective but not dominant, three are program-based interventions and two are regulatory interventions. 'Workplace intervention to reduce sedentary behaviour' appears at the bottom of the league table. This was a program based intervention that was relatively expensive to implement and targeted sedentary behaviour in the workplace. However the modelling was restricted to benefits related to increased physical activity. The other two program-based interventions ('Financial incentives for weight loss by private health insurers' and 'Community-based interventions') also require significant investment, with total intervention costs ranging from $878M to $1.7 billion (B). Both these program-based interventions scored best on the strength of evidence criteria (high on strength of evidence on BMI).

4.3 Regulatory interventions versus program-based interventions

The difference in the cost-effectiveness of regulatory versus program-based interventions is largely driven by the increased costs of program-based interventions.

The majority of the regulatory interventions (7 of 9) were dominant, compared to around half (4 of 7) of the program-based interventions. The average intervention cost of program-based interventions was over 12 fold greater than regulatory interventions, whereas regulatory interventions resulted in approximately 1.7 times more total HALYs than program-based interventions. This shows that the difference in the cost-effectiveness of regulatory versus program-based interventions is largely driven by the increased costs of program-based interventions. In addition, some program-based interventions reached a smaller proportion of the population, resulting in lower health benefits overall.

Differential costing methodology between program-based and regulatory interventions may have influenced the differential costs between these two categories of interventions. More detailed costing was undertaken for program-based interventions, facilitated by the availability of higher quality data. Regulatory interventions generally included higher levels of uncertainty around cost inputs to reflect the quality of the available data.

It is important to note that the cost to industry for regulation implementation and compliance was included in all the evaluations; however, due to limited data availability there is not a high level of certainty in these figures. Also due to the lack of data, only a small number of regulatory intervention evaluations considered revenue losses to industry related to decreased consumption of regulated goods.

4.4 Implementation considerations

Strength of evidence: Only two interventions scored a high certainty of effect on BMI outcomes ('Community-based interventions' and 'Financial incentives for weight loss by private health insurers'). This is largely because most of the evaluated interventions (despite having strong program logic of their effect on BMI) have not been implemented in Australia or other jurisdictions, and, even if implemented, most have not yet been in place long enough to detect impact on BMI. Many of the intervention studies that evaluations were based on had short time frames during which a change in BMI is less likely to be observed. A key evidence gap for many interventions was therefore the extent of compensatory behaviour (e.g., compensatory eating or physical inactivity/sedentariness) following a change in one aspect of diet or physical activity.

Equity: Different aspects of equity were considered in order to make a final judgement. The vast majority of the interventions evaluated (all except 'Financial incentives for weight loss provided by private health insurers') are likely to have a positive impact on equity of health outcomes because there is a larger burden of disease associated with elevated BMI in lower SEP groups. Two interventions ('Sugar sweetened beverages tax (20%)' and 'Restricting television advertising of unhealthy foods') used the ACE-Obesity Policy SEP model. Both interventions were found to have a positive equity impact on health outcomes, with increased HALY gains in the lower SEP groups compared to the higher SEP groups. This effect was largely driven by the higher consumption of sugar sweetened beverages and the higher exposure to television in the lower SEP groups compared to the higher SEP groups. Qualitatively, 12 of the 16 interventions were assessed as either having a neutral or positive impact on equity. 'Financial incentives for weight loss by private health insurers' was the only intervention that had a negative impact on equity of access because the intervention was restricted to those who could afford private health insurance cover. Three of the interventions that were assessed as having a negative impact on equity impacted the price of regulated products, and, therefore, affected lower SEP groups disproportionately relative to income.

Acceptability: Nine interventions were rated as high for acceptability to the relevant government (state, federal, local). These interventions were also assessed as having either high or medium acceptability to industry and the general public. Interventions that were assessed as having low acceptability to the public ('Fuel excise: 10c per litre increase', 'Package size cap on sugar-sweetened beverages', 'Alcohol price increase: uniform volumetric tax', and 'Restrictions on price promotions of sugar-sweetened beverages) all impacted the cost or value-for-money of products.

Feasibility: Most interventions were assessed favourably on feasibility criteria. Two interventions were assessed to have low feasibility due to limited evidence of previous implementation in the Australian or international contexts ('Package size cap on sugar-sweetened beverages' and 'Restrictions on price promotions of sugar-sweetened beverages').

Sustainability: The majority (6 of 9) of the regulatory interventions were assessed as having high sustainability. Nine interventions were assessed as having medium sustainability based on the requirement for ongoing funding or ongoing industry action. 'Workplace intervention to reduce sedentary behaviour' was assessed to have low sustainability as it required ongoing funding from the business community, ongoing development and dissemination of employee education, and there was limited empirical evidence of sustainability.

4.5 Impact on state and federal governments

Implementation of all 16 cost-effective interventions (including the 11 dominant interventions) would require significant investment from state and/or federal governments. It is estimated that the initial outlay for governments over the first three years would be over $3B. Over those first three years, the cost-savings are estimated to be approximately $126M, with additional downstream cost-savings over the modelled time horizon. However, from the perspective of a decision-maker faced with a budget constraint, all of these interventions may not necessarily be implemented despite their enormous capacity to yield health benefits and downstream cost-savings. Given that Australia spends approximately $2B on prevention each year (17), a budget allocation of one-tenth of that to obesity prevention ($200M) would only allow the top five dominant interventions ('Alcohol price increase: uniform volumetric tax', 'Sugar-sweetened beverages tax (20%)', 'Restricting television advertising of unhealthy foods', 'Package size cap on sugar-sweetened beverages', and 'Supermarket shelf tags on healthier products') to be implemented over the initial three years.

There are many positive financial effects on governments that were not captured in the cost-effectiveness modelling. Revenue from taxation-based interventions are likely to be significant, with the intervention related to sugar-sweetened beverages tax alone estimated to produce annual tax revenue of over $600M. There are also downstream effects of improved productivity in the population resulting in increased income from taxation and lower welfare payments.

Apart from budgetary impacts, there are many considerations that decision-makers are likely to need to balance when prioritising interventions. Given that all the evaluated interventions are cost-effective, decision-makers may wish to consider other aspects of interventions, based on political realities. For example, if, there is a political preference for interventions targeting children, there are four interventions that are relevant ('Restricting television advertising of unhealthy foods', 'School-based intervention to reduce sedentary behaviour', 'School-based intervention to increase physical activity', and 'Community-based interventions'). If certainty of effect is highly desirable, there are two cost-effective interventions that scored high on strength of evidence for BMI outcomes ('Financial incentives for weight loss by private health insurers', and 'Community-based interventions'). If public acceptability rates highly, then there are eight interventions that can be prioritised (see Table 6).

4.6 Comparison to other reports

The direct comparison of ACE-Obesity Policy study results with those from other priority-setting studies (22, 23, 26-28) is not recommended, given the differing populations of interest, study timeframes, data sources and methodologies. Nevertheless, a comparison of common themes across different obesity-related priority-setting studies is instructive.

Findings from the ACE-Obesity Policy study generally align with those of other priority-setting studies conducted both within Australia (22, 23) and internationally (26-28). All ACE-Obesity Policy interventions were found to be cost-effective; this is consistent with other priority-setting studies where policy based interventions targeting the food environment were found to be most cost-effective (20, 22, 23, 28). Regulatory interventions that by nature are relatively low cost and have a high population reach were found to be most cost-effective, in accordance with previous priority-setting study findings (22, 28).

The ACE-Obesity Policy study considered the cost-effectiveness of a number of interventions that have not previously been evaluated as part of a large-scale obesity prevention priority-setting study. Two interventions were modelled for the ACE-Obesity Policy study that updated previous Australian evidence for cost-effectiveness (22, 23) or had been examined internationally (28) but not within the Australian obesity prevention context ('Restricting television advertising of unhealthy foods' and 'Sugar sweetened beverages tax (20%)'). Restrictions on marketing of unhealthy foods to children has consistently been evaluated as a cost-effective intervention for obesity prevention (22, 26, 28, 71), with the results from the ACE-Obesity Policy study providing further evidence of the likely positive impact of the intervention on equity (72). Similarly, whilst a sugar-sweetened beverage tax has been found to be cost-effective internationally (73), the cost-effectiveness results from the ACE-Obesity Policy study suggest both the significant potential for the intervention to achieve cost-effectiveness within the Australian context and the likely positive impact of the intervention on equity of health outcomes (46).

Regulatory interventions that by nature are relatively low cost and have a high population reach were found to be most cost-effective, in accordance with previous priority-setting study findings.

4.7 Strengths and limitations

A key strength of the ACE-Obesity Policy study is that the economic credentials of a wide range of policy-relevant obesity prevention interventions were evaluated, with a mix of interventions that:

- are recommended by authoritative obesity prevention reports and health promotion bodies (10, 74) (e.g., 'Sugar-sweetened beverages tax (20%)', 'Restricting television advertising of unhealthy foods' and 'National mass media campaign related to sugar-sweetened beverages');
- are new promising interventions that have not previously been evaluated for cost-effectiveness from an obesity prevention perspective (i.e., 'Alcohol price increase: uniform volumetric tax/ minimum floor price', 'Restrictions on price promotions of sugar-sweetened beverages', 'Workplace interventions to reduce sedentary behaviour', 'School-based interventions to reduce sedentary behaviour' and 'Supermarket shelf tags on healthier products');
- have been implemented on a small scale or in other jurisdictions (i.e., 'Community-based interventions', and 'Financial incentives for weight loss by private health insurers'); and
- are currently being implemented by Australian governments (i.e., 'Reformulation in response to the Health Star Rating system' and 'Menu kilojoule labelling on fast food').

It is important for priority-setting studies to use methods and produce results that are comparable. A key strength of this study is the application of technical rigour in the economic evaluations through the use of consistent methodology for intervention and disease modelling, extensive uncertainty analyses, and the incorporation of a nuanced assessment of the strength of evidence. Furthermore, these technical results were presented alongside rigorous qualitative analyses of key implementation considerations.

The comparability of these results is nonetheless limited by a number of factors. First, the range of interventions evaluated, many of which have not been implemented, meant there were variations in the assumptions related to the duration of the intervention and the duration of effect. Second, when reviewing the results, it is observed that interventions with better quality evidence of effect were also the interventions that were modelled using more conservative assumptions. For example, the 'Financial incentives for weight loss by private health insurers' intervention assumed gradual weight regain, with no intervention effect 11 years post intervention. This assumption was based on studies with long term follow-up. However, with interventions that have not been implemented long-term (e.g., 'Alcohol price increase: uniform volumetric tax' and several other interventions), lifetime effectiveness was assumed. This assumption is partly based on the mechanism of action, where it is believed that a permanent change to the environment (for example, a lasting change to the price of alcohol) is likely to have a more sustained effect than weight loss programs (7). However, there are no longitudinal studies to demonstrate this sustained effect.

The ACE-Obesity Policy model utilised in this study entailed several improvements over previous iterations of the model. These improvements allowed for a better assessment of interventions targeted at children, across different SEP groups, and interventions targeting other risk factors related to BMI (i.e., physical activity and fruit and vegetable intake). However, there remain areas for further improvement. Firstly, the ACE-Obesity Policy model does not account for the other potential impacts of obesity in childhood other than HRQoL (for example, on academic achievement (75) or conditions such as asthma or sleep apnoea (76)). In addition, for adults, productivity impacts of interventions may also be important information for inclusion. Future iterations of the model could develop these areas.

Another limitation was the use of 2010 as the base year for expressing all values. In the early years of this five-year project, this was the most up-to-date data available; however, in recent years more current data have become available. Updating the model inputs will be an ongoing task.

Additionally, the modelling was not able to take into account the potential joint effects of implementing multiple interventions simultaneously[8] (as is recommended by multiple reports on obesity prevention), and therefore it is not possible to inform decision-makers on the value-for-money of different packages of obesity prevention interventions. This is due to the structure of the model, its multi-sector focus, as well as the limited available evidence of joint effects. Although out of scope for the current study, an ongoing body of work will be needed to update and refine the ACE-Obesity Policy model.

Finally, the ACE-Obesity Policy study set out to evaluate obesity prevention interventions across a broad range of sectors; however, this was limited by the availability of evidence at this time to complete full economic evaluations in the areas of agriculture, transport, built environment, environment and trade.

4.8 Recommendations for policy makers

The ACE-Obesity Policy study provides important information on the cost-effectiveness of policy options for obesity prevention. The results provide policy makers with the comparative assessment of a suite of obesity prevention policy interventions. For governments aiming to develop a comprehensive obesity prevention strategy, the results of this study should be particularly instructive.

There is now sufficient evidence:

- of a comprehensive suite of cost-effective, cross-sectoral policy options for obesity prevention in Australia. As the cost burden and implementation responsibilities will likely be spread across multiple stakeholders, inter-departmental co-operation and co-ordination will be required in order to achieve successful implementation. This means that a whole-of-government approach to obesity prevention is required.
- that policies targeting the whole population are likely to be cost-effective, even when the strength of evidence for an intervention is currently low. In particular, interventions that are low cost and have high levels of population reach represent good value-for-money from an obesity prevention perspective. In terms of likely cost-effectiveness, it is not necessary to wait for better evidence of effectiveness (e.g., directly-measured impacts of specific obesity prevention interventions on obesity levels, disease rates and health expenditure).
- that strong governmental leadership will be required, particularly given that acceptability to industry for many interventions is likely to be relatively low. Successful implementation of policies will require political courage and commitment.
- that value-for-money from effective obesity prevention interventions, especially in children, is less likely to materialise in the short term, but will accrue over time through the prevention of chronic disease. Given that the health benefits and healthcare cost-savings of obesity prevention are unlikely to be realised within any single political cycle, an ongoing commitment to obesity prevention is required from all sides of government.
- that obesity prevention interventions have the potential to address inequities in health that exist within the Australian population. Obesity prevention interventions that are cost-effective and have positive impacts on equity should be given a high priority for implementation.
- that social and political support for obesity prevention policy implementation needs to be mobilised. The results from this study demonstrating the great potential for achieving health benefits in a cost-effective manner (and in many cases while saving money in the long term), can be used to garner support for these policies.

8 Simply adding the impacts of a desired package of interventions would give a good approximation of the combined effect, with some overestimation. There may also be synergies realised in the costs and benefits.

Five Intervention reports

Alcohol price increase: uniform volumetric tax / minimum floor price

Authors: Ella Robinson, Phuong Nguyen, Jaithri Ananthapavan, Anita Lal, Heng Jiang, Michael Livingston, Gary Sacks

Publication status: manuscript in progress

The intervention

- Scenario 1: Replace the current taxation system on alcohol with a uniform volumetric tax equal to 84 cents[i] per standard drink, applied across all alcohol products.
- Scenario 2: Introduce a floor price on alcohol at $1.30 per standard drink.

What we already know

- High intake of alcohol is linked to weight gain, and the energy (kJ) contribution from alcohol in the diet is significant (e.g., alcohol contributes ~6.6% of energy intake for males aged 51-70).[ii]
- Increasing the price of alcohol has been shown to be an effective measure for reducing consumption of alcohol. While the impact of alcohol taxes on traditional harms associated with alcohol (e.g., road traffic accidents, violence and injuries) have been previously examined, their potential impact on obesity-related diseases has not been explored.
- In 2018, the Northern Territory introduced a floor price on alcohol at $1.30 per standard drink.[iii]

Key elements of the modelled intervention

- Alcohol intake by age and sex was extracted from 2011-12 Australian Health Survey data. Expected changes in prices, by alcohol type and point of purchase (off-premise and on-premise)[iv] were calculated for each scenario. Recent Australian-specific own- and cross-price elasticity estimates were used to calculate expected mean changes in consumption post-intervention. Relative changes in energy intake and BMI were then calculated for each scenario. Other benefits directly related to reduction in alcohol consumption were not modelled. Substitution to non-alcoholic beverages/foods was assumed to be zero.
- Costs to government included the costs of passing the legislation; administering, supporting and monitoring implementation; and running consumer education campaigns. Costs to the alcohol industry included expected compliance costs to alcohol retailers and venues (e.g., pubs, hotels). Changes to industry revenue and tax revenue are not included in the analyses.

Key findings

- Scenario 1 would cost $32M to implement, predominantly increasing the price of off-premise beer and wine (average of 29%), and cask wine (121%). This would lead to a 16% reduction in mean alcohol consumption (reduction of 202ml alcohol/week); a 0.7kg reduction in mean population body weight; 471,165 HALYs gained and cost offsets of $4.9B.
- Scenario 2 would cost $30M to implement. This scenario would largely not affect the price of on-premise alcohol, but would increase the price of some off-premise alcohol (e.g., wine by 14% and cask wine by 168%). This would lead to a 9% decrease in mean alcohol consumption (reduction of 117ml alcohol/week); a 0.45kg reduction in mean population body weight; 317,653 HALYs gained and costs offsets of $3.3B.
- Both scenarios were shown to be dominant (cost saving and health promoting), and would lead to significant obesity-related health benefits to the Australian population.

Conclusion

Price interventions aimed at reducing alcohol consumption in the population are likely to be cost-effective from an obesity prevention perspective, over and above the benefits related directly to reduce alcohol consumption. Public acceptability of these interventions is likely to be low.

Scenarios description and cost-effectiveness results

Table 1 *Description of selected scenarios*

	Scenario 1 Uniform volumetric tax equiv. to a 10% increase in the tax applied to spirits, applying to all alcohol - replacing current tax regime	Scenario 2 Floor price of $1.30 per standard drink for all alcohol
Risk factor(s) addressed by intervention	BMI	
Population targeted	Australian drinking age population, aged 14-100 years	
Weighted average reduction in body weight (95% UI)	0.68kg (0.64 to 0.73)	0.45kg (0.42 to 0.48)
Weighted average reduction in BMI (95% UI)	0.28kg/m^2 (0.26 to 0.30)	0.19kg/m^2 (0.17 to 0.20)
Effect decay	100% maintenance of effect	
Costs included	Government: cost of legislation, consumer awareness campaign, tax administration and monitoring. Industry: implementation and compliance costs	Government: cost of legislation, consumer awareness campaign, monitoring and advice to industry. Industry: implementation and compliance costs
Type of model used	Population model with quality of life in children	

Notes: BMI: Body mass index; kg: kilogram; m: metre; UI: uncertainty interval

Table 2 *Cost-effectiveness results, mean (95% UI)*

	Scenario 1	Scenario 2
Total HALYs gained	471,165 (413,231 to 535,804)	317,653 (276,334 to 361,573)
Total intervention costs	$32M ($31M to $33M)	$30M ($26M to $36M)
Total healthcare cost savings	$4.8B ($4.3B to $5.5B)	$3.3B ($2.9B to $3.7B)
Total net cost *	-$4.8B (-$5.5B to -$4.2B)	-$3.3B (-$3.7B to -$2.8B)
Mean ICER	Dominant (Dominant to Dominant)	Dominant (Dominant to Dominant)
Probability of being cost-effective #	100%	100%
Overall result	**Dominant**	**Dominant**

*Notes: B: billion; Dominant: the intervention is both cost-saving and improves health; HALY: health adjusted life year; ICER: incremental cost effectiveness ratio; M: million; $: 2010 Australian dollars; * Negative total net costs equate to cost savings; # The willingness-to-pay threshold for this analysis is $50,000 per HALY.*

Figure 1 ***Cost–effectiveness plane***

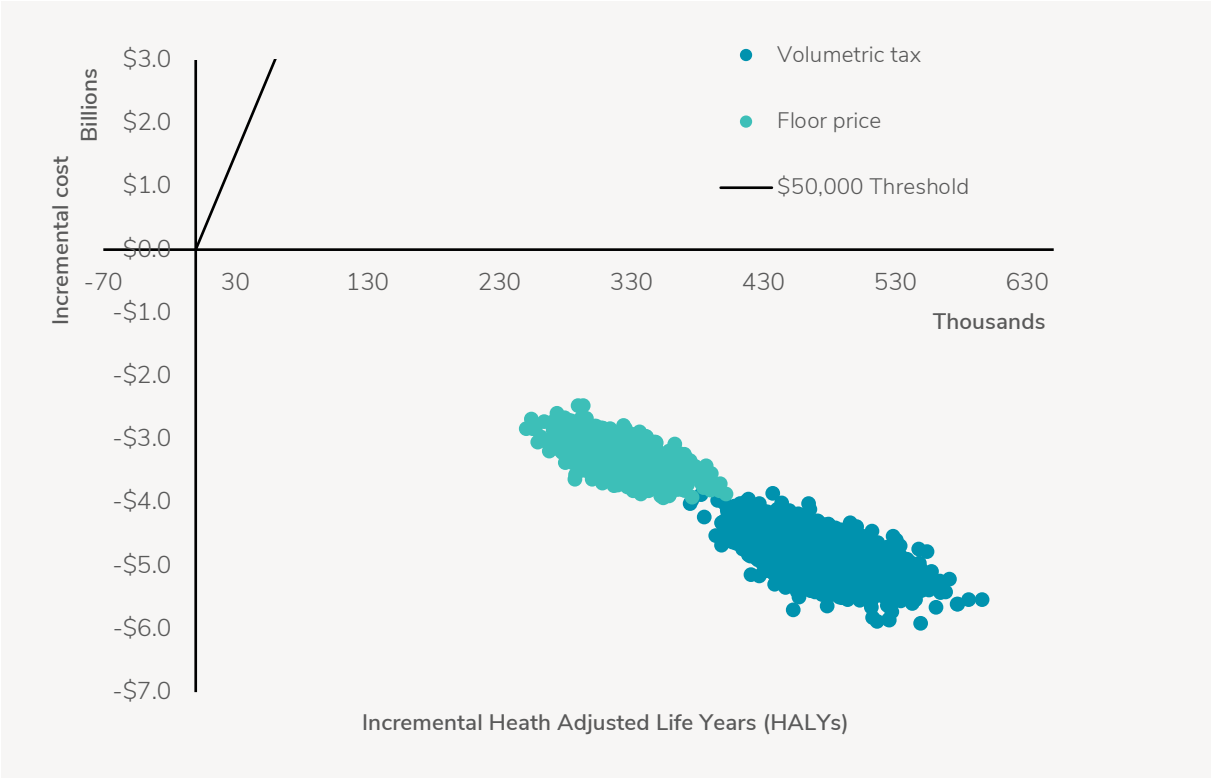
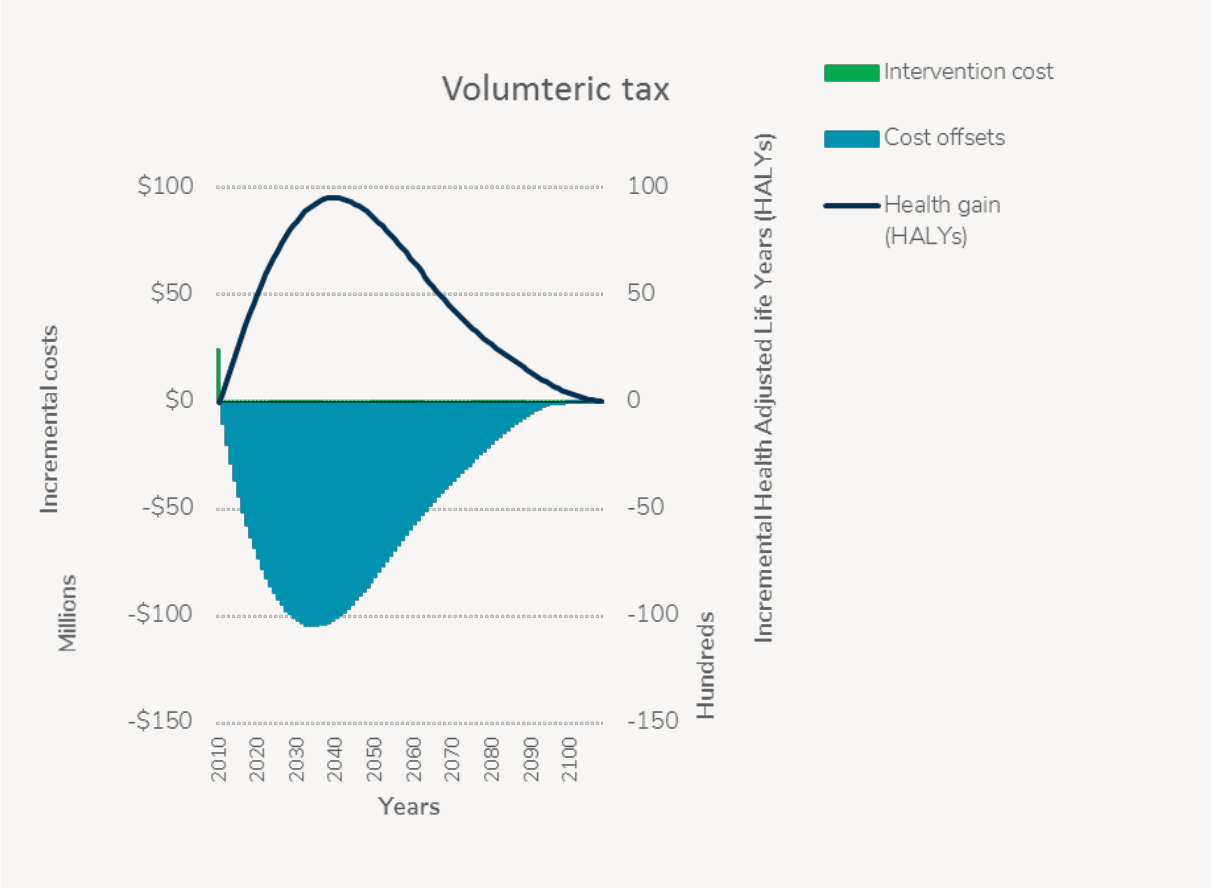


Figure 2 ***Costs, cost offsets and health gains over time (uniform volumetric tax)***



Implementation considerations

Consideration	Details	Assessment
Strength of evidence	Low certainty of the effect of reductions in alcohol consumption on Body Mass Index / body weight outcomes due to absence of relevant studies.	Low
	Medium certainty of effect regarding how changes in price affect alcohol consumption and the corresponding impact on energy intake. Limited available evidence on potential substitution to non-alcoholic beverages/foods.[v]	Medium
Equity	Scenario 1: Price of all alcoholic beverages, particularly alcohol that is currently taxed at a low rate (e.g., cask wine), would increase. This will affect low-income consumers proportionately more.	Negative
	Scenario 2: This intervention would predominantly increase the price of low cost alcohol (e.g., cask wine). This will be somewhat regressive for low-income consumers; however, purchasing of low-cost alcohol is predominantly associated with drinking pattern (e.g., heavy drinkers) rather than income level.[vi]	
Acceptability	**Government:** Governments in Australia have shown strong support for taxes on alcohol, although have been reluctant to undertake large-scale changes to the existing alcohol taxation system. The Northern Territory (NT) government introduced a floor price on alcohol of $1.30 in 2018, indicating its acceptability in that context.	Medium
	Industry: The alcohol industry is strongly opposed to increases in taxes and government intervention with respect to price. Evidence suggests that alcohol retailers and certain sectors of the alcohol industry (e.g., beer, spirits) may be somewhat supportive of a floor price on alcohol, particularly considering that revenue from the price increase will go to them.[vii]	Low
	Public: The majority of the public are likely to oppose increases in alcohol prices.	Low
Feasibility	Scenario 1: Various excise taxes on alcohol are currently in place, although this intervention will involve substantial change to the current alcohol tax regime.	High
	Scenario 2: A floor price would require a significant change to the current system. Nevertheless, the NT government has demonstrated the feasibility of this approach in that context.	
Sustainability	Scenario 1: Likely to be high due to the regulatory nature of the intervention.	High
	Scenario 2: The floor price would need to be indexed on a regular basis.	Medium
Other considerations	Likely to be substantial additional benefits from reducing alcohol consumption, e.g., violence, injuries and road accidents. Self-reported alcohol consumption has been shown to be approximately 50% lower than what is actually consumed. This model relied on self-reported data; therefore, the results are likely to be a conservative estimate of the potential health gains. The differential impact of the intervention on heavy drinkers was not considered. The potential impact on industry profits was not considered.	

[i] This is equivalent to a 10% increase in the current tax applied to off-premise spirits
[ii] Australian Bureau of Statistics 2014, Australian Health Survey: Nutrition First Results - Food and Nutrients 2011-12
[iii] Northern Territory Government 2018. Floor price: Northern Territory Alcohol Policies and Legislation Reform, passed 22 August 2018. Darwin
[iv] On-premise includes alcohol bought from licensed premises (e.g., bars, clubs, restaurants and hotels). Off-premise includes alcohol bought from liquor stores and other retail outlets.
[v] One study (Quirmbach et al, *h*, vol. 72, no. 4, p. 324).indicates that introducing taxes on sugar-sweetened beverages leads to increased consumption of alcohol, which may indicate potential substitution effects from alcohol price interventions.
[vi] Vandenberg, B & Sharma, A 2016, 'Are Alcohol Taxation and Pricing Policies Regressive? Product-Level Effects of a Specific Tax and a Minimum Unit Price for Alcohol', *Alcohol and Alcoholism*, vol. 51, no. 4, pp. 493-502.
[vii] The Foundation for Alcohol Research and Education (2017). The Price is Right: Setting a Minimum Unit Price on Alcohol in the Northern Territory. FARE: Canberra.

Community-based interventions

Authors: Jaithri Ananthapavan, Phuong Nguyen, Gary Sacks, Marj Moodie

Publication citation: manuscript submitted

The intervention

- Community based interventions (CBIs) were defined as a co-ordinated program of community-level strategies to promote both healthy eating and physical activity at the population-level.
- This analysis explored implementation of CBIs across all local government areas (LGAs) in Australia.

What we already know

- Systematic reviews have shown that CBIs can be effective in preventing unhealthy weight gain especially in school aged children.
- Best-practice recommendations indicate that CBIs should include multiple strategies, have multiple components, be implemented in multiple settings, and target both physical activity and nutrition.
- CBIs have been supported, funded and delivered by all levels of government in Australia.
- The limited evidence available suggests that CBIs can be cost-effective.

Key elements of the modelled intervention

- A meta-analysis of 10 quasi-experimental trials was undertaken to assess the effectiveness of CBIs, reported as a change in BMI (body mass index) z-score.
- The population modelled was primary and secondary school children (5-18 years).
- Individual components of several CBIs were costed to estimate the average cost of each component. A generic CBI was costed based on several components including administration, capacity building, awareness raising, three school-based physical activity and four nutrition strategies, plus wider community actions. Costs were applied across the 577 LGAs in Australia, with each assumed to have 10 schools implementing the CBI.
- Sensitivity analyses investigated the impact on primary school children only (aged 5-12 years), and explored a best case scenario with lower intervention intensity coupled with a larger BMI effect.

Key findings

- The cost of implementing CBIs across all LGAs in Australia was estimated to be AUD878M over three years, and was estimated to save approximately $452M in healthcare costs.
- CBIs were predicted to result in 51,792 HALYs gained over the lifetime of the cohort. The mean ICER was $8,155 per HALY gained with a 95% probability of being cost-effective.
- Scenario analyses showed that the intervention was more cost-effective when the best case scenario was applied, and was dominant when limited to primary school children.

Conclusion

CBIs are likely to be cost-effective obesity prevention initiatives. CBIs are equitable and are strongly supported by evidence of effectiveness; however, the feasibility of implementing CBIs across all Australian LGAs is questionable due to its relatively large budget impact.

Scenarios description and cost-effectiveness results

Table 1 *Description of selected scenarios*

	Base case Interventions in primary and secondary schools	Scenario 1 Interventions in primary schools only	Scenario 2 Best case
Risk factor(s) addressed by intervention	BMI		
Population targeted	5 to 18 year olds	5 to 11 year olds	5 to 18 year olds
Reduction in BMI z-score MD (95% UI)	0.07 (0.01 to 0.13)	0.12 (0.01 to 0.23)	0.08 (0.02 to 0.15)*
Effect decay	100% maintenance of effect		
Costs included	Costs for average CBIs in both primary and secondary schools	Costs for average CBIs in just primary schools	Less intensive CBIs in both primary and secondary schools
Type of model used	Child matrix model		

Notes: BMI: Body mass index; CBI: community-based intervention; MD: mean difference; UI: uncertainty interval
** Effect size estimated from meta-analysis results where only studies reporting adjusted mean differences were included.*

Table 2 *Cost-effectiveness results, mean (95% UI)*

	Base case	Scenario 1	Scenario 2
Total HALYs gained	51,792 (6,816 to 96,972)	98,754 (7,675 to 186,244)	58,331 (10,103 to 108,728)
Total intervention costs	$878M ($794M to $963M)	$716M ($645M to $792M)	$743M ($668M to $820M)
Total healthcare cost savings	$452M ($58M to $854M)	$887M ($78M to $1,661M)	$509M ($92M to $941M)
Total net cost *	$426M ($3M to $823M)	-$170M (-$931M to $640M)	$234M (-$198M to $651M)
Mean ICER ($/HALY gained)	8,155 (237 to 81,021)	Dominant (Dominant to 30,448)	4,012 (Dominant to 62,271)
Probability of being cost-effective #	95%	97%	97%
Overall result	**Cost-effective**	**Dominant**	**Cost-effective**

*Notes: Dominant: the intervention is both cost-saving and improves health; HALY: health adjusted life year; ICER: incremental cost effectiveness ratio; M: million; $ 2010 Australian dollars; * Negative total net costs equate to cost savings.*
 # The willingness-to-pay threshold for this analysis is $50,000 per HALY.

Figure 1 ***Cost–effectiveness plane***

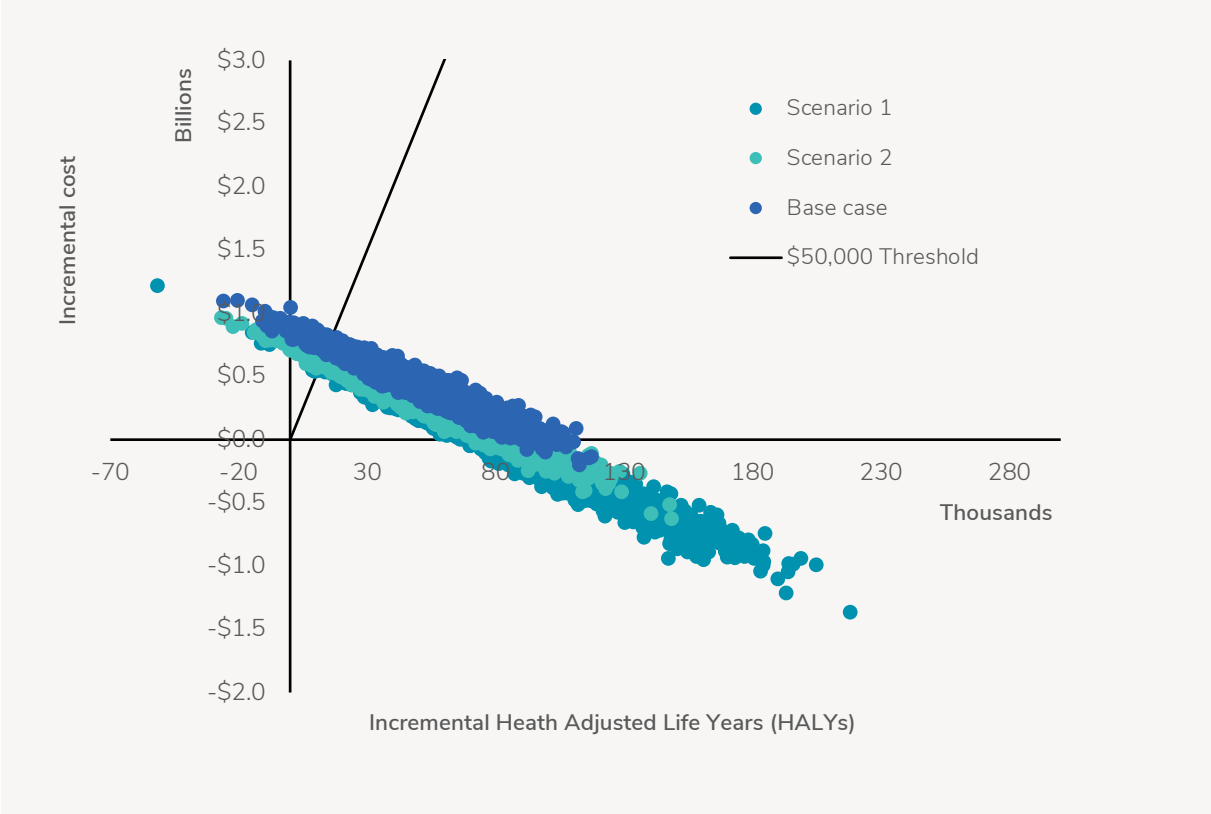
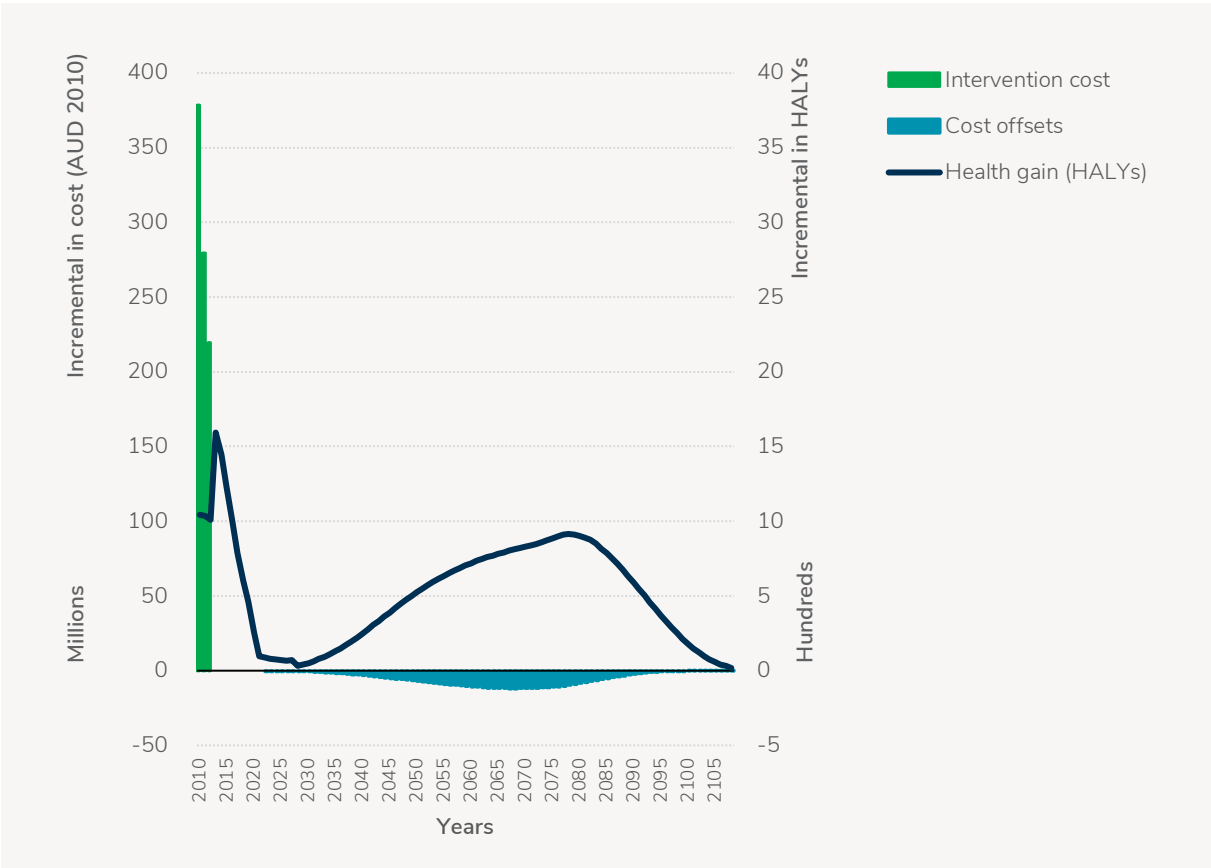


Figure 2 ***Costs, cost offsets and health gains over time (base case)***



Implementation considerations

Consideration	Details	Assessment
Strength of evidence	High certainty of effect for BMI outcomes based on systematic reviews of RCTs. The effect size for this intervention was estimated from a meta-analysis of 10 quasi-experimental studies.	High
Equity	Studies have found that CBIs could prevent the widening of inequalities in obesity. However, our modelling shows a considerable financial contribution from individuals that could preclude some students from lower income families participating, potentially resulting in negative equity impacts. The specific strategies implemented could be tailored to the socio-economic profile of the community, and could include subsidies.	Neutral
Acceptability	**Government:** CBIs align well with state and local governments' policy objectives related to encouraging healthy eating and physical activity in childhood. In 2013, approximately 104 CBIs had been implemented around Australia. The highest proportion (30%) were implemented in Victoria as part of the Healthy Together Victoria initiative, followed by New South Wales (19%), South Australia (14%) and Queensland (10%).	High
	Industry: There is evidence that CBIs have been successful in engaging local industry partners.	High
	Public: Highly participatory methods for the design and implementation of CBIs are likely to boost acceptability and participation. There may nonetheless be some concern around affordability for families to participate in CBI activities (e.g. payment for afterschool sports activities).	High
Feasibility	The widespread implementation of CBIs is evidence of their feasibility in a range of contexts. The relatively high implementation cost (compared with current investment in prevention) may lower feasibility of national implementation. However, a staged implementation plan may assist in increasing feasibility.	Medium
Sustainability	The effectiveness of CBIs are dependent on the continuous review, evaluation and modification of CBI strategies. However, there is evidence of effective CBIs 12 years post-commencement. Intervention sustainability is highly dependent on funding and engagement of key community members, especially within schools.	Medium
Other considerations	**Positive side effects:** CBIs may have "spill-over" effects on neighbouring communities who implement aspects of the intervention. CBIs could help create new social norms around nutrition and physical activity. This evaluation estimated the impact of CBIs on school aged children. It is likely that there will be wider positive impacts on all members of the community. There are also likely to be benefits related to community cohesion and empowerment.	

Notes: BMI: body mass index; CBIs: community-based interventions; RCT: randomized controlled trial

Financial incentives for weight loss by private health insurers

Authors: Jaithri Ananthapavan, Phuong Nguyen

Publication citation: manuscript in progress

The intervention

- Financial incentives for weight loss ($200 cash payment per year for 5 years, contingent on meeting weight loss and subsequent weight maintenance goals) provided by private health insurers (PHIs) alongside an initial 1 year commercial weight loss program (WLP).
- PHI members who are overweight or obese and have extras/ancillary cover would be eligible for this intervention.

What we already know

- Many Australian PHIs offer subsidises for commercial WLPs for members with extras cover.
- Systematic reviews have shown that incentivising weight loss as part of a WLP increased uptake and increased weight loss compared to non-incentive programs[1].
- Weight is often regained post-WLPs. It is unclear whether incentives could help maintain weight loss.

Key elements of the modelled intervention

- Intervention effectiveness was calculated using a network meta-analysis, where the effectiveness of incentivised WLPs compared to current practice was indirectly estimated via non-incentive WLPs[2].
- Cost components of the incentivised WLP included participant recruitment, WLP fees, financial incentives, program administration and participant time.
- We assumed that the usual weight regain post-WLP (13% each year) would be halved by providing an incentive for weight maintenance. Once the maintenance incentive ceased, the weight regain reverted to 13% per year[3]. We tested this assumption in a scenario analysis.
- Given the lack of knowledge on 'current practice' for those eligible for this program, scenario analyses tested different assumptions.

Key findings

- 21% of the Australian population was eligible for the intervention, with estimated 48% uptake.
- The network meta-analysis showed that the incentivised WLP resulted in weight loss after 6 months of 9.30kg/person (95% UI: 7.91 to 10.70), compared to a 'do-nothing' comparator; a reduction of 5.88 kg/person (95% UI: 3.96 to 7.66) when compared to self-help or the usual-care comparator; and a reduction of 2.11 kg/person (95% UI: 0.96 to 3.28) when compared to commercial WLPs alone.
- When modelled for the whole population, the intervention was estimated to result in weighted mean change in population body weight of -0.69kg after 5 years, which translated to a total of 140,110 HALYs gained and healthcare cost savings of $692 million.
- Incremental intervention costs were estimated to be $1.7 billion with approximately $1.1 billion accrued by PHI. The mean ICER was $7,516 per HALY gained.

Conclusion

The intervention represents good value for money from a societal perspective, but it does not produce a positive return on investment to the PHI. The extent of implementation by PHI will depend on the marketing advantage of offering such a program.

Scenarios description and cost-effectiveness results

Table 1 *Description of selected scenarios*

	Base case No effect after 11 years	Scenario 1 No weight maintenance incentive, no effect after 7 years
Risk factor(s) addressed by intervention	BMI	
Population targeted	Australian population aged 18 and above, who are overweight or obese and have private health insurance with "extras cover"	
Comparator	A current practice comparator consists of 11% of the eligible population enrolled in a commercial WLP, half of the remaining population sought GP-based weight loss advice, and the remainder 'did nothing different', i.e. 11% WLP; 44.5% GP advice; 44.5% do nothing.	
Average incremental reduction in body weight (95% UI) for the intervention group	6.88kg (95% UI: 5.84 to 7.92 to)	
Average incremental reduction in BMI (95% UI) for the intervention group	2.93kg/m^2 (2.49 to 3.39)	
Effect decay	6% per year for 5 years, 13% per year after 5 years	13% per year
Costs included	Intervention: financial incentives, program administration, WLP fees (for individuals and PHI), Comparator: Commercial WLP, GP visits	Exclude weight loss maintenance costs
Type of model used	Population model with quality of life in children	

Notes: BMI: Body mass index; GP: general practitioner; kg: kilogram; m: metre; UI: uncertainty interval; WLP: weight loss program

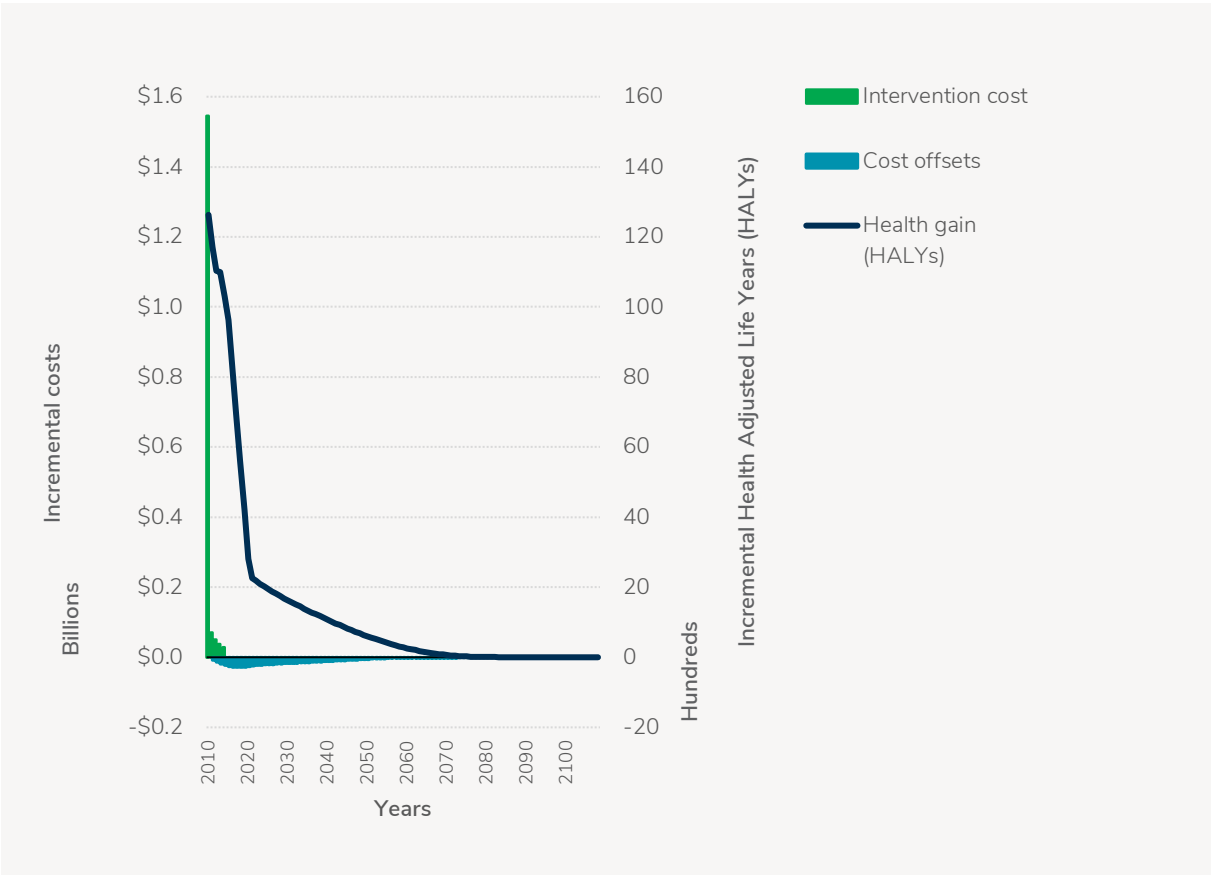
Table 2 *Cost-effectiveness results, mean (95% UI)*

	Base case	Scenario 1
Total HALYs gained	140,110 (112,899 to 170,243)	84,787 (68,142 to 104,248)
Total incremental intervention costs	$1.7B ($882M to $2.7B)	$1.6B ($839M to $2.5B)
Total healthcare cost savings	$692M ($515M to $890M)	$407M ($304M to $528M)
Total net cost	$1.0B ($157M to $2.0B)	$1.2B ($425M to $2.1B)
Mean ICER ($/HALY gained)	7,376 (1,022 to 15,146)	14,549 (4,767 to 26,793)
Probability of being cost-effective #	100%	98%
Overall result	**Cost-effective**	

Notes: B: billion; HALY: health adjusted life year; ICER: incremental cost effectiveness ratio; M: million; $: 2010 Australian dollars; # The willingness-to-pay threshold for this analysis is $50,000 per HALY.

Figure 1 ***Cost–effectiveness plane***

Figure 2 ***Costs, cost offsets and health gains over time (base case)***



Implementation considerations

Consideration	Details	Assessment
Strength of evidence	High certainty of effect for weight outcomes based on systematic reviews of RCTs comparing incentivised WLP to non-incentive WLP. However the effect size for this intervention compared to current practice was estimated from a network meta-analysis due to a lack of trials directly measuring the impact of incentivised WLP compared to current practice as we have defined it. There is also some uncertainty regarding the weight regain assumptions.	High
Equity	This intervention is limited to the 44% of the adult population who have PHI with extras cover. People living in areas with relatively high levels of socio-economic disadvantage had the lowest levels of private health insurance in Australia (33.6%).[4]	Negative
Acceptability	**Government:** The government is likely to be supportive of PHI administered programs to encourage healthy lifestyles, contingent on compliance with the community rating system[5].	High
	Industry: There are many international examples of PHI providing financial incentives for healthy behaviours, and many Australian PHI offer subsidies for commercial WLPs. From the perspective of the PHI, the costs of the program will not be fully recovered from future health care savings, and therefore the investment decision will depend on the marketing advantage of offering this program.	Medium
	Public: There is no evidence of the public support for financial incentives for weight loss, but it is likely to have little opposition.	Medium
Feasibility	PHI companies currently are likely to have the appropriate administration systems to implement this program.	High
Sustainability	There is international evidence of PHI providing incentives for healthy lifestyles for over 20 years.	Medium
Other considerations	We modelled the cost-effectiveness of financial incentives for weight loss provided by PHI. This intervention is also likely to be cost-effective if provided by the government through public health insurance. This intervention is likely to boost uptake of WLPs, and is therefore likely to boost the profits of commercial WLP providers.	

Notes: PHI: private health insurance/private health insurer; RCT: randomised control trial; WLP: weight loss program

[1] Ananthapavan J, Peterson A, Sacks G. Paying people to lose weight: the effectiveness of financial incentives provided by health insurers for the prevention and management of overweight and obesity – a systematic review. Obesity Reviews. 2018;19(5):605-13.
[2] Gudzune KA, Doshi RS, Mehta AK, Chaudhry ZW, Jacobs DK, Vakil RM, et al. Efficacy of Commercial Weight-Loss Programs An Updated Systematic Review Efficacy of Commercial Weight-Loss Programs. Annals of internal medicine. 2015;162(7):501-12.
[3] Forster M, Veerman JL, Barendregt JJ, Vos T. Cost-effectiveness of diet and exercise interventions to reduce overweight and obesity. International Journal of Obesity. 2011;35(8):1071-8.
[4] Australian Bureau of Statistics 4364.0.55.002 - Health Service Usage and Health Related Actions, Australia, 2014-15.
[5] The community rating system is part of the Private Health Insurance Act. It stipulates that Private Health Insurers must charge the same premium for the same product regardless of the health profile of members. Financial incentives could be considered akin to reducing premiums, limited to those who are able to participate in weight loss programs. However, discounts on premiums of up to 12% are allowed and therefore we have limited the annual financial incentive to $200 per year. https://www.privatehealthcareaustralia.org.au/private-health-insurance-community-rating-system/; http://www.med.monash.edu.au/assets/docs/sphpm/health-insurance.pdf

Fuel excise: 10 cent per litre increase

Publication citation: Brown V, Moodie M, Cobiac L, Mantilla Herrera AM, Carter R (2017). Obesity-related health impacts of fuel excise taxation – an evidence review and cost-effectiveness study. *BMC Public Health* 17(359)

The intervention

- The intervention was defined as a $0.10 per litre increase to the existing national fuel excise tax. The proportional amount of fuel excise tax levied would still be less than in countries such as Switzerland, the Netherlands and the United Kingdom.

What we already know

- Limited evidence on the effect of policies such as fuel taxation on health-related behaviours currently exists.
- Increasing the relative cost of driving through an increase in fuel taxation may increase rates of active transport (defined as walking, cycling and using public transport), thereby decreasing population prevalence of obesity and other diseases where physical inactivity is a risk factor.

Key elements of the modelled intervention

- Given limited data on transport behaviours, the intervention population was defined as the working age population (18-64 years). The impact of commuting modal switch from private motor vehicle to public transport (PT) was modelled as a hypothetical result of the intervention.
- Intervention effectiveness was based on conservative estimates of cross-price elasticity of demand for PT with respect to fuel price, distance walked to access PT and metabolic equivalent task (MET) values. A "plausible case" was then modelled using less conservative, but still plausible, inputs.
- Costs included legislative costs, with compliance and administrative burdens estimated as relatively low. Vehicle operating cost-savings were estimated and reported separately.

Key findings

- The intervention would cost $4.4M to implement.
- Under conservative assumptions, the intervention would result in a population weighted mean increase in physical activity of 0.1 MET minutes per week, and weighted mean BMI reduction of 0.0002kg/m^2. The intervention would be cost-effective, resulting in 237 HALYs gained and total healthcare cost-savings of $2.6M over the lifetime.
- Under "plausible case" assumptions, the intervention would result in a larger increase in physical activity (0.8 MET minutes per week) and population weighted mean BMI reduction (0.002kg/m^2). The intervention would be more cost-effective, resulting in 3,181 HALYs gained and total healthcare cost-savings of $34.2M.

Conclusion

The intervention demonstrates potential for cost-effectiveness, but the analysis is limited in terms of quality of evidence of effect and sustainability of effect. Concerns around equity and acceptability would need to be addressed.

Scenarios description and cost-effectiveness results

Table 1 *Description of selected scenarios*

	Base case Conservative input parameters to model to intervention effect	Scenario 1 Conservative input parameters to model to intervention effect - BMI effect only	"Plausible case" Less conservative, but still plausible, input parameters to model to intervention effect
Risk factor(s) addressed by intervention	BMI/PA/Injury	BMI	BMI/PA/Injury
Population targeted	Australian working population, aged 18-64 years		
Weighted average reduction in BMI (95% UI)	0.0002kg/m^2 (0.0001 to -0.0003)		0.002kg/m^2 (0.001 to 0.003)
Weighted average reduction in PA, MET mins/week (95% UI)	0.1 (0.001 to 0.11)	N/A	0.8 (0.6 to 0.9)
Effect decay	100% maintenance of effect		
Costs included	Cost of legislation. Vehicle operating cost-savings reported separately.		
Type of model used	Population model with quality of life in children		

Notes: BMI: Body mass index; kg: kilogram; m: metre; MET: metabolic equivalent task; mins: minutes; PA: physical activity; UI: uncertainty interval

Table 2 *Cost-effectiveness results, mean (95% UI)*

	Base case	Scenario 1	"Plausible case"
Total HALYs gained	237 (138 to 351)	195 (85 to 314)	3,181 (1,797 to 4,633)
Total intervention costs	$4M ($3M to $5M)		
Total healthcare cost savings	$2M ($1M to $4M)	$2M ($962,352 to $4M)	$34M ($17M to $51M)
Total net cost *	$2M ($1M to $3M)	$2M ($1M to $3M)	-$30M (-$47M to -$14M)
Mean ICER ($/HALY gained)	7,684 (7,617 to 10,919)	10,568 (3,700 to 52,684)	Dominant (Dominant to Dominant)
Probability of being cost-effective #	99%	99%	100%
Overall result	**Cost-effective**	**Cost-effective**	**Dominant**

*Notes: Dominant: the intervention is both cost-saving and improves health; HALY: health adjusted life year; ICER: incremental cost effectiveness ratio; M: million; $: 2010 Australian dollars; * Negative total net costs equate to cost savings. # The willingness-to-pay threshold for this analysis is $50,000 per HALY.*

Figure 1 ***Cost–effectiveness plane***

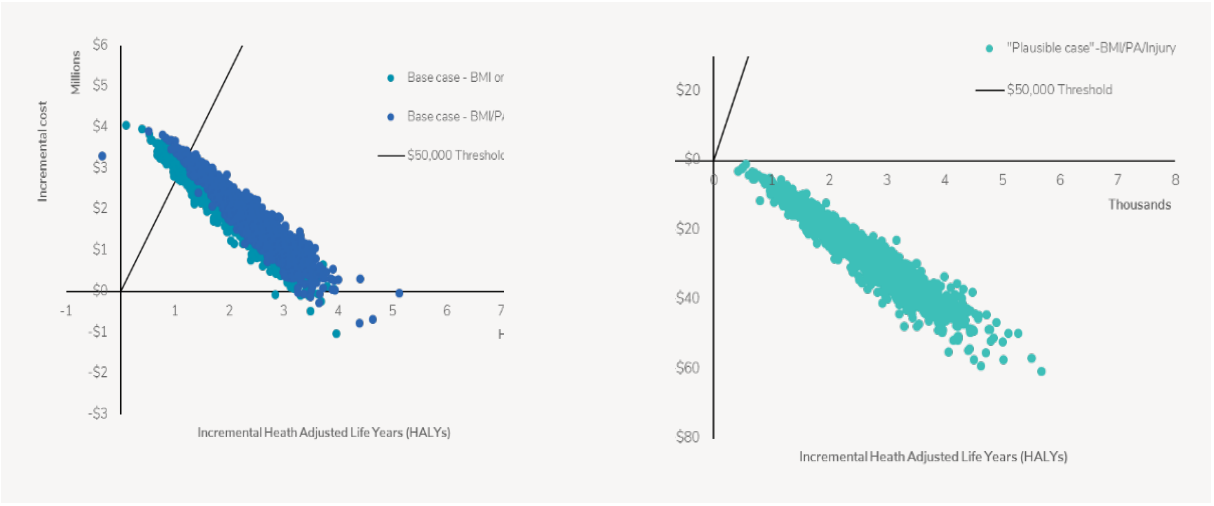
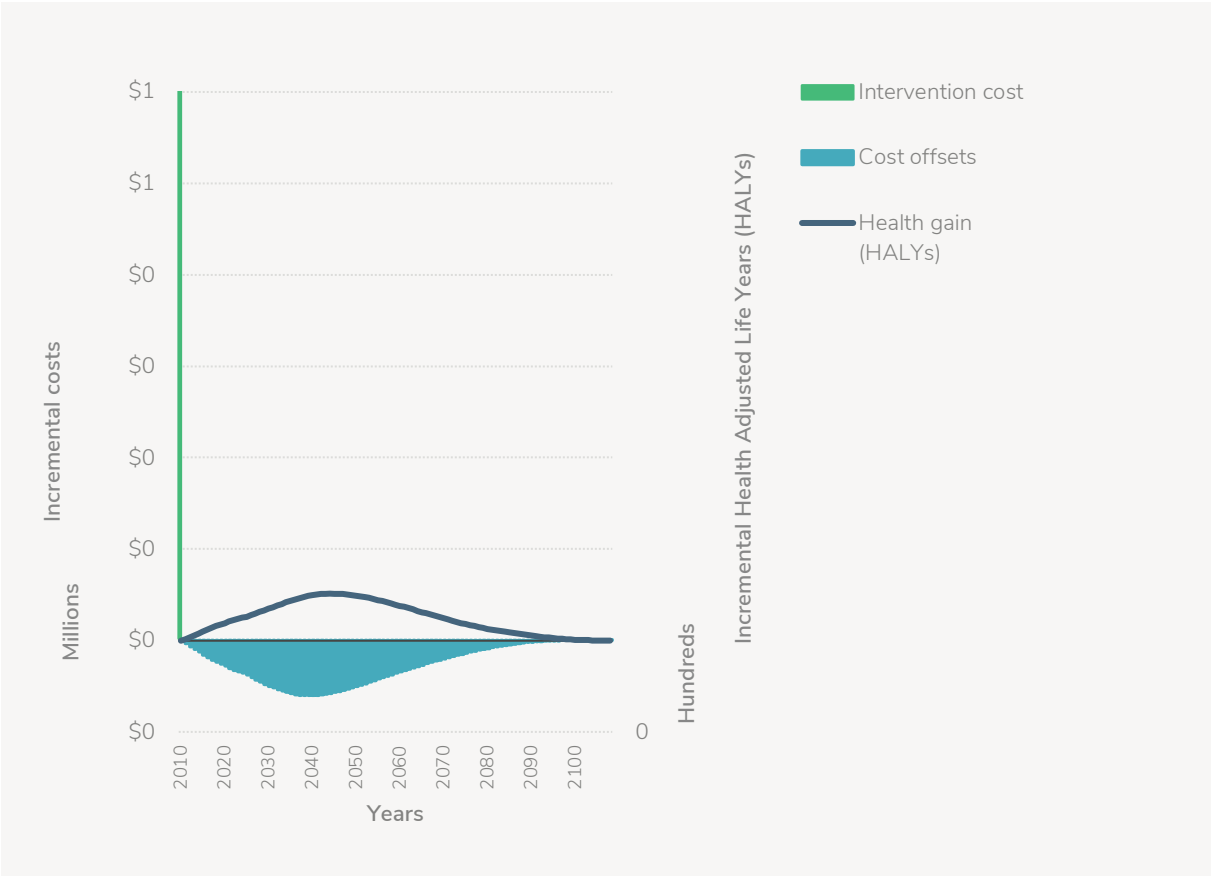


Figure 2 ***Costs, cost offsets and health gains over time***



Implementation considerations

Consideration	Details	Assessment
Strength of evidence	Low certainty of effect for BMI outcomes due to absence of relevant studies.	**Low**
	Low certainty of effect for PA outcomes. Quantity and quality of evidence supporting association between fuel price or taxation and active transport is limited. PA effect modelled using estimates of cross price elasticity of demand for public transport, with respect to fuel price. All results based on hypothetical scenarios using best available evidence.	**Low**
Equity	Disproportionate burden of tax across low, middle and high income households. Middle income households most affected as a proportion of overall weekly household expenditure. High income households least affected as proportion of overall weekly expenditure. Evidence suggests that public transport is less accessible for persons with disabilities, the elderly, those living in areas not well-serviced by comprehensive networks and those from disadvantaged backgrounds.	**Negative**
Acceptability	**Government:** Fuel excise taxation is already levied by the Australian government, however government acceptability for this intervention is expected to be low given low public acceptability of rising fuel prices.	**Low**
	Industry: Fuel excise, with bi-annual indexation, already occurs within Australia at the point of production/import. Relatively few producers/importers exist.	**Medium**
	Public: Automotive fuels are relatively own-price elastic, and public acceptability of any increase in fuel price is expected to be low.	**Low**
Feasibility	This legislative intervention is feasible to implement in the Australian setting.	**High**
Sustainability	Given its legislative nature, the intervention is sustainable.	**High**
Other considerations	**Positive side effects:** Potential for less traffic, pollution, safer environments for pedestrians and cyclists. **Negative side effects:** Potential strain on public transport systems in the short term, whilst capacity is improved.	

Notes: BMI: Body Mass Index; PA: physical activity.

Menu kilojoule labelling on fast food

Authors: Ana Maria Mantilla Herrera, Holly E. Erskine, Miaobing Zheng, Gary Sacks, Jason Wu, Jaithri Ananthapavan, Michelle Crino, Yong Yi Lee

Publication status: manuscript in progress

The intervention

- Mandatory regulations for all fast food outlets across Australia to display the energy content of food products on printed menus, online menus and/or menu boards, with accompanying government-sponsored consumer education campaign.

What we already know

- Menu kilojoule labelling aims to provide consumers with information about the energy content of available food options to inform healthier food choices.
- Mandatory menu kilojoule labelling is already in place across several Australian states/territories, including the Australian Capital Territory, New South Wales (NSW), Queensland, South Australia and Victoria. The regulations are similar across jurisdictions, general applying to large supermarkets and chain food businesses with either >=20 outlets per state, or >50 outlets nationally.
- A recent meta-analysis indicated that energy intake from fast food reduces in response to menu kilojoule labelling, resulting from both changes in consumer behaviour on the demand side and product reformulation (to reduce energy content) on the supply side.[i]

Key elements of the modelled intervention

- The mean change in energy intake (kJ) from fast food resulting from mandatory menu energy labelling was obtained from a report commissioned for the NSW Government as part of an evaluation of their regulations in the area. The kJ reduction was applied to the mean energy intake from fast food at baseline (i.e., pre-implementation), obtained from the 2011-2012 National Nutrition and Physical Activity Survey (NNPAS), adjusted for the percentage of individuals who reported consuming fast food products.
- Intervention costs were extrapolated from data included in the NSW Food Authority fast food labelling review, including costs to government in each jurisdiction (passing the legislation; administering, supporting and monitoring implementation; and running consumer education campaigns) and costs to industry (implementation and compliance).
- Scenario analyses were conducted to test different assumptions around effect size and duration.

Key findings

- The intervention was estimated to reduce mean daily energy intake by approximately 25kJ, leading to changes in mean body weight of -0.2 kg and 63,492 HALYs gained.
- Total intervention costs were estimated as $170M, which includes initial implementation and ongoing maintenance costs for government and industry.
- The intervention was shown to be dominant (cost saving and health promoting) even if the intervention effect was reduced by 50%.

Conclusion

Mandatory menu kilojoule labelling is likely to be a cost-effective component of a comprehensive obesity prevention strategy. It has proved highly feasible in Australia, with broad acceptance amongst key stakeholders.

Scenarios description and cost-effectiveness results

Table 1 *Description of selected scenarios*

	Base case Mandatory menu kilojoule labelling	Scenario 1 50% reduction in the intervention effect size
Risk factor(s) addressed by intervention	BMI	
Population targeted	Australian population, aged 2-100 years	
Weighted average reduction in body weight (95% UI)	0.2kg (0.1 to 0.4)	0.1kg (0.1 to 0.2)
Weighted average reduction in BMI (95% UI)	0.08kg/m^2 (0.05 to 0.12)	0.04kg/m^2 (0.03 to 0.06)
Effect decay	100% maintenance of effect	
Costs included	Cost of state-based legislation, administration, monitoring and consumer education campaigns (government); implementation and compliance (industry)	
Type of model used	Population model with quality of life in children	

Notes: BMI: Body mass index; kg: kilogram; m: metre; UI: uncertainty interval

Table 2 *Cost-effectiveness results, mean (95% UI)*

	Base case	Scenario 1
Total HALYs gained	63,492 (37,540 to 107,253))	31,748 (18,127 to 53,188)
Total intervention costs	$170M ($131M to $209M)	$170M ($131M to $209M)
Total healthcare cost savings	$672M ($368M to $1.2B)	$335M ($179M to $579M)
Total net cost *	-$502M (-$1.0B to -$191M)	-$165M (-$409M to -$7.0M)
Mean ICER	Dominant (Dominant to Dominant)	Dominant (Dominant to Dominant)
Probability of being cost-effective #	100%	100%
Overall result	**Dominant**	**Dominant**

*Notes: B: billion; Dominant: the intervention is both cost-saving and improves health; HALY: health adjusted life year; ICER: incremental cost effectiveness ratio; M: million; $: 2010 Australian dollars; * Negative total net costs equate to cost savings; # The willingness-to-pay threshold for this analysis is $50,000 per HALY.*

Figure 1 ***Cost–effectiveness plane***

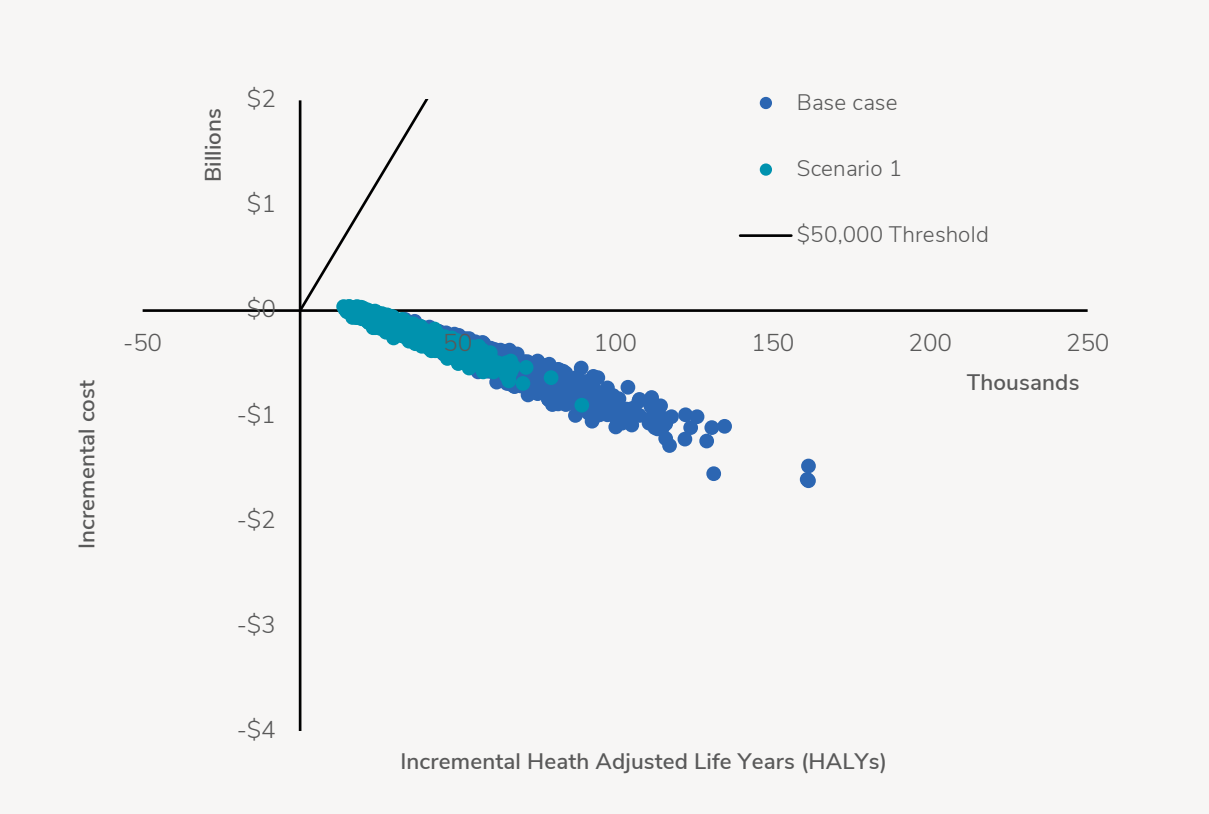
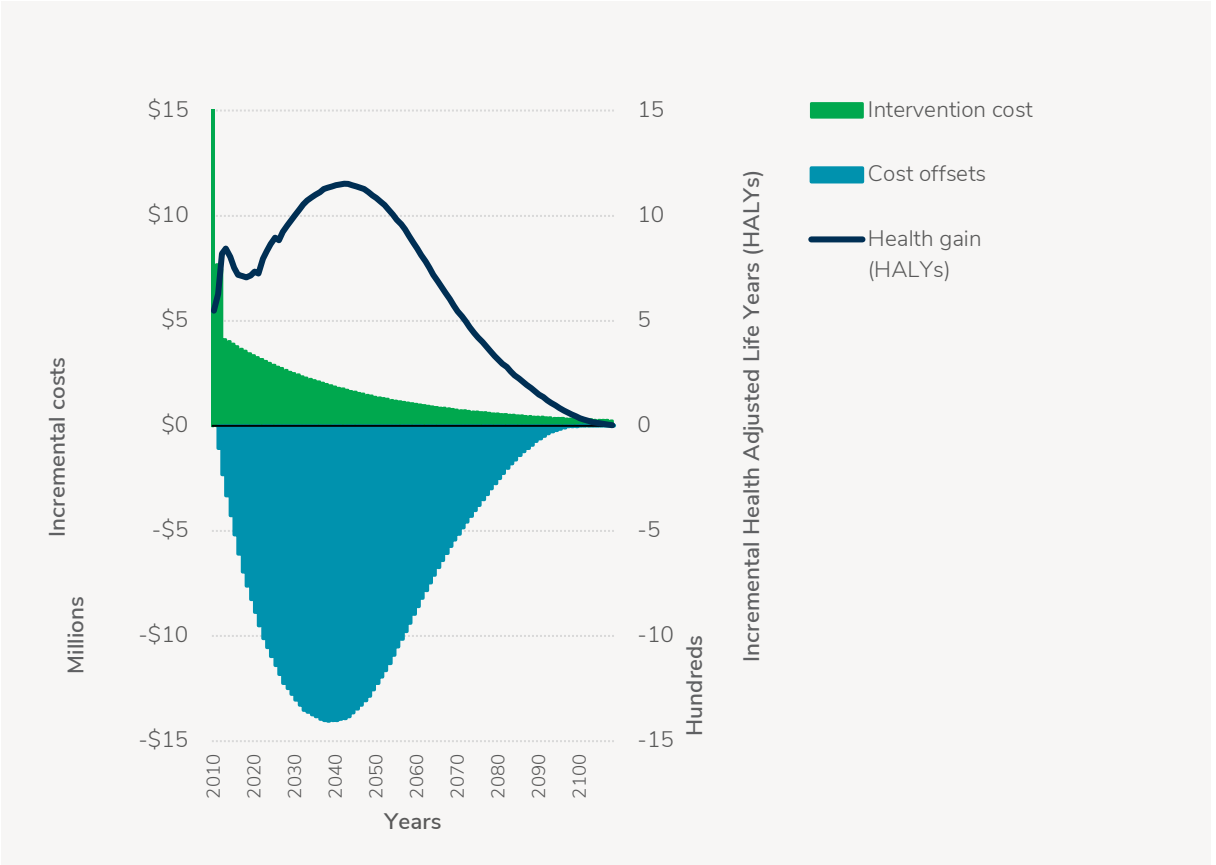


Figure 2 ***Costs, cost offsets and health gains over time (base case)***



Implementation considerations

Consideration	Details	Assessment
Strength of evidence	Low certainty of effect for BMI and weight outcomes due to lack of relevant studies.	Low
	Medium certainty of effect on dietary outcomes. The estimated mean change in energy intake from fast food resulting from mandatory menu kilojoule labelling was obtained from an Australian study, and was generally consistent with findings of a meta-analysis based predominantly on studies from the United States. Experimental studies have shown that consumers continue to consume the same quantity of foods and beverages (post-reformulation) without compensating for any changes in kJ; however, the impact on overall daily consumption is not well established.	Medium
Equity	Mandatory menu kilojoule labelling accompanied by an education campaign has been shown as likely to reduce the adverse impacts of the obesity gradient.[ii] However, the ability to interpret the labelling is likely to be lower in lower SEP groups. Reformulation to reduce energy content of fast food will benefit all groups., However, fast food consumption is higher in low SEP groups so these groups may benefit more from supply side changes.	Neutral
Acceptability	**Government:** Mandatory menu kilojoule labelling s currently in place in five jurisdictions in Australia (New South Wales, Queensland, Victoria, South Australia and the ACT).	High
	Industry: Industry bares some cost related to implementation and compliance, but acceptability has increased in response to implementation in five jurisdictions.	Medium
	Public: There is likely to be strong public support for this intervention.	High
Feasibility	This intervention has been implemented in five jurisdictions in Australia, and several internationally.	High
Sustainability	High sustainability due to the regulatory nature of the intervention.	High
Other considerations	This analysis did not take into account potential health benefits from fast food product reformulation related to salt reduction and type of fat used. The increased use of online food delivery in Australia is changing patterns of fast food consumption. These changing patterns have not been taken into account in this analysis.	

Notes: ACT: Australian Capital Territory; BMI: body mass index, kJ: kilojoule; SEP: socioeconomic position

[i] Zlatevska, N, et al. (2018).Mandatory Calorie Disclosure: A Comprehensive Analysis of Its Effect on Consumers and Retailers. *Journal of Retailing* 94(1): 89-101

[ii] Beauchamp, A., et al. (2014). The effect of obesity prevention interventions according to socioeconomic position: a systematic review. *Obesity Reviews* **15**(7): 541-554

National mass media campaign related to sugar-sweetened beverages

Authors: Nikki McCaffrey, Belinda Morley, Alison McAleese, Vicki Brown, Anita Lal, Melanie Wakefield, Helen Dixon, Jaithri Ananthapavan, Craig Sinclair, Lennert Veerman, Gary Sacks, Maria Szybiak, Maurice Swanson, Rob Carter

Publication status: manuscript in progress

The intervention

- A Federally-funded three-year, national, public education mass media campaign (run as 12 six-week bursts) to reduce sugar-sweetened beverage (SSB) consumption and associated longer term sequelae.
- The campaign highlighted the link between SSBs and toxic fat, encouraging individuals to cut back on SSBs and included metro, regional and national TV, cinema, radio and online and social media advertising.

What we already know

- Evidence from systematic reviews suggests increased SSB consumption is associated with higher body weight and the prevalence of overweight or obese children and adults.
- Public education mass media campaigns have the potential to be effective means of disseminating population-wide messages about SSB consumption and have been shown to influence knowledge, attitudes, and behaviours in this context.

Key elements of the modelled intervention

- The effectiveness of a three-year national campaign at reducing SSB consumption in adults was estimated using self-reported data from a pre-post, controlled cohort study of the Victorian SSB public education mass media campaign which ran for six weeks in October 2015.
- The estimated reduction in SSB consumption was converted to a change in energy intake, leading to a change in body weight of Australian adults.
- The average cost of the campaign per head of Victorian population aged ≥18 years was calculated and multiplied by the adult Australian population to estimate the total cost of a national campaign.

Key findings

- On average, the campaign was estimated to reduce consumption of SSBs by 14.8%, reducing mean weighted population body weight by 0.38kg.
- The intervention was estimated to be dominant (i.e., cost-saving and health promoting) resulting in 13,958 HALYs gained and healthcare cost savings of $157 million when implemented over 3 years.
- The intervention costs were estimated to be $30.5M over the 3 year intervention period.

Conclusion

A national SSB public education mass media campaign is likely to be cost-effective, improving the health of the population and producing substantial savings to government expenditure in the long term. Evaluation of longer campaigns with multiple exposure is needed to determine sustainability and the optimal duration and number of campaigns.

Scenarios description and cost-effectiveness results

Table 1 *Description of selected scenarios*

	Base case 3 years campaign	**Scenario 1** 1 year campaign	**Scenario 2** Including intervention development costs
Risk factor(s) addressed by intervention	BMI		
Population targeted	Australian population 2010, aged 18-100 years		
Weighted average reduction in body weight (95% UI)	0.38kg (0.36 to 0.40)		
Weighted average reduction in BMI (95% UI)	0.16kg/m^2 (0.14 to 0.17)		
Effect decay	100% maintenance of effect for 3 years		
Costs included	Metro, regional and national TV, cinema, radio, online and social media advertising and MAMS fee		Also includes cost of development of 'LiveLighter' campaign
Type of model used	Population model with quality of life in children		

Notes: BMI: Body mass index; MAMS fee: Master Agency Media Services; UI: uncertainty interval

Table 2 *Cost-effectiveness results, mean (95% UI)*

	Base case	**Scenario 1**	**Scenario 2**
Total HALYs gained	13,958 (11,946 to 16,319)	4,823 (4,165 to 5,598)	14,016 (12,135 to 16,186)
Total intervention costs	$31M ($28M to $33M)	$10M ($10M to $11M)	$37M ($34M to $40M)
Total healthcare cost offsets	$157M ($137M to $178M)	$54M ($48M to $61M)	$158M ($138M to $$178M)
Total net cost *	-$127M (-$148M to -$106M)	-$44M (-$51M to -$37M)	-$121M (-$101M to -$141M)
Mean ICER	Dominant (Dominant to Dominant)	Dominant (Dominant to Dominant)	Dominant (Dominant to Dominant)
Probability of being cost-effective #	100%	100%	100%
Overall result*	**Dominant**	**Dominant**	**Dominant**

*Notes: Dominant: the intervention is both cost-saving and improves health; HALY: health adjusted life year; ICER: incremental cost effectiveness ratio; M: million; $: 2010 Australian dollars; * Negative total net costs equate to cost savings; # The willingness-to-pay threshold for this analysis is $50,000 per HALY.*

Figure 1 ***Cost–effectiveness plane***

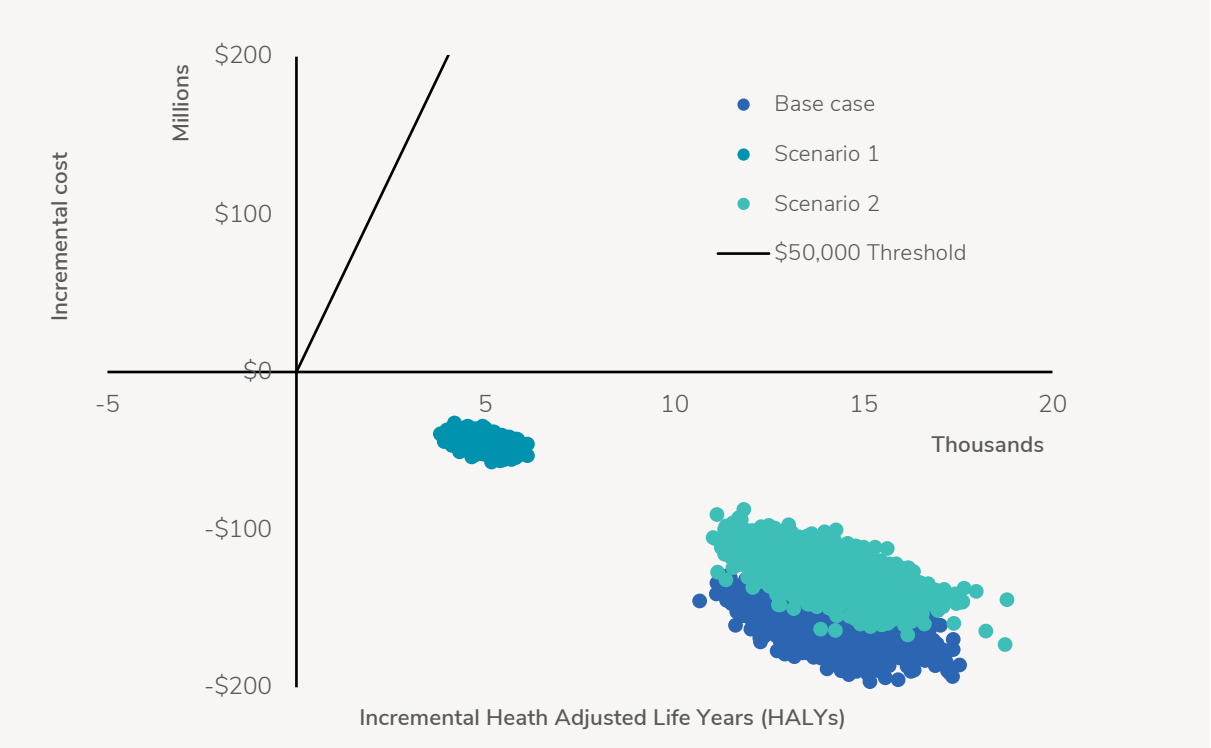
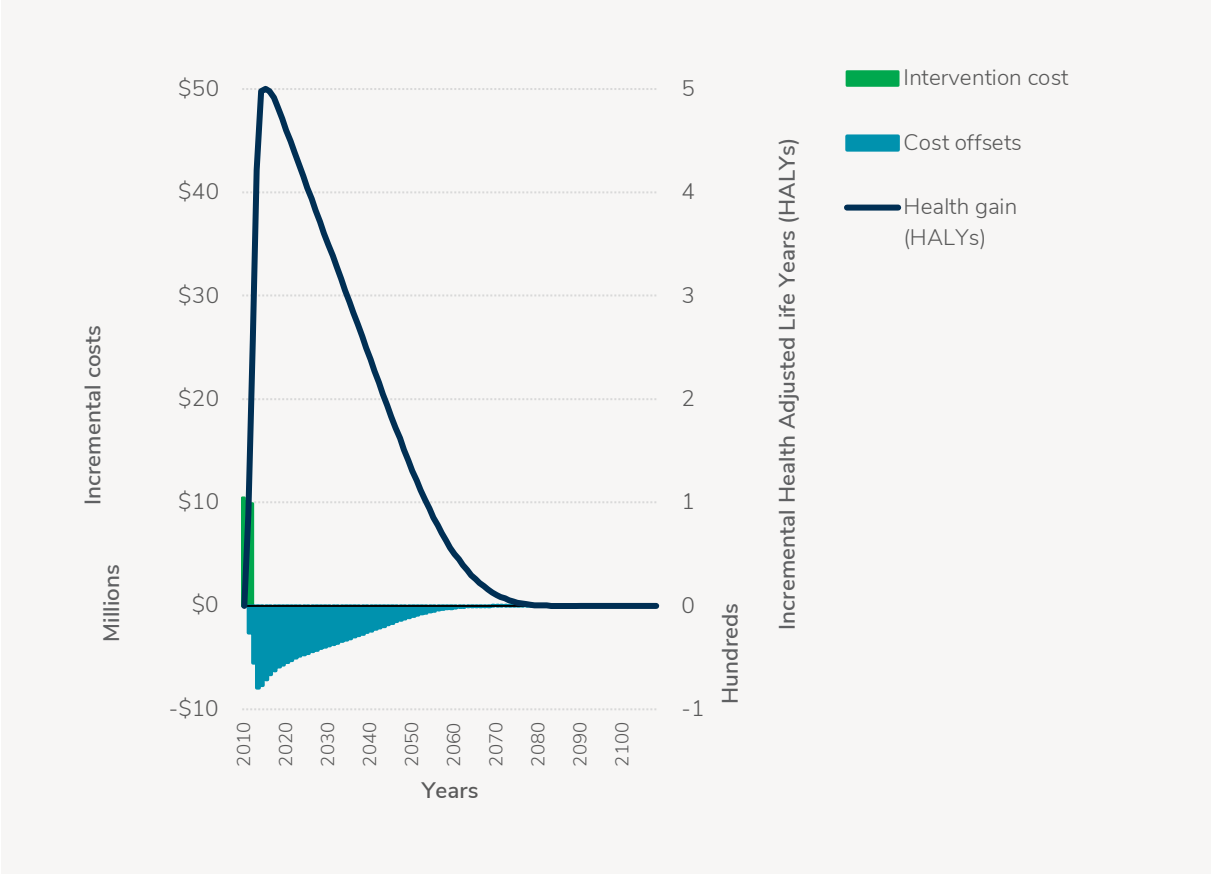


Figure 2 ***Costs, cost offsets and health gains over time***



Implementation considerations

Consideration	Details	Assessment
Strength of evidence	Low certainty of the effect on body weight outcomes due to absence of relevant studies.	Low
	Low certainty of the effect on diet. The effect size for this intervention was based on a short-term (6-week) controlled cohort study in an exposed (Victoria) versus unexposed (South Australia) adult population, using self-reported data.	
Equity	Consistent with evaluation of an earlier campaign phase, the findings from the 6-week controlled cohort study indicate a SSB public education mass media campaign does not promote negative social stereotypes of overweight individuals. Campaign awareness also showed no evidence of significant differentiation by socioeconomic position. Therefore, such campaigns are unlikely to widen socioeconomic inequalities.	Neutral
Acceptability	**Government:** Public education mass media campaigns have been supported, funded and delivered by State and Federal governments. There may be some reluctance to support the hard-hitting nature of the campaign materials.	Medium
	Industry: Local industry's willingness to accept a SSB public education mass media campaign may be challenging as the campaign could impact revenues.	Medium
	Public: The level of public engagement with SSB public education mass media campaigns suggests generally strong support for this intervention. However, there may be some concerns from groups concerned about body image issues.	Medium
Feasibility	The campaign is highly feasible to implement on a national scale and requires a relatively modest investment from State and Federal governments.	High
Sustainability	There is little evidence available on the durability of public education mass media campaigns to reduce SSB consumption. Sufficient, ongoing funding support by State and Federal governments is likely required for a sustained effect. Campaign materials are likely to need frequent updates.	Medium
Other considerations	**Positive side effects:** Broader positive impact on healthy behaviours, improved nutritional quality of readily available drinks, changes to social norms. **Negative side effects:** Potential for fat shaming and obesity stigma.	

Note: SSB: sugar-sweetened beverage

Reformulation in response to the Health Star Rating nutrition–labelling system

Publication citation: Mantilla Herrera AM, Crino M, Erskine HE, Sacks G, Ananthapavan J, Mhurchu CN, Lee YY. Cost-Effectiveness of Product Reformulation in Response to the Health Star Rating Food Labelling System in Australia. *Nutrients*. 2018;10(5)

The intervention

- The Health Star Rating (HSR) system is a government-endorsed interpretative front-of-pack nutrition labelling initiative that provides customers with summary information on the nutritional value of foods.
- This intervention examined the potential impact of the HSR system on product reformulation (and energy content in particular) with voluntary and mandatory uptake of the system.

What we already know

- Evidence from New Zealand has shown that reformulation (to improve nutritional quality) of HSR-labelled products was greater than that of non-HSR-labelled products.
- In 2014, the HSR system was endorsed by the Australian government for voluntary implementation by the food industry.

Key elements of the modelled intervention

- Changes in energy density (kJ per 100g) between 2013 and 2016 of pre-packaged foods with and without the HSR were analysed to assess the extent of product reformulation that could be attributed to the HSR system.
- Changes in energy density were applied to food consumption data by food category, age, and sex from the 2011-12 Australian Health Survey. It was assumed that no compensatory changes to diet would take place in response to the intervention.
- Costs to industry included HSR implementation and monitoring costs. Costs to government included education and promotion, and ongoing costs of monitoring and evaluation.

Key findings

- Small (7.11 kJ/100g; 95% UI: 0.1 to 14.2) reductions in energy density were found in the 1,004 food products that displayed an HSR label in 2016.
- The intervention was estimated to result in mean reductions of population body weight of 0.01kg (voluntary uptake) and 0.11kg (mandatory uptake).
- The voluntary implementation of the HSR rating was estimated to cost $46 million, whereas the mandatory implementation was estimated to cost $686 million.
- The HSR system was estimated to be cost-effective under both the voluntary and mandatory implementation scenarios with a mean ICER of $1,728 per HALY gained for the voluntary scenario and a mean ICER of $4,752 per HALY gained for the mandatory scenario.

Conclusion

The intervention demonstrates significant potential for cost-effectiveness. Voluntary implementation of the HSR is more favourable to government and industry stakeholders than mandatory implementation.

Scenarios description and cost-effectiveness results

Table 1 *Description of selected scenarios*

	Base case Voluntary implementation of HSR	Scenario 1 Mandatory implementation of HSR
Risk factor(s) addressed by intervention	BMI	
Population targeted	Australian population, aged 2-100 years	
Weighted average reduction in body weight (95% UI)	0.01kg (0.006 to 0.012)	0.11kg (0.07 to 0.14)
Weighted average reduction in BMI (95% UI)	0.03kg/m^2 (0.02 to 0.04)	0.04kg/m^2 (0.03 to 0.05)
Effect decay	100% maintenance of effect	
Costs included	Administration and monitoring (government); implementation (industry)	Legislation, administration and monitoring (government); implementation (industry)
Type of model used	Population model with quality of life in children	

Notes: BMI: Body mass index; kg: kilogram; m: metre; UI: uncertainty interval

Table 2 *Cost-effectiveness results, mean (95% UI)*

	Base case	Scenario 1
Total HALYs gained	4,207 (2,438 to 6,081)	49,949 (29,291 to 72,153)
Total intervention costs	$46.1M ($32M to $60M)	$686M ($483M to $849M)
Total healthcare cost savings	$41.6M ($22.1M to $61.6M)	$488.7 ($265.9M to $722.8M)
Total net cost *	$4.5M ($-21.2M to $28.2M)	$197M ($123.2M to $513.3M)
Mean ICER ($/HALY gained)	1,728 (95% UI: Dominant to 10,445)	4,752 (95% UI: Dominant to 16,236)
Probability of being cost-effective #	100%	100%
Overall result	**Cost-effective**	**Cost-effective**

Notes: Dominant: the intervention is both cost-saving and improves health; HALY: health adjusted life year; ICER: incremental cost effectiveness ratio; M: million; $: 2010 Australian dollars; * Negative total net costs equate to cost savings; # The willingness-to-pay threshold for this analysis is $50,000 per HALY.

Figure 1 ***Cost–effectiveness plane***

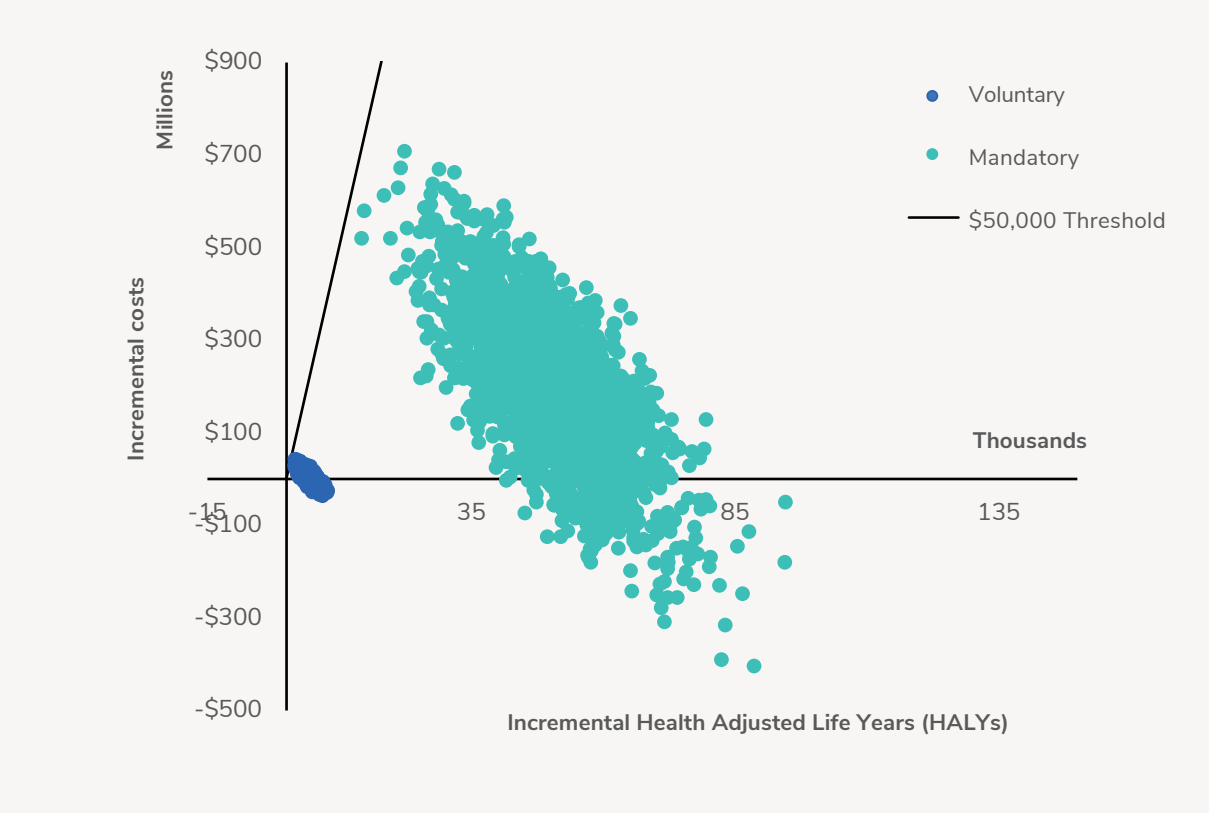
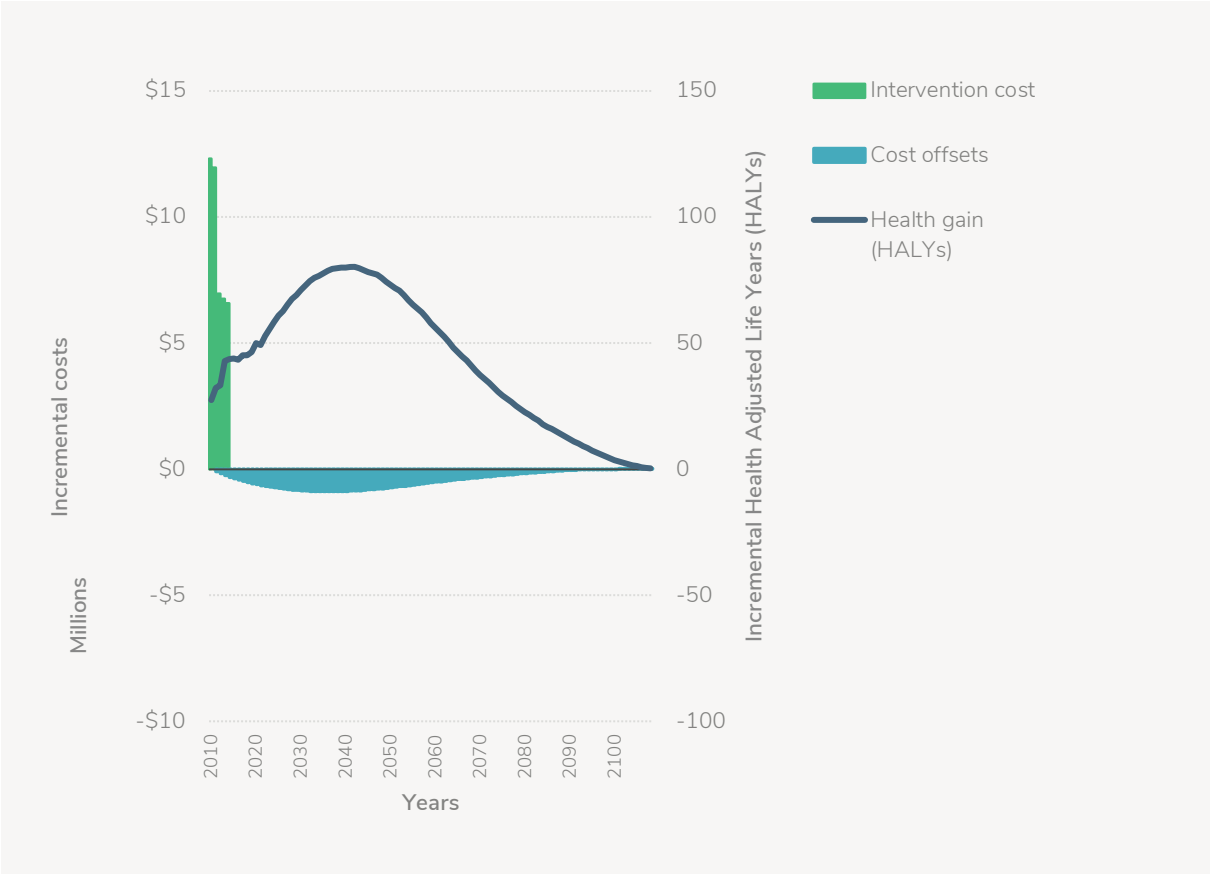


Figure 2 ***Costs, cost offsets and health gains over time (base case)***



Implementation considerations

Consideration	Details	Assessment
Strength of evidence	Low certainty of effect on BMI / body weight outcomes due to absence of relevant studies.	Low
	Medium certainty of effect on dietary outcomes. Experimental studies have shown that consumers continue to consume the same quantity of foods and beverages (post-reformulation) without compensating for any changes in kJ resulting from product reformulation.	Medium
Equity	Reformulation will impact all consumers of the affected products without any differential impacts according to socio-economic group.	Positive
Acceptability	Government: The Australian government has demonstrated commitment to the HSR system, and has identified reformulation as a focus area for the Healthy Food Partnership. The government has indicated a preference for voluntary implementation.	High
	Industry: There is increasing uptake of the HSR system with approximately 10,000 products with the HSR in Australia in 2018. However, manufacturers preferentially apply the HSR on their healthier products. Industry has indicated that it prefers voluntary implementation.	Medium
	Public: Strong consumer support for widespread implementation of HSR [i]	High
Feasibility	Front of pack nutrition labelling initiatives have been implemented in several countries both on a mandatory and voluntary basis.	High
Sustainability	If this intervention was implemented on a mandatory basis, sustainability is likely to be high, although there may be ongoing pressure from the food industry to remove the regulations. If this intervention was implemented on a voluntary basis, relying on industry commitments to implement and maintain the intervention, sustainability is likely to be lower and subject to competitive pressures on the industry.	Medium
Other considerations	This analysis is limited to the impact of the HSR on product reformulation with respect to energy content. There may be additional benefits related to product reformulation with respect to other nutrients e.g., sugar, salt, saturated fat. The analysis did not take into account potential changes in consumer behaviour in response to the HSR system e.g. shifting purchases to products with a higher HSR.	
Notes: BMI: body mass index; HSR: Health Star Rating		

[i] Colmar Brunton, 2018, 2018 Health Star Rating monitoring and evaluation: Year 2 follow-up research report, prepared for the Health Promotion Agency

Restricting television advertising of unhealthy foods

Publication citation: Brown V, Ananthapavan J, Veerman L, Sacks G, Lal A, Peeters A, Backholer K, Moodie M (2018). The potential cost-effectiveness and equity impacts of restricting television advertising of unhealthy food and beverages to Australian children. *Nutrients* 10(5)

The intervention

- Legislation to implement restrictions of unhealthy food and beverage marketing on free-to-air television (TV) until 9:30pm.
- The intervention was modelled at the population level, and by socioeconomic position based on Socio-Economic Indexes for Areas (SEIFA) for quintile 1 (Q1, most disadvantaged) and quintile 5 (Q5, least disadvantaged).

What we already know

- A mix of legislated broadcasting standards and voluntary self-regulatory measures currently exist, however Australian children are still exposed to TV advertising of unhealthy foods and beverages while watching shows not specifically designed for children.
- Australian children with a lower socioeconomic position (SEP) are more likely to watch TV and for longer periods of time compared to those with a higher SEP, and may therefore be exposed to greater levels of TV advertising for unhealthy foods and beverages compared to children with a higher SEP.

Key elements of the modelled intervention

- Intervention effectiveness was based on meta-analysis of experimental studies, with adjustments for compensatory intake and 'real-world' applicability.
- Older adolescents and adults may also benefit from reduced exposure to TV advertisements for unhealthy foods, however the modelled benefits were limited to benefits in children aged 5-15 years.
- Costs included legislative costs and on-going compliance costs. Sensitivity analysis explored the effect of including short-term (1 year) loss of revenue to TV networks.

Key findings

- The intervention would cost $5.9M and result in a mean decrease in energy intake of approximately 115kJ/day and a mean BMI reduction of 0.35kg/m^2.
- The intervention would be dominant, resulting in 88,396 HALYs gained and total healthcare cost-savings of $784M over the lifetime of the modelled population.
- The intervention may reduce health inequities, resulting in 1.5 times more HALYs gained and 1.4 times higher total cost-savings in children living in the most disadvantaged areas compared to the least disadvantaged areas.
- The intervention remained dominant when short-term loss of revenue to TV networks were included (probability of being cost-effective was 100%).

Conclusion

The intervention demonstrates significant potential for cost-effectiveness, positive equity effects and is feasible, sustainable and acceptable to the Australian general public. However, there is limited direct evidence of effectiveness, and it is likely to be opposed by industry stakeholders.

Scenarios description and cost-effectiveness results

Table 1 *Description of selected scenarios*

	Base case * Restricting TV advertising to children	Scenario 1 Incorporating short-term loss of revenue to TV networks	Scenario 2 Smaller effect estimate#, loss of revenue to TV networks included
Risk factor(s) addressed by intervention	BMI		
Population targeted	Australian population children 2010, aged 5-15 years		
Weighted average reduction in body weight (95% UI)	Population: 0.82kg (0.51 to 1.02)	Population: 0.82kg (0.51 to 1.02)	0.28kg (0.16 to 1.88)
Weighted average reduction in BMI, kg/m² (95% UI)	Population: 0.35kg/m² (0.22 to 0.44) Q1: 0.39; Q5: 0.30	0.35kg/m² (0.22 to 0.44)	0.12kg/m² (0.07 to 0.8)
Effect decay	100% maintenance of effect		
Costs included	Cost of legislation, administration and compliance	Base case plus short-term (1 year) TV network loss of revenue, based on percentage of published estimate of overall TV advertising revenue	
Type of model used	Child matrix model		

*Notes: *Base case scenario estimated at the population level (i.e. all Australian children aged 5 to 15 years, and by SocioEconomic Index for Areas (SEIFA) quintiles. # Smaller effect estimate based on most conservative meta-analysis result and higher rate of adjustment to real-world setting.*
BMI: body mass index; kg: kilogram; m: metre; Q1: most disadvantaged Socioeconomic Index for Areas (SEIFA) quintile; Q5: least disadvantaged SEIFA quintile; TV: television; UI: uncertainty interval.

Table 2 *Cost-effectiveness results, mean (95% UI)*

	Base case (population level)	Base case (Q1)	Base case (Q5)	Scenario 1	Scenario 2
Total HALYs gained	88,396 (54,559 to 123,199)	17,512 (10,372 to 25,155)	11,321 (6,812 to 15,679)	88,453 (53,764 to 123,373)	33,463 (4,299 to 89,269)
Total intervention costs	$5.9M ($5.8M to $7M)	$1.2M^ ($1.1M to $1.3M)	$1.2M^ ($1.1M to $1.3M)	$105M ($84M to $132M)	$105M ($84M to $132M)
Total healthcare cost savings	$784M ($376M to $1B)	$128M ($60M to $198M)	$92M ($45M to $138M)	$788M ($373M to $1B)	$296M ($34M to $816M)
Total net cost *	-$778M (-$1B to -370M)	-$126M (-$197M to -$59M)	-$91M (-$136M to -$44M)	-$683M (-$868M to -$289M)	-$191M (-$684M to -$50M)
Mean ICER ($/HALY gained)	Dominant (Dominant to Dominant)				Dominant (16,432 to Dominant)
Probability of being cost-effective #	100%				99.5%
Overall result	**Dominant**				

*Notes: Dominant: the intervention is both cost-saving and improves health; B: billion; HALY: health adjusted life year; ICER: incremental cost effectiveness ratio; M: million; Q1: most disadvantaged Socioeconomic Index for Areas (SEIFA) quintile; Q5: least disadvantaged SEIFA quintile; $: 2010 Australian dollars; * Negative total net costs equate to cost savings; # The willingness-to-pay threshold for this analysis is $50,000 per HALY; ^ Assumed attribution of one-fifth of total intervention cost to each quintile.*

Figure 1 ***Cost–effectiveness plane (base case)***

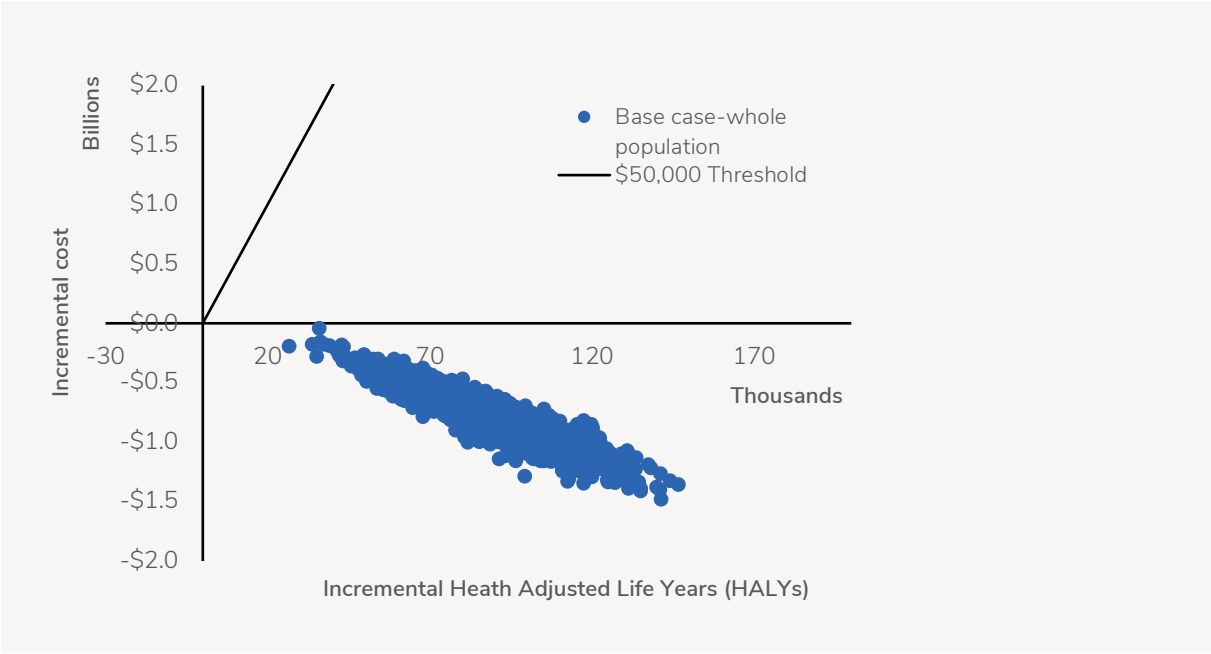
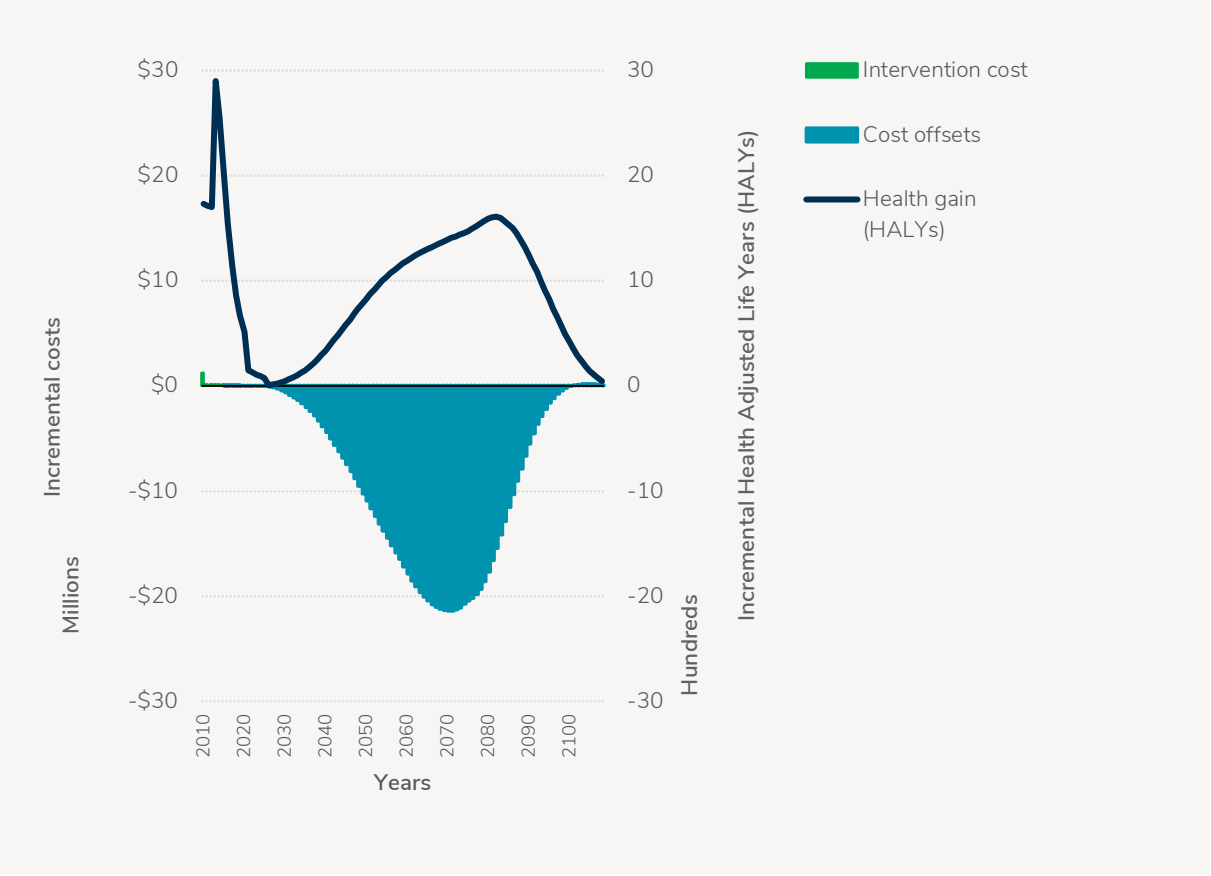


Figure 2 ***Costs, cost offsets and health gains over time (base case)***



Implementation considerations

Consideration	Details	Assessment
Strength of evidence	Low certainty of effect on BMI/body weight outcomes due to absence of relevant studies exploring real world implementation of the intervention.	Low
	Medium certainty of effect for short term dietary outcomes. The intervention is modelled using an effect estimate derived from meta-analysis of non-naturalistic experimental evidence. Extent of compensatory behaviours (over a full day) not well established.	Medium
Equity	Modelling results suggest increased health benefits and healthcare cost-savings in children with low versus high SEP.	Positive
Acceptability	**Government:** To date, political motivation to enact legislation in Australia has been low but may vary by political party and over time. International experience in countries such as Ireland and the United Kingdom suggests the potential for political acceptability.	Medium
	Industry: Acceptability from the food, media and advertising industries is likely to be low.	Low
	Public: Public support for government regulation of advertising of HFSS food and beverages to children is high[1,2].	High
Feasibility	This legislative intervention is feasible to implement in the Australian setting.	High
Sustainability	Given its legislative nature, the intervention is sustainable. The ACMA already has regulatory responsibilities and could oversee compliance monitoring.	High
Other considerations	**Positive side effects:** The intervention may have an impact on the food preferences and consumption behaviours of older children and adults. **Negative side effects:** The intervention may result in loss of revenue to TV networks (likely to be a short-term effect).	

Notes: ACMA: Australian Communications and Media Authority; BMI: body mass index; HFSS: High in fat, sugar or salt; SEP: socioeconomic position; TV: television.

[1] Parents' Voice. Junk Food Marketing 2017 [cited 2017 10 November]. Available from: https://parentsvoice.org.au/our-work/junk-food-marketing/.

[2] Sainsbury E, Hendy C, Magnusson R, Colagiuri S. Public support for government regulatory interventions for overweight and obesity in Australia. BMC Public Health. 2018;18(1):513.

Restrictions on price promotions of sugar-sweetened beverages

Authors: Oliver Huse, Jaithri Ananthapavan, Adrian Cameron, Gary Sacks, Christina Zorbas, Anna Peeters, Marj Moodie, Jane Martin, Kathryn Backholer

Publication citation: manuscript in progress

The intervention

- Regulatory restriction on the price promotion, including temporary price discounts and multi-buy specials, of sugar sweetened beverages (SSBs) in Australia.
- SSBs included: carbonated beverages (soft drinks, soda); flavoured water; sports, energy, and fruit drinks; and cordials (concentrates) containing added sugar. Milk-based beverages and 100% fruit juices were excluded.

What we already know

- SSBs are typically high in sugar, while offering little to no nutritional value.
- Up to 40% of foods and beverages are purchased on price promotion in Australia[1]. Typically, price promotions are more frequently available on less healthy options[2].
- The United Kingdom (UK) Government has stated an intention to ban multi-buy and buy-one-get-one-free offers on unhealthy foods and beverages in the retail and out-of-home sector through legislation.

Key elements of the modelled intervention

- A UK analysis estimated that population-level sugar consumption would be reduced by 0.8% if price promotions on SSBs were removed. In this study, we applied this level of reduction to age- and sex-specific SSB consumption data using the 2011/12 Australian Health Survey[3].
- Costs included passing of legislation, assisting retailers with implementation, marketing the policy and auditing retailers for compliance. It was assumed there were no implementation costs to retailers.
- In response to this intervention, industry might lower the average 'every day' retail price of SSBs. Threshold analyses tested the proportional lowering of the retail price of SSBs that would have to occur in order for intervention net costs to be $0.

Key findings

- The intervention was estimated to result in mean reductions in population body weight of 0.11kg.
- The intervention was estimated to cost $17M and result in approximately $498M in healthcare cost savings.
- The policy was predicted to result in savings of 48,336 HALYs over the lifetime of the population. Overall, the intervention was dominant.
- An 11.5% lowering of the average 'every day' retail price of SSBs as a retailer response would result in intervention net costs being approximately $0. Currently, price promotions on SSBs are, on average, 33% lower than 'everyday' retail prices[ii].

Conclusion

A regulatory restriction on all price promotions of SSBs in Australia is likely to be cost-effective, although the way in which industry and consumers would respond is largely unknown, and the feasibility and sustainability of implementation in the Australian context is unclear.

Scenarios description and cost-effectiveness results

Table 1 *Description of scenario modelled*

	Base case
Risk factor(s) addressed by intervention	BMI
Population targeted	Australian population, aged 2-100 years
Weighted average reduction in body weight (95% UI)	0.11kg (0.08 to 0.13)
Weighted average reduction in BMI (95% UI)	0.04kg/m^2 (0.03 to 0.05)
Effect decay	100% maintenance of effect
Costs included	Costs for passing legislation; promoting, monitoring and assisting supermarkets with the intervention
Type of model used	Population model with quality of life in children

Notes: BMI: Body mass index; kg: kilogram; m: metre; UI: uncertainty interval

Table 2 *Cost-effectiveness results, mean (95% UI)*

	Base case
Total HALYs gained	48,336 (36,293 to 63,932)
Total intervention costs	$17M ($10M to $26M)
Total healthcare cost savings	$498M ($378M to $653M)
Total net cost *	-$481M (-$638M to -$361M)
Mean ICER	Dominant (Dominant to Dominant)
Probability of being cost-effective #	100%
Overall result	**Dominant**

*Notes: Dominant: the intervention is both cost-saving and improves health; HALY: health adjusted life year; ICER: incremental cost effectiveness ratio; M: million; $: 2010 Australian dollars; * Negative total net costs equate to cost savings; # The willingness-to-pay threshold for this analysis is $50,000 per HALY.*

Figure 1 ***Cost–effectiveness plane***

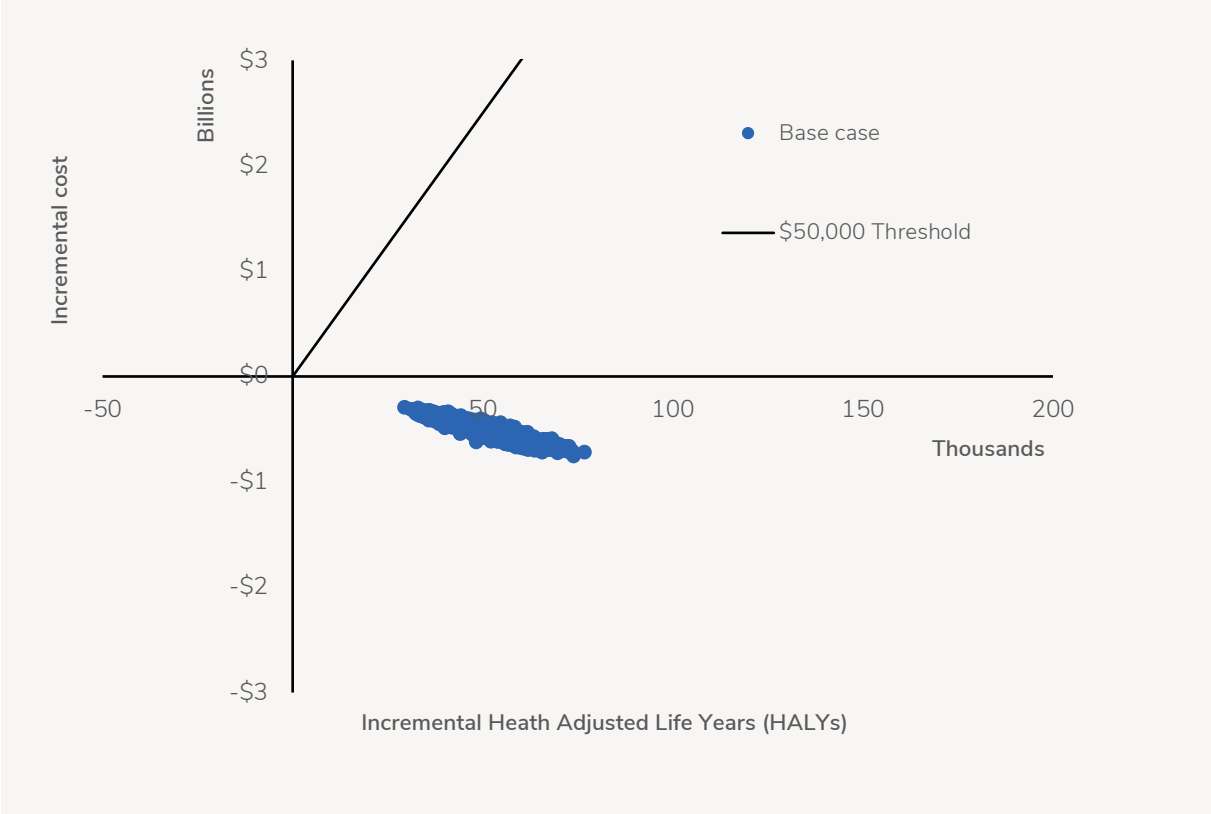
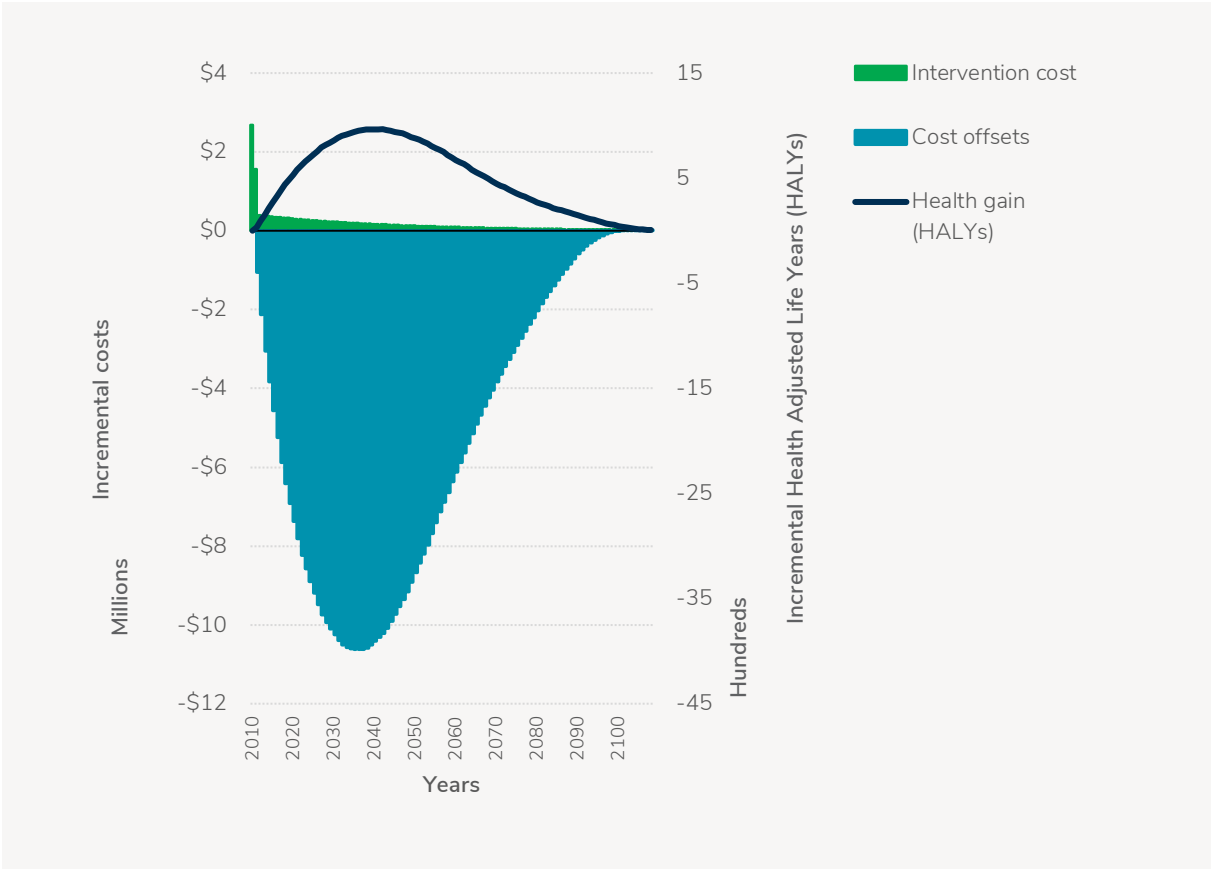


Figure 2 ***Costs, cost offsets and health gains over time***



Implementation considerations

Consideration	Details	Assessment
Strength of evidence	Low certainty of effect on BMI / body weight outcomes due to a lack of relevant studies.	**Low**
	Low certainty of effect on dietary outcomes due to a lack of relevant studies.	**Low**
Equity	For low socioeconomic groups, expenditure on SSBs as a proportion of household expenditure would increase; however, these groups are more likely to reduce overall consumption and so experience a great health impact. Those from higher SEP groups (who are less responsive to price) are less likely to change consumption.	**Negative**
Acceptability	**Government:** The Australian government is generally opposed to additional regulations on industry and has not considered this as an obesity prevention intervention. However, there is emerging evidence from the UK and Scotland that governments are willing to consider regulation in this area.	**Low**
	Industry: As the regulations are likely to result in decreased purchases of SSBs, industry is unlikely to be supportive of such a policy. We have no evidence of differences in support from supermarkets and manufacturers.	**Low**
	Public: Consumers are likely to oppose any policy which may increase the price that they pay for SSBs. However, the public is increasingly aware of the adverse health consequences associated with SSB consumption.	**Low**
Feasibility	The way in which this could be implemented in Australia is unclear. Nevertheless, the UK and Scotland are currently undertaking public consultations on plans to implement such a strategy.	**Low**
Sustainability	If legislated, the intervention is likely to be sustainable. However there is a lack of real-world evidence of implementation and sustainability.	**High**
Other considerations	This intervention is predicted to result in a reduction in sugar intake, which is also likely to have a positive impact on oral health outcomes. The likely impact of this intervention on retailers and manufacturers, on the prices of other foods, and on consumer behaviour more generally is largely unknown.	

Notes: BMI: Body Mass Index; SEP: Socioeconomic Position; SSBs: sugar-sweetened beverages

[1] Zeviani, Raone. Are we really getting value from our promotions? USA : Nielsen, 2018.
[2] Beth Gilham, Christina Zorbas, Tara Boelsen-Robinson, Miranda RC Blake, Anna Peeters, Adrian J Cameron, Jason HY Wu and Kathryn Backholer. The frequency and magnitude of beverage price promotions available for sale in Australian supermarkets (manuscript under review).
[3] Public Health England. Sugar Reduction: The evidence for action. Annex 4: An analysis of the role of price promotions on the household purchases of food and drinks high in sugar. 2016

School-based intervention to reduce sedentary behaviour and/or increase physical activity

Authors: Vicki Brown, Lauren Sheppard, Marj Moodie

Publication citation: manuscript in progress

The intervention

- *Transform-Us!* was a 30-month multi-arm primary school-based randomised controlled trial (RCT) to reduce sedentary behaviour and/or increase physical activity in 8-9 year old (Grade 3) children.
- Intervention participants were randomised by school into one of four arms: sedentary behaviour (SB), physical activity (PA), combined sedentary behaviour and physical activity (SB+PA), or current practice (C; no intervention).
- The intervention comprised a mixture of educational (learning messages, homework tasks), behavioural (standing lessons, active breaks) and environmental strategies (equipment).

What we already know

- In Australia, only 19% of children aged 5-17 years meet the national daily PA guidelines and 29% meet the SB screen time guidelines.[1]

Key elements of the modelled intervention

- Effectiveness was modelled based on efficacy data from two intervention arms of the RCT (PA and SB). Participants in the SB intervention arm reported a mean reduction of 0.14 BMIz and a 33 minute reduction in sedentary time per day. Participants in the PA intervention arm reported a mean reduction of 0.13 BMIz, but no statistically significant reduction in sedentary time per day.
- Reductions in sedentary time were converted to a change in PA assuming sitting time was replaced with standing time using published values.
- Major intervention cost categories included teacher time to prepare intervention delivery, equipment costs and on-going implementation costs (newsletters reinforcing messages).
- Cost-effectiveness analyses extrapolated the costs and outcomes of the trial to the Australian population of Grade 3 students in government schools. The cost of a program administrative officer in each Australian state and territory was included.

Key findings

- When extrapolated to the Australian population, the intervention was estimated to cost $10M (PA) or $15M (SB).
- The PA and SB arms were both estimated to be dominant, resulting in 60,780 HALYs gained and $641M in total healthcare cost-savings (PA); 61,989 HALYs gained and $661M in total healthcare cost-savings (SB).
- Assuming intervention effect fully decays after 10 years, health benefits are more modest (PA: 2,479 HALYs gained, SB: 2,660 HALYs gained), however the mean ICERs remained cost-effective (PA: $4,056 per HALY gained, SB: $5,788 per HALY gained; probability of cost-effectiveness PA: 98%, SB: 99%).

Conclusion

The PA and SB *Transform-Us!* intervention arms have significant potential for cost-effectiveness as obesity prevention measures.

Scenarios description and cost-effectiveness results

Table 1 *Description of selected scenarios*

	Scenario 1 Physical activity intervention	Scenario 2 Sedentary behaviour intervention
Risk factor(s) addressed by intervention	BMI	BMI/PA
Population targeted	Grade 3 children in government schools in Australia	
Mean reduction in BMI z-score (95% UI)	0.13 (0.03 to 0.24)	0.14 (0.03 to 0.24)
Mean change in MET minutes per week	-	94 (49-147)
Effect decay	100% maintenance of effect	
Costs included	Teacher costs, equipment costs, implementation costs, salary costs of program administration officer	
Type of model used	Child matrix model	

Notes: BMI: body mass index; MET: metabolic equivalent task; PA: physical activity; UI: uncertainty interval

Table 2 *Cost-effectiveness results, mean (95% UI)*

	Scenario 1 (PA)	Scenario 2 (SB)	Scenario 1 with zero effect after ten years	Scenario 2 with zero effect after ten years
Total HALYs gained	60,780 (15,007 to 109,413)	61,989 (15,834 to 107,779)	2,479 (558 to 4,333)	2,660 (771 to 4,482)
Total intervention costs	$10M ($7M to $15M)	$15M ($10M to $25M)	$10M ($7M to $15M)	$15M ($10M to $25M)
Total healthcare cost savings	$641M ($165M to $1.1B)	$661M ($173M to $1.1B)	$0 ($0 to $0)	$23,338 ($16K to $30K)
Total net cost *	-$631M (-$1.1B to -$155M)	-$646M (-$1.1B to -$155M)	$10M ($7M to $15M)	$15M ($10M to $25M)
Mean ICER ($/HALY gained)	Dominant (Dominant to Dominant)		4,056 (1,983 to 19,781)	5,788 (2,881 to 22,372)
Probability of being cost-effective #	99%	99%	98%	99%
Overall result	**Dominant**		**Cost-effective**	

*Notes: Dominant: the intervention is both cost-saving and improves health; HALY: health adjusted life year; ICER: incremental cost effectiveness ratio; M: million; PA: physical activity intervention; SB: sedentary behaviour intervention; $: 2010 Australian dollars; * Negative total net costs equate to cost savings; # The willingness-to-pay threshold for this analysis is $50,000 per HALY.*

Figure 1 ***Cost–effectiveness plane***

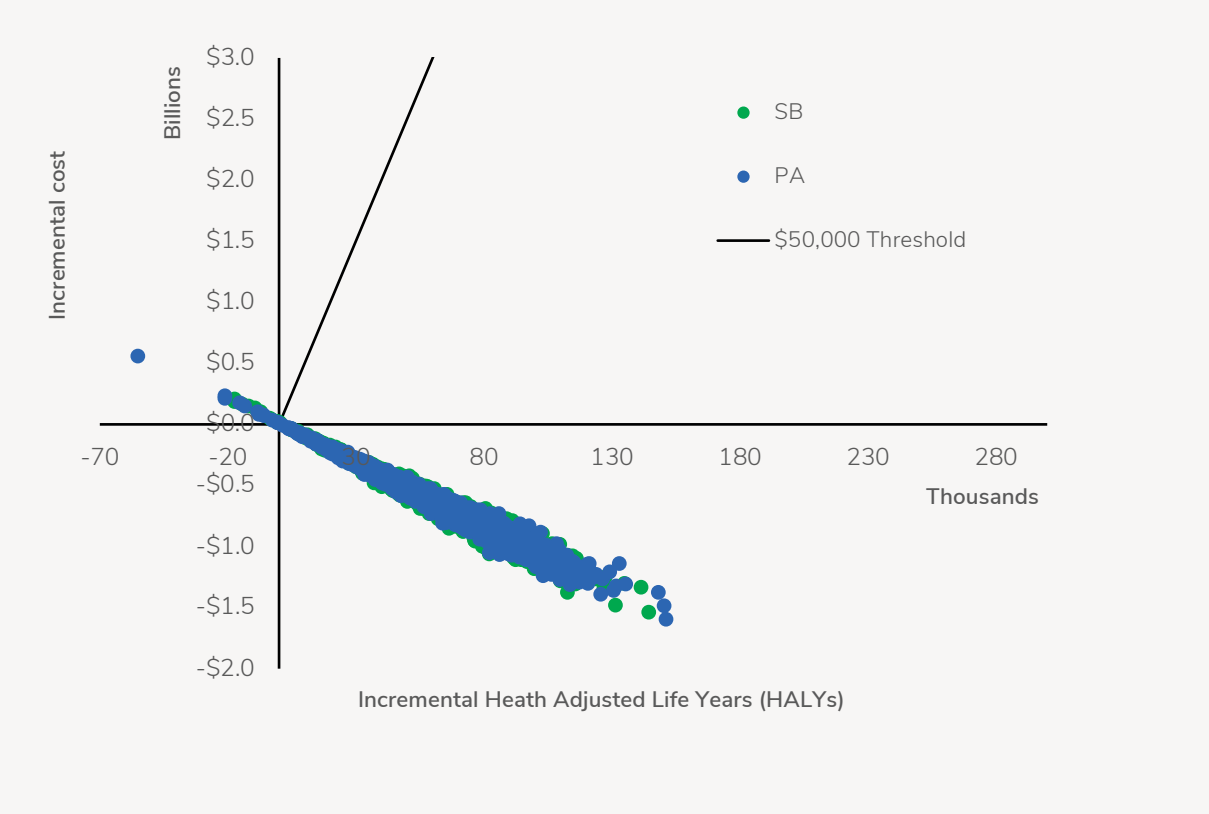
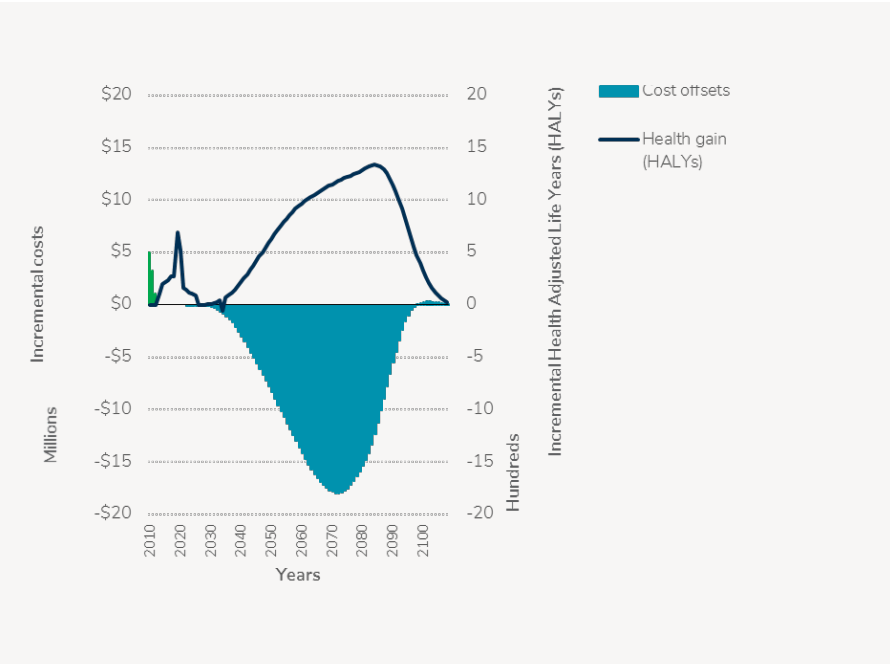


Figure 2 ***Costs, cost offsets and health gains over time (physical activity intervention)***



Implementation considerations

Consideration	Details	Assessment
Strength of evidence	Medium certainty of BMI effect, objectively measured in one high quality RCT in the Australian-context.	Medium
	Medium certainty of PA effect, objectively measured in one high quality RCT in the Australian-context.	Medium
Equity	The intervention is delivered in schools, and therefore is likely to be equitable. Delivery in the school setting ensures broad reach to all Grade 3 students enrolled in government schools.	Positive
Acceptability	**Government:** Federal and State governments are generally supportive of programs designed to improve the health of school students. The intervention may help to fulfil the criteria for several Australian Curriculum guidelines, focused on health and physical education.	High
	Industry: The intervention could provide valuable resources for teachers and schools to meet the Australian Curriculum guidelines. Process evaluation of the RCT demonstrated that teachers and schools were generally receptive to the intervention, but listed time constraints and competing demands as potential barriers to program delivery.	High
	Public: The general public is likely to be supportive of programs that improve the health of school children. Process evaluation of the RCT demonstrated that the intervention was positively received by parents and children.	High
Feasibility	This intervention has been successfully delivered in the Australian school environment.	High
Sustainability	Interventions delivered in the school environment are sustainable provided there is ongoing support and appropriate funding.	Medium
Other considerations	**Positive side effects:** The intervention may have a positive effect on the families of children who participate, however no evidence of this effect is currently available.	

Notes: BMI: Body Mass Index, PA: physical activity; RCT: randomized controlled trial

[1] Australian Health Survey: Physical Activity 2011-12, Australian Bureau of Statistics, Canberra, Australia.

Sugar-sweetened beverages tax

Publication citation: Lal A Mantilla-Herrera AM, Veerman L, Backholer K, Sacks G, Moodie M, Siahpush M, Carter R, Peeters A. (2017) Modelled health benefits of a sugar sweetened beverage tax across different socioeconomic groups in Australia: a cost-effectiveness and equity analysis. *PLOS Med 14(6)*

The intervention

- For this study, a tax on sugar sweetened beverages (SSBs) was defined as an additional 20% sales tax (scenario analyses investigated different tax rates). SSBs included soft drinks; flavoured water; sports, energy, and fruit drinks; and cordials (concentrates) containing added sugar (scenario analyses investigated expanding the definition to also include flavoured milks).
- The effect of the tax was modelled across Socioeconomic Index for Areas (SEIFA) quintiles.

What we already know

- Consumers are sensitive to price changes with respect to SSBs.
- Over 35 countries have implemented taxes on SSBs.
- Previous real-world evaluations of a tax on SSBs in Mexico show that the tax led to a reduction of SSBs purchases for the total population, with larger reductions in lower-income households.

Key elements of the modelled intervention

- The change in intake of SSBs was based on an Australian study that derived own-price elasticities and cross-price elasticities across income groups, based on supermarket purchases.
- Change in SSBs consumption due to the tax was converted to changes in daily energy intake. Subsequent change in weight was calculated based on published relationships between changes in energy expenditure and body weight at the population level.
- Costs included implementation, administration and compliance of the tax based on United States estimates. Cost of passing the legislation was calculated for Australia.
- Out-of-pocket taxes was estimated for each SEIFA quintile.
- Different tax rates were analysed by varying the percentage of sales tax (10%-30%) as well as a rate of $0.50 per litre.

Key findings

- A 20% SSB tax would lead to an average decrease of approximately 60kJ per day, health adjusted life year (HALY) gains of 175,300, half of which would accrue to the two lowest quintiles, as well as healthcare cost savings of $1,733 million over the lifetime of the population.
- Annual tax paid per capita was estimated to be $3.80 higher in the lowest SEIFA quintile (most disadvantaged), compared to the highest quintile.
- Annual tax revenue was estimated at $642.9m.
- The tax is cost-effective under all tax scenarios, with the highest HALY gains under a 30% tax.

Conclusion

A tax on SSBs is estimated to be cost-effective and to increase health equity. Whilst the most disadvantaged group would pay the most tax per capita, the difference is less than $5 per year. The substantial tax revenue raised could be earmarked to disadvantaged groups. The widespread implementation of SSB taxes globally indicates its feasibility in the Australian context.

Scenarios description and cost-effectiveness results

Table 1 *Description of selected scenarios*

	Base case 20% tax	Scenario 1 30% tax	Scenario 2 10% tax	Scenario 3 50c/litre tax	Scenario 4 20% tax includes flavoured milk
Risk factor(s) addressed by intervention	BMI				
Population targeted	Australian population, aged 2-100 years				
Weighted average reduction in body weight, kg (95% UI)	0.47kg (0.19 to 0.72)	0.69kg (0.65 to 0.73)	0.26kg (0.25 to 0.28)	0.32kg (0.30 to 0.34)	0.68kg (0.38 to 0.72)
Effect decay	100% maintenance of effect				
Costs included	Implementation, administration and compliance related to the tax, including cost of passing legislation.				
Type of model used	Population model with quality of life in children				

Notes: BMI: body mass index; c: cent; kg: kilogram; m: metre; UI: uncertainty interval

Table 2 *Cost-effectiveness results for base case by SEIFA quintiles, mean (95%UI)*

	Quintile 1 (most disadvantaged)	Quintile 2	Quintile 3	Quintile 4	Quintile 5 (least disadvantaged)
Total HALYs gained	52,300 (15,400 to 85,200)	49,900 (28,200 to 71,500)	48,800 (19,700 to 75,300)	31,700 (26,300 to 38,800)	27,400 (12,700 to 42,700)
Total healthcare cost savings	$435M ($308M to $564M)	$430M ($247M to $606M)	$394M ($335M to $461M)	$294M ($241M to $358M)	$255M ($218M to $296M)

Notes: HALY: health adjusted life year; M: million; SEIFA: Socioeconomic Index for Areas; $: 2010 Australian dollars

Table 3 *Cost-effectiveness results of scenarios, total population, mean (95%UI)*

	Base case	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Total HALYs gained	175,300 (68,700 to 277,800)	224,500 (91,600 to 346,000)	89,000 (33,600 to 144,800)	167,500 (148,500 to 189,600)	192,700 (75,800 to 301,000)
Total intervention costs	$120M ($92M to $162M)				
Total healthcare cost savings	$1.7B ($650M to $2.7B)	$2.5B ($2.2B to $2.8B)	$958M ($830M to $1.1B)	$1.8B ($1.6B to $2.0B)	$1.9B ($718M to $3.0B)
Total net cost *	-$1.7B (-$1.9B to -$1.5B)	-$2.1B (-$3.4B to -$670M)	-$650M (-$1.2B to -$72M)	-$1.5B (-$1.7B to -$1.3B)	-$1.4B (-$2.4B to -$357M)
Mean ICER	Dominant (Dominant to Dominant)				
Probability of being cost-effective #	100%				
Overall result	**Dominant**				

*Notes: Dominant: the intervention is both cost-saving and improves health; B: billion; HALY: health adjusted life year; ICER: incremental cost effectiveness ratio; M: million; $ 2010 Australian dollars; * Negative total net costs equate to cost savings; # The willingness-to-pay threshold for this analysis is $50,000 per HALY.*

Figure 1 ***Cost–effectiveness plane***

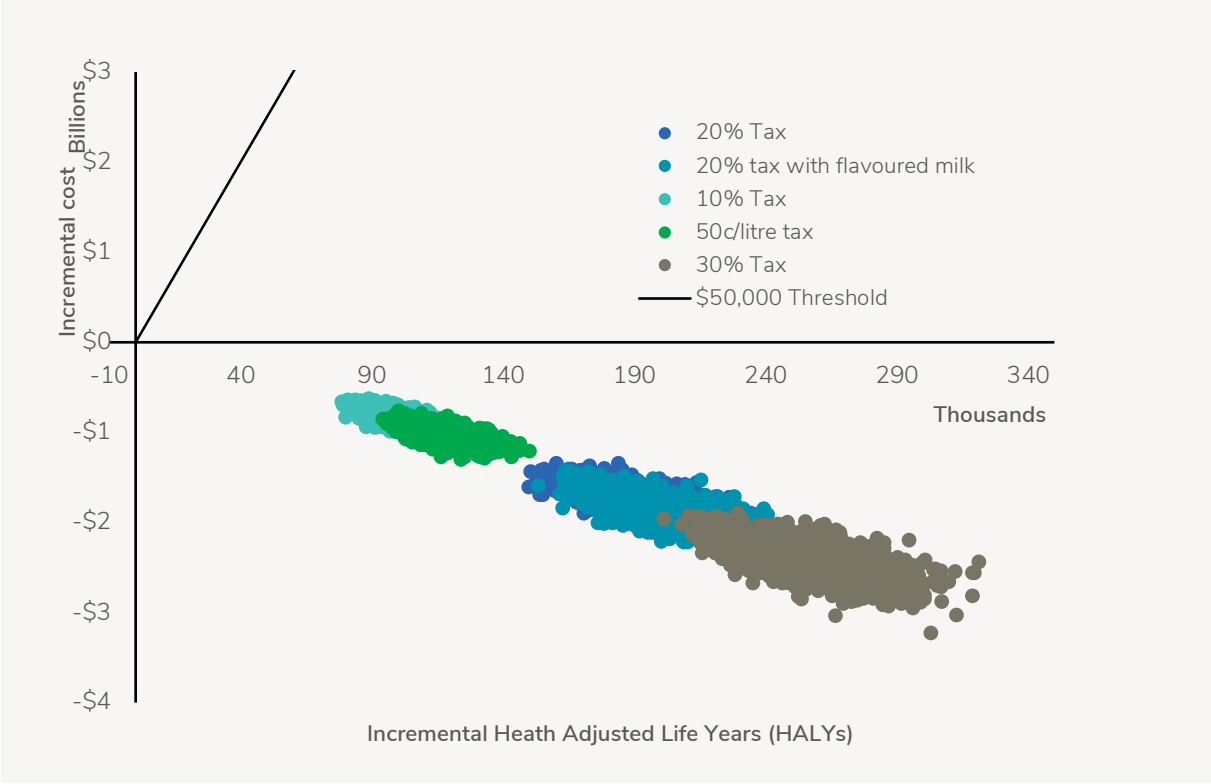


Figure 2 ***Costs, cost offsets and health gains over time (base case)***

Implementation considerations

Consideration	Details	Assessment
Strength of evidence	Low certainty of effect for BMI and body weight outcomes due to absence of relevant studies. Systematic reviews and meta-analyses provide evidence support the causative role of SSBs in obesity[1].	Low
	Medium certainty of effect for the impact of taxes on SSBs on diet. This is based on evidence of price elasticity of demand for SSBs from real world data in Australia, implementation of SSBs taxes in other countries (e.g., Mexico), and parallel evidence from tobacco taxes. Long-term compensatory behaviours not well-established.	Medium
Equity	The estimated annual tax paid per capita was $3.80 higher in the lowest quintile when compared to the highest. Quantitative evaluation showed that half of the total health gains accrue to the two most disadvantaged quintiles. Healthcare cost savings as a percentage of household expenditure were highest in the most disadvantaged groups.	Neutral
Acceptability	**Government:** The current government has stated that they do not support a tax on SSBs at this time. Over 35 countries have implemented SSB taxes globally, and acceptability in Australia may increase as more countries around the globe implement this type of tax.	Medium
	Industry: The beverage and sugar industries have stated their opposition to taxes on SSBs.	Low
	Public: There have been no nationally representative studies, however Australian evidence shows that if revenue from a SSB tax was earmarked for subsidising healthy food and/or tackling childhood obesity, public support for such a tax would likely be strong.	Medium
Feasibility	Over 35 countries have implemented taxes on SSBs, and several reports have outlined the mechanisms for doing so in Australia.	High
Sustainability	Due to the regulatory nature of the intervention, sustainability is likely to be high, although there would likely be ongoing pressure from the food industry to remove the tax. The impact is likely to be sustained based on history of tobacco taxes, although may require periodic increases in the tax rate.	High
Other considerations	Consumption of SSBs in Australia has been declining over recent years. If this trend continues, the contribution of SSBs to mean population energy intake may be lower than estimated in this analysis. The effect of manufacturers or retailers absorbing part of the tax could decrease the impact of the tax and the resulting health benefits; however, based on our predicted results for a 50% pass-through, the healthcare cost savings are nevertheless likely to be substantial. There could be an additional `halo effect' from the introduction of the tax caused by increased public health awareness of the role of SSBs in obesity, leading to further decrease in purchasing of SSBs, over and above what has been included in this analysis. Reformulation (to reduce sugar content) has occurred in the UK in response to the introduction of a tax on SSBs – the potential impact of reformulation has not been included in this analysis.	

Notes: BMI: Body mass index; SSBs: sugar-sweetened beverages

[1] Taylor R, Scragg R, Quigley R. Do Sugary Drinks Contribute To Obesity In Children? New Zealand: Scientific Committee of the Agencies for Nutrition Action 2005. Malik VS, Schulze MB, Hu FB. Intake of sugar-sweetened beverages and weight gain: a systematic review. Am J Clin Nutr. 2006;84(2):274-88.
Vartanian LR, Schwartz MB, Brownell KD. Effects of soft drink consumption on nutrition and health: a systematic review and meta-analysis. Am J Public Health. 2007;97(4):667-75.

Package size cap on sugar-sweetened beverages

Publication citation: Crino M, Herrera A, Ananthapavan J, Wu J, Neal B, Lee Y, Zheng M, Lal A, Sacks G. Modelled cost-effectiveness of a package size cap and a kilojoule reduction intervention to reduce energy intake from sugar-sweetened beverages in Australia. *Nutrients*. 2017;9(9):983

The intervention

- Package size cap of 375ml on packaged single-serve sugar-sweetened beverages (SSBs) sold in Australia. The cap size was selected based on recommendations in the Australian Dietary Guidelines that specify that a serving of discretionary food, such as SSBs, should provide a maximum of 600kJ, which translates to approximately 375ml (1 can).
- The Australian government has identified changes in portion size as a key focus area as part of the Healthy Food Partnership – one of their flagship food and nutrition initiatives.

What we already know

- Package and portion size are known to influence the quantity of food an individual selects and consumes. When offered larger packages or portions of food or beverages, individuals are known to consume more and are unlikely to compensate by increasing their physical activity.
- Globally, initiatives targeting package and portion size have been identified as a promising approach to reduce obesity and obesity-related diseases.

Key elements of the modelled intervention

- The effectiveness of this intervention was modelled based on consumption data and assumptions related to how changing available single-serve package sizes would change consumption.
- Total consumption of SSBs by age and sex was estimated using the Australian Health Survey.
- Consumption from all package sizes of single-serve SSBs >375ml were reduced by the volume greater than 375ml. These were summed and applied uniformly across the population consumption data to determine the overall reduction in SSB consumption and corresponding mean daily energy intake reductions.
- Costs to government included the costs of passing the legislation (where relevant), and for administering and monitoring implementation. Costs to the food industry were derived based on previous analyses of expected costs of implementation of a food labelling intervention affecting packaged food in Australia.
- Scenario analyses tested variations in the level of substitution to other types of SSBs, and the extent to which manufacturers implemented the package size cap (100% for mandatory implementation, 20% of eligible products for voluntary implementation).

Key findings

- A package size cap on single-serve SSBs was estimated to result in mean reductions in population body weight of 0.15kg (if implemented on a mandatory basis) and 0.03kg (if implemented on a voluntary basis).
- The intervention was estimated to be dominant (i.e., cost-saving and health promoting) in all scenarios investigated. Mandatory implementation would result in 73,883 HALYs gained and healthcare cost savings of $751 million over the lifetime of the modelled population.

Conclusion

The intervention demonstrates significant potential for cost-effectiveness, with expected positive equity effects. However, it is likely to be opposed by industry stakeholders, and the specific changes in industry marketing and consumer behaviour in response to the intervention are largely untested.

Scenarios description and cost-effectiveness results

Table 1 *Description of selected scenarios*

	Base case Legislation banning the sale of packaged single-serve SSBs >375ml. No compensatory eating	Scenario 1 Assumed 10% of individuals substitute targeted SSBs for equivalent single-serve portions of sugar-free alternatives	Scenario 2 Voluntary industry pledge to cease supply of packed single-serve SSBs >375ml. No compensatory eating
Risk factor(s) addressed by intervention	BMI		
Population targeted	Australian population, aged 2-100 years		
Weighted average reduction in body weight (95% UI)	0.15kg (0.12 to 0.18)	0.65kg (0.54 to 0.79)	0.03kg (0.02 to 0.04)
Weighted average reduction in BMI (95% UI)	0.05kg/m^2 (0.04 to 0.06)	0.22kg/m^2 (0.20 to 0.24)	0.02kg/m^2 (0.01 to 0.03)
Effect decay	100% maintenance of effect		
Costs included	Cost of legislation, administration and monitoring (government); implementation (industry)		No costs to government of passing legislation, lower industry costs due to lower level of implementation
Type of model used	Population model with quality of life in children		

Notes: BMI: Body mass index; kg: kilogram; m: metre; SSBs: sugar sweetened beverages; UI: uncertainty interval

Table 2 *Cost-effectiveness results, mean (95% UI)*

	Base case	Scenario 1	Scenario 2
Total HALYs gained	73,883 (57,038 to 96,264)	348,236 (267,567 to 455,788)	14,781 (11,260 to 19,170)
Total intervention costs	$210M ($148M to $273M)	$210M ($148M to $273M)	$45M ($31M to $58M)
Total healthcare cost savings	$751M ($556M to $991M)	$4B ($3B to $5B)	$151M ($112M to $201M)
Total net cost *	-$541M (-$793M to -$341M)	-$3B (-$5B to -$2.4B)	-$106M (-$160M to -$66M)
Mean ICER	Dominant (Dominant to Dominant)	Dominant (Dominant to Dominant)	Dominant (Dominant to Dominant)
Probability of being cost-effective #	100%	100%	100%
Overall result	**Dominant**	**Dominant**	**Dominant**

*Notes: B: billion; Dominant: the intervention is both cost-saving and improves health; HALY: health adjusted life year; ICER: incremental cost effectiveness ratio; M: million; $: 2010 Australian dollars; * Negative total net costs equate to cost savings. # The willingness-to-pay threshold for this analysis is $50,000 per HALY.*

Figure 1 ***Cost–effectiveness plane***

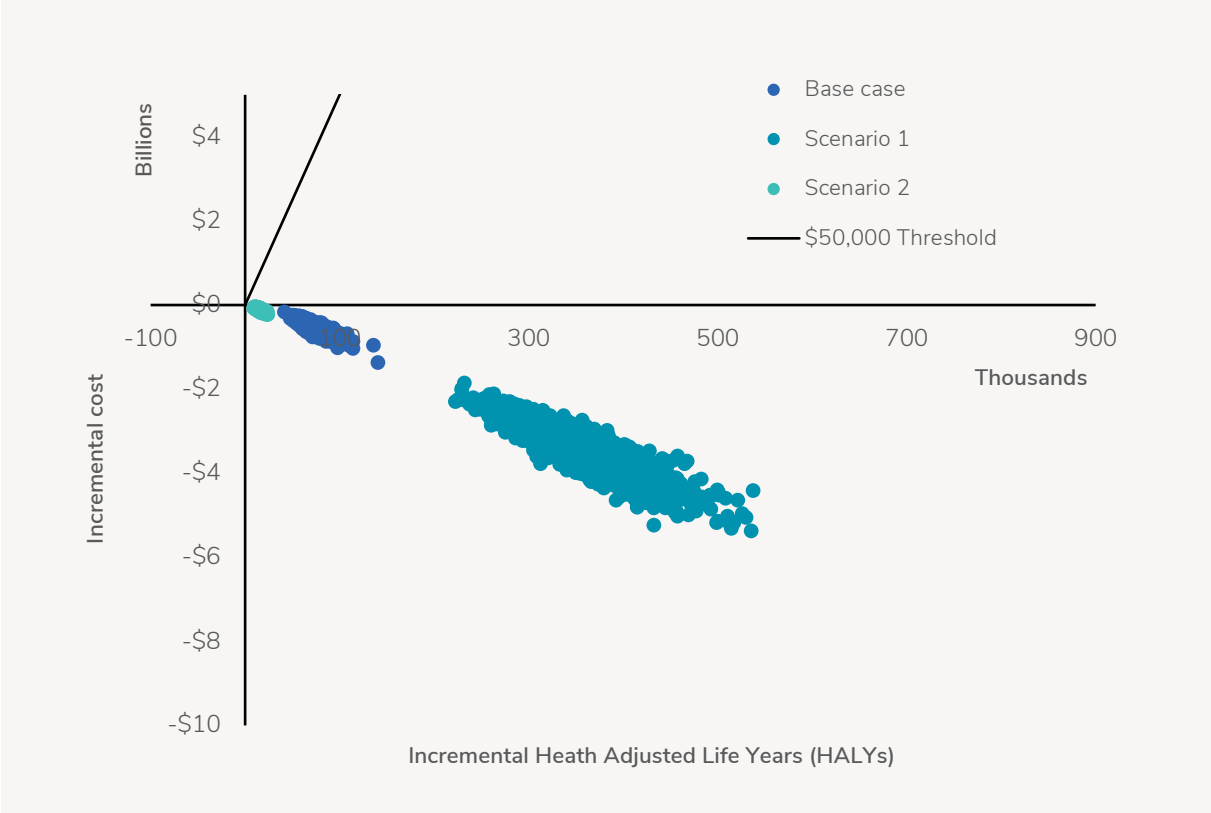
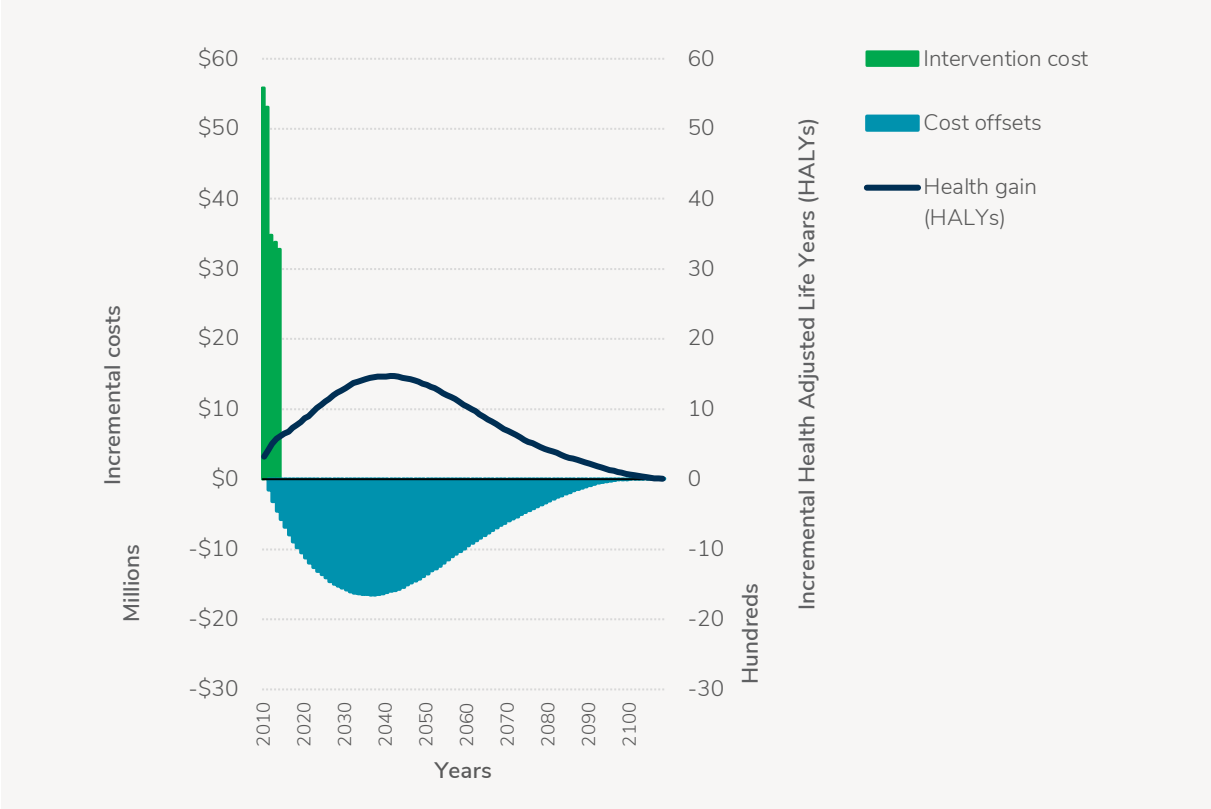


Figure 2 ***Costs, cost offsets and health gains over time (base case)***



Implementation considerations

Consideration	Details	Assessment
Strength of evidence	Low certainty of effect on BMI / body weight outcomes due to absence of relevant studies and lack of real world implementation.	Low
	Low certainty of effect on dietary outcomes due to absence of relevant studies and lack of real world implementation, particularly regarding compensatory behaviours in response to the intervention.	Low
Equity	Consumption of SSBs is known to be higher in lower socio-economic groups. Accordingly, this intervention is likely to have a greater health impact in lower socio-economic groups.	Positive
Acceptability	**Government:** The Australian government has identified portion size as a focus area for the Healthy Food Partnership. The government is likely to prefer voluntary implementation (Scenario 2).	Low
	Industry: Beverage manufacturers are likely to oppose package size caps on single-serve SSBs.	Low
	Public: There is no available evidence regarding the level of public support for this intervention. It could be expected that consumers of SSBs are likely to oppose package size caps on single-serve SSBs.	Low
Feasibility	Most SSBs are already sold in a variety of single-serve package sizes. Removing the largest package sizes (>375ml) is likely to be highly feasible.	Low
Sustainability	If this intervention was implemented on a mandatory basis, sustainability is likely to be high, although there would likely be ongoing pressure from the food industry to remove the regulations. If this intervention was implemented on a voluntary basis, relying on industry commitments to implement and maintain the package size cap, sustainability is likely to be lower and subject to competitive pressures on the industry.	Medium
Other considerations	This intervention has not been implemented previously and, therefore, the pricing and marketing response from industry and changes in consumer purchasing are largely unknown.	

Notes: BMI: Body mass index; SSBs: sugar-sweetened beverages

Reformulation to reduce sugar in sugar-sweetened beverages

Authors: Gary Sacks, Phuong Nguyen

Publication citation: Crino M, Herrera A, Ananthapavan J, Wu J, Neal B, Lee Y, Zheng M, Lal A, Sacks G. Modelled cost-effectiveness of a package size cap and a kilojoule reduction intervention to reduce energy intake from sugar-sweetened beverages in Australia. *Nutrients*. 2017;9(9):983

The intervention

- Reduction in sugar content of sugar-sweetened beverages (SSBs) in Australia to lower the average energy content (kJ) per 100g by 5% from current levels.
- Mandatory and voluntary reformulation targets were modelled.

What we already know

- In 2011, SSBs contributed to 4% of total energy consumed and 17% of total sugars consumed.
- There is strong evidence that SSBs are associated with poor health.
- Evidence from other regions (e.g., the United Kingdom) indicates that sugar reduction in SSBs is highly feasible. The Australian government has identified product reformulation as a key focus area as part of the Healthy Food Partnership – a flagship food and nutrition initiative.

Key elements of the modelled intervention

- Total consumption of SSBs by age and sex was estimated using the Australian Health Survey. Energy intake related to SSBs was reduced by 5% for each age and sex group. It was assumed that no compensatory changes to diet occurred in response to the intervention.
- Scenario analyses tested variations in the extent to which SSBs manufacturers implemented the intervention (all SSBs consumed for 'mandatory', 20% of SSBs consumed for 'voluntary').
- Costs to government included the costs of passing the legislation (where relevant), and for administering and monitoring implementation. Costs to SSB manufacturers were derived based on previous analyses of expected costs of implementation of a food labelling intervention affecting packaged food in Australia.

Key findings

- Total consumption of SSBs by age and sex was estimated using the Australian Health Survey. Energy intake related to SSBs was reduced by 5% for each age and sex group. It was assumed that no compensatory changes to diet would take place in response to the intervention.
- Scenario analyses tested variations in the extent to which SSBs manufacturers implemented the intervention (all SSBs consumed for 'mandatory', 20% of SSBs consumed for 'voluntary').
- Costs to government included the costs of passing the legislation (where relevant), and for administering and monitoring implementation. Costs to SSB manufacturers were derived based on previous analyses of expected costs of implementation of a food labelling intervention affecting packaged food in Australia.

Conclusion

The intervention demonstrates significant potential for cost-effectiveness, with expected positive equity effects. Voluntary implementation is likely to be favoured by government and industry stakeholders; whereas mandatory implementation is likely to be less acceptable to these groups.

Scenarios description and cost-effectiveness results

Table 1 *Description of selected scenarios*

	Base case Voluntary industry pledge to reduce kJ/100g by 5% for all SSBs	Scenario 1 Government imposes legislation to reduce kJ/100g by 5% for all SSBs
Risk factor(s) addressed by intervention	BMI	
Population targeted	Australian population, aged 2-100 years	
Weighted average reduction in body weight (95% UI)	0.06kg (0.05 to 0.07)	0.29kg (0.24 to 0.34)
Weighted average reduction in BMI (95% UI)	0.02kg/m^2 (0.01 to 0.03)	0.11kg/m^2 (0.10 to 0.12)
Effect decay	100% maintenance of effect	
Costs included	Cost of administration and support (government); implementation (industry)	Cost of passing legislation, administration and monitoring (government); implementation (industry)
Type of model used	Population model with quality of life in children	

Notes: BMI: Body mass index; kg: kilogram; m: metre; SSBs: sugar sweetened beverages; UI: uncertainty interval

Table 2 *Cost-effectiveness results, mean (95% UI)*

	Base case	Scenario 1
Total HALYs gained	28,981 (21,884 to 37,976)	144,621 (109,050 to 189,848)
Total intervention costs	$45M ($31M to $58M)	$210M ($148M to $273M)
Total healthcare cost savings	$295M ($217M to $391M)	$1.5B ($1.1B to $1.9B)
Total net cost *	-$251M (-$347M to -$217M)	-$1.3B (-$1.9B to -$869M)
Mean ICER	Dominant (Dominant to Dominant)	Dominant (Dominant to Dominant)
Probability of being cost-effective #	100%	100%
Overall result	**Dominant**	**Dominant**

Notes: B: billion; Dominant: the intervention is both cost-saving and improves health; HALY: health adjusted life year; ICER: incremental cost effectiveness ratio; M: million; $: 2010 Australian dollars; * Negative total net costs equate to cost savings; # The willingness-to-pay threshold for this analysis is $50,000 per HALY.

Figure 1 ***Cost–effectiveness plane***

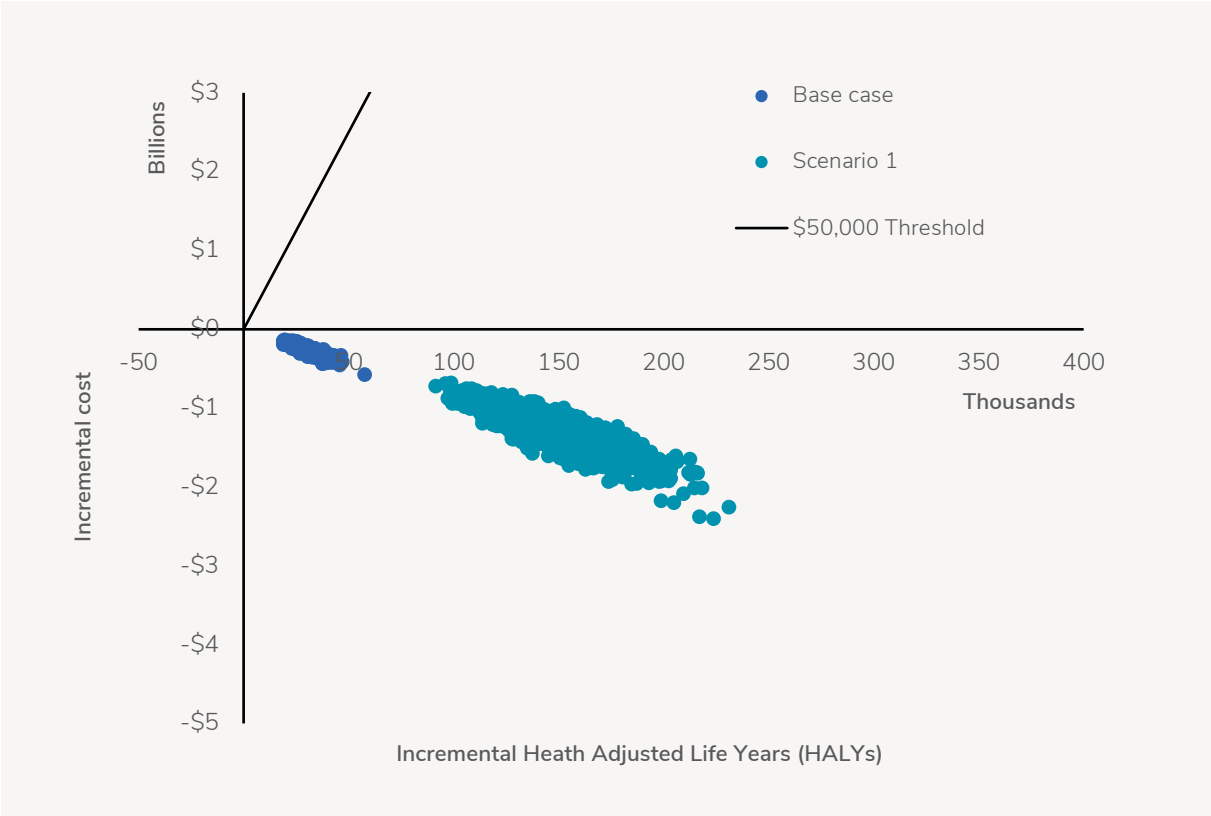


Figure 2 ***Costs, cost offsets and health gains over time (base case)***

Implementation considerations

Consideration	Details	Assessment
Strength of evidence	Low certainty of effect on BMI / body weight outcomes due to absence of relevant studies and lack of real world implementation.	Low
	Medium certainty of effect on dietary outcomes. Experimental studies have shown that consumers continue to consume the same quantity of foods and beverages (post reformulation) without compensating for any changes in kJ.	Medium
Equity	Consumption of SSBs is known to be higher in lower socio-economic groups. Accordingly, this intervention is likely to have a greater health impact in lower socio-economic groups.	Positive
Acceptability	**Government:** The Australian government has identified reformulation as a focus area for the Healthy Food Partnership. The government is likely to prefer voluntary implementation.	High
	Industry: Beverage manufacturers are actively committing to some voluntary reformulation targets, but are likely to oppose mandatory reformulation targets.	Medium
	Public: There is no available evidence regarding the level of public support for this intervention. However, as the intervention does not directly affect consumer behaviour, and past reformulation efforts (when brought into place slowly over time) have been shown to be widely accepted by consumers.	Medium
Feasibility	Reformulation to lower the sugar content of SSBs has been demonstrated as feasible in a number of other countries.	High
Sustainability	If this intervention was implemented on a mandatory basis, sustainability is likely to be high, although there may be ongoing pressure from the food industry to remove the regulations. If this intervention was implemented on a voluntary basis, relying on industry commitments to implement and maintain the intervention, sustainability is likely to be lower and subject to competitive pressures on the industry.	Medium
Other considerations	SSB consumption has been slowly declining over recent years. If this trend continues, the contribution of SSBs to mean population energy intake may be lower than estimated in this analysis.	

Notes: BMI: body mass index; SSBs: sugar-sweetened beverages

Supermarket shelf tags on healthier products

Authors: Jaithri Ananthapavan, Adrian Cameron, Gary Sacks, Marj Moodie

Publication citation: manuscript in progress

The intervention

- A voluntary intervention supported by state governments, that encourages and assists supermarket chains to identify healthier products to customers by installing and maintaining shelf tags on healthier products.
- The modelled intervention is based on a 12-week controlled trial (CT) where shelf tags were prominently placed on all packaged products eligible for 4.5 or 5 stars using the Health Star Rating (HSR) system. The study was undertaken in seven supermarkets in regional Victoria.

What we already know

- Front of pack (FOP) labelling systems aim to promote healthier food choices. The HSR system was endorsed by the Australian government in 2014 for voluntary implementation.
- A small number of international on-shelf nutrition labelling systems have been evaluated for their impact on customer purchases, demonstrating small but positive shifts toward the purchasing of more healthy products.

Key elements of the modelled intervention

- Based on the CT, the percentage change in the energy density of all packaged foods purchased in the intervention (compared to the control) stores was used to estimate changes in average population energy intake from packaged foods.
- It was assumed that the top four supermarket chains (incorporating over 80% of the market share) implemented the intervention on a voluntary basis.
- Costs accrued by each supermarket chain was based on the CT. The cost for state governments to advise and support the supermarket chains was also included.
- Scenarios included variations in the length of intervention implementation and effect.

Key findings

- The shelf tag intervention resulted in a 9% reduction in the energy density of packaged foods purchased. Assuming volume consumed remains static, 3 years of implementation and effect translated to an estimated mean reduction in population body weight of 1.32kg.
- The intervention was estimated to be dominant (i.e., cost-saving and health promoting) resulting in 72,532 HALYs gained and healthcare cost savings of approximately $647 million.
- Implementation costs accrued by the participating supermarkets was approximately $8.1M.

Conclusion

This intervention is likely to be highly cost-effective, acceptable to most stakeholders and feasible to implement. Longer term real-world evidence is required to better inform intervention effect, acceptability to the supermarket industry, sustainability and equity impacts.

Scenarios description and cost-effectiveness results

Table 1 *Description of selected scenarios*

	Base case 3 year implementation	Scenario 1 1 year implementation
Risk factor(s) addressed by intervention	BMI	
Population targeted	Australian population 2010, aged 2-100 years	
Weighted average reduction in body weight (95% UI)	1.33kg (0.60 to 2.18)	
Weighted average reduction in BMI (95% UI)	0.49kg/m^2 (0.22 to 0.80)	
Effect decay	100% maintenance of effect for 3 years	100% maintenance of effect for 1 year
Costs included	Cost of support and monitoring (state government); shelf tag matching, design, installation, and replacement (industry)	
Type of model used	Population model with quality of life in children	

Notes: BMI: Body mass index; kg: kilogram; m: metre; UI: uncertainty interval

Table 2 *Cost-effectiveness results, mean (95% UI)*

	Base case	Scenario 1
Total HALYs gained	72,532 (31,857 to 116,010)	26,704 (12,177 to 43,017)
Total intervention costs	$8.5M ($6.5M to $11.6M)	$3.5M ($1.9M to $6.0M)
Total healthcare cost savings	$647M ($290M to $1,045M)	$222M ($102M to $359M)
Total net cost *	-$638M (-$1,038M to -$282M)	-$218M (-$356M to -$99M)
Mean ICER	Dominant (Dominant to Dominant)	Dominant (Dominant to Dominant)
Probability of being cost-effective #	99.9%	100%
Overall result	**Dominant**	**Dominant**

*Notes: Dominant: the intervention is both cost-saving and improves health; HALY: health adjusted life year; ICER: incremental cost effectiveness ratio; M: million; $: 2010 Australian dollars; * Negative total net costs equate to cost savings; # The willingness-to-pay threshold for this analysis is $50,000 per HALY.*

Figure 1 ***Cost–effectiveness plane***

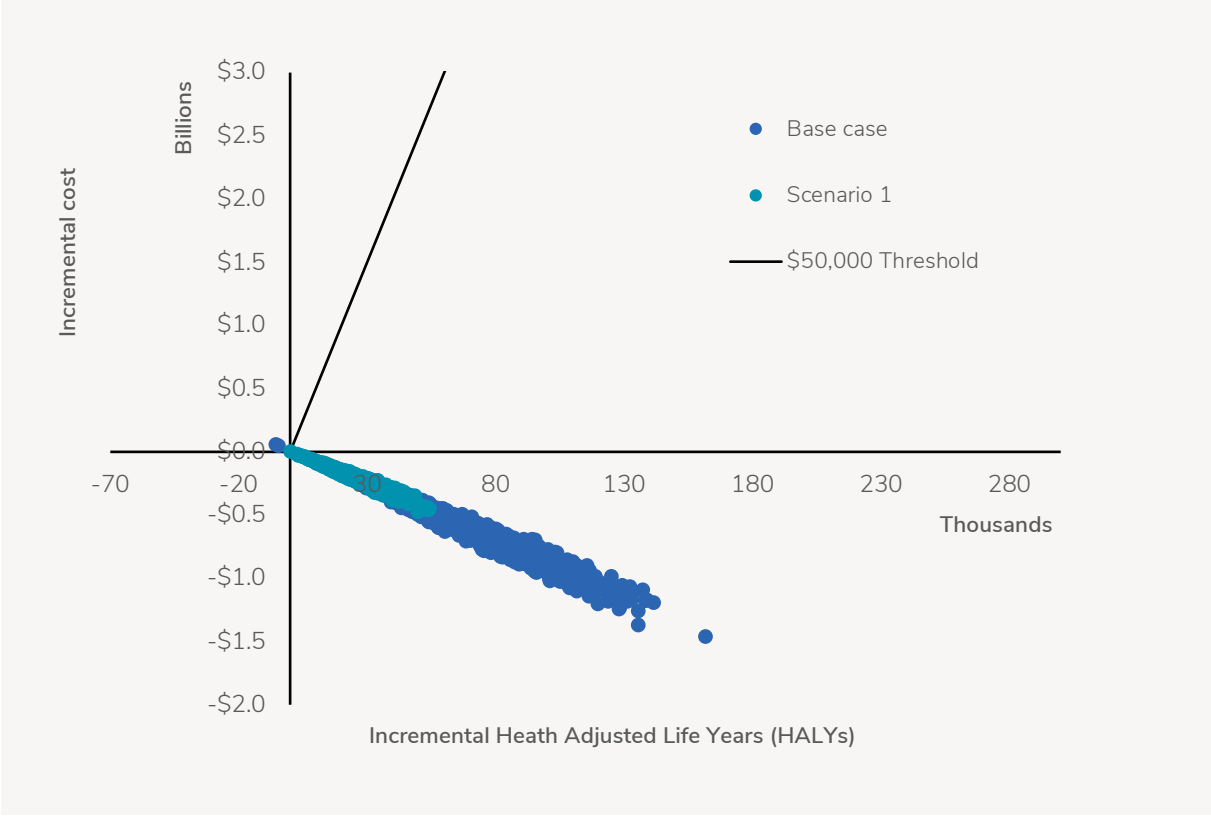
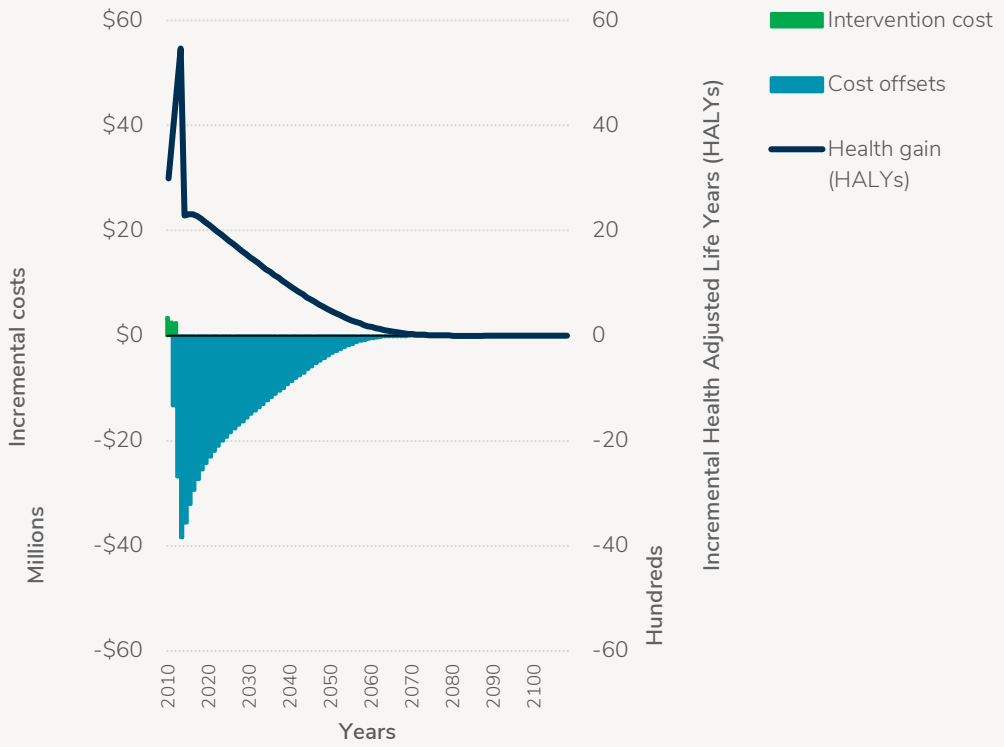


Figure 2 ***Costs, cost offsets and health gains over time (base case)***



Implementation considerations

Consideration	Details	Assessment
Strength of evidence	Low certainty of the effect on weight/BMI outcomes due to absence of relevant studies.	Low
	Medium certainty of effect on diet based on consistent evidence from an Australian controlled trial and several international quasi-experimental studies demonstrating that shelf tags resulted in the purchasing of healthier products. The effect size was based on a short-term (12 week) Australian study, with no long term follow-up post-intervention.	Medium
Equity	There is a lack of empirical evidence on the equity impact of shelf tags. However, interpretive labelling like the HSR system is likely to be better understood than traditional back-of-pack labelling across all levels of socio-economic position. The trial that the intervention was based on was conducted in disadvantaged areas and therefore the effect size is applicable to those from lower socioeconomic backgrounds.	Neutral
Acceptability	**Government:** Given that this intervention was based on the government-endorsed HSR system, it is likely to be acceptable to government stakeholders. The costs borne by state governments to support this intervention are relatively low.	High
	Industry: The main supermarket chains have been the leaders in the implementation of the HSR system. Given that this intervention was based on the HSR system, it is possible it will also be embraced by the industry. The relatively high costs borne by supermarkets may decrease acceptability, however there may be efficiencies that could be achieved such as incorporating the HSR into price tags (that are already in place).	Medium
	Public: Evidence from customer feedback from the 12-week CT and other shelf tag labelling studies suggests strong public support for this intervention.	High
Feasibility	The feasibility of the shelf tag intervention is enhanced by its use of the government-endorsed HSR system. International experience suggests that shelf tag labelling systems can be implemented across chain supermarkets[1].	High
Sustainability	Sustainability of the intervention is dependent on the installation and replacement of shelf tags becoming a routine task in each of the supermarket stores. This is dependent on the commitment each supermarket chain makes to implement and sustain this intervention.	Medium
Other considerations	**Negative side effects:** Highlighting the healthier packaged food products may encourage purchasing of packaged products at the expense of fresh food (fruits, vegetables and meats) items that aren't designed for the HSR system. Methods to highlight the relative healthiness of non-packed foods in supermarkets should be considered.	

Notes: BMI: Body Mass Index; CT: controlled trial; HSR: Health Star Rating

1 Hobin et al. *The Milbank Quarterly* 2017; 95(3): 494-534

Workplace intervention to reduce sedentary behaviour

Publication citation: Gao L, Flego A, Dunstan DW, Winkler EAH, Healy GN, Eakin GE, Willenberg L, Owen N, LaMontagne AD, Lal Am Wiesner GH, Hadgraft NT, Moodie ML. Economic evaluation of a randomized controlled trial of an intervention to reduce office workers' sitting time: the "Stand-Up Victoria" trial. *Scand J Work Environ Health* 2018; 44(5): 503-511

The intervention

- *Stand Up Victoria* was a multi-component workplace-delivered intervention designed to reduce workplace sitting time by a "Stand Up, Sit Less, Move More" policy.
- It comprised organisational, environmental and individual-level strategies (including consultation with managerial staff, a workplace information session, emails from worksite managers, installation of sit-stand workstations, and individual health coaching). A voluntary policy implemented nationally was modelled.

What we already know

- High levels of sitting are detrimentally associated with a range of health outcomes.
- Desk-based workers typically sit for approximately 75% of their workday, with much of this sitting time accrued in prolonged unbroken bouts.
- Interventions that adopt a multi-component approach have been shown to be most successful in reducing workplace sitting time.

Key elements of the modelled intervention

- A within-trial cost-efficacy analysis was performed using the efficacy and cost data from the randomised controlled trial of *Stand Up Victoria* in 14 worksites of a single organisation.
- A cost-effectiveness analysis was conducted to translate short-term benefits observed in the trial (i.e., increased physical activity in terms of standing time) into the long-term health benefits (i.e. health-related quality of life).
- The intervention was modelled for both the trial and national eligible populations (office-based workers) modelled with intervention effect lasting for five-years. The duration of effect was varied in scenario analyses.

Key findings

- When scaled up to the national level, the intervention would affect around 0.6 million workers, and would reduce sedentary behaviour. This would result in 7,492 HALYs gained.
- The intervention was associated with healthcare cost saving of $54 million and a resultant net cost of $344 per participant.
- The resultant incremental cost-effectiveness ratio was $28,703 per HALY gained, with both having 100% probability of being cost-effective.

Conclusion

The *Stand Up Victoria* intervention was shown as likely to be cost-effective when scaled up to the national workforce. However, the intervention relies on voluntary uptake, a relatively large level of investment from companies, and will likely need sustained funding and other resources to remain effective.

Scenarios description and cost-effectiveness results

Table 1 *Description of selected scenarios*

	Base case Voluntary policy; 20% per annum intervention decay	Scenario 1 Voluntary policy; 10% per annum intervention decay
Risk factor(s) addressed by intervention	PA	
Population targeted	Australian population 2010, aged 18-65 years	
Weighted average reduction in PA, MET mins/day (95% UI)	63.3 (35.7 to 90.9)	
Effect decay	20% decay per annum, no effects after 5 years	10% decay per annum, no effects after 10 years
Costs included	Recruitment, information sessions, sit-stand workstations, consultations, telephone check-ups, email tips plus costs of national delivery	
Type of model used	Population model with quality of life in children	

Notes: MET: metabolic equivalent task; mins: minutes; PA: physical activity; UI: uncertainty interval

Table 2 *Cost-effectiveness results, mean (95% UI)*

	Base case	Scenario 1
Total HALYs gained	7,492 (6,555 to 8,428)	11,612 (10,301 to 12,986)
Total intervention costs	$269M	$269M
Total healthcare cost savings	$54M ($46M to $63M)	$84M ($72M to $96M)
Total net cost	$215M ($207M to $224M)	$185M ($173M to $197M)
Mean ICER ($/HALY gained)	28,703 (24,547 to 34,088)	15,954 (13,345 to 19,166)
Probability of being cost-effective #	100%	100%
Overall result	**Cost-effective**	**Cost-effective**

Notes: HALY: health adjusted life year; ICER: incremental cost effectiveness ratio; M: million; $: 2010 Australian dollars; # The willingness-to-pay threshold for this analysis is $50,000 per HALY.

Figure 1 ***Cost–effectiveness plane***

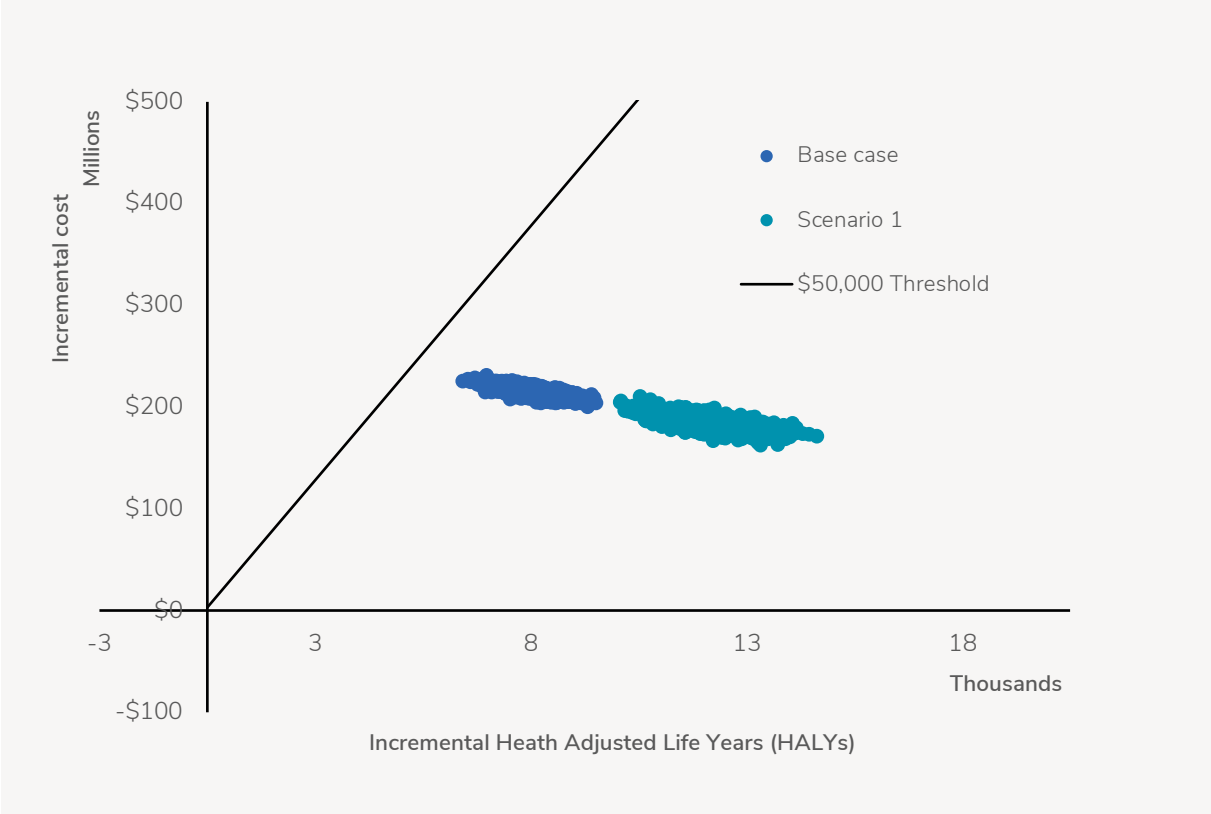
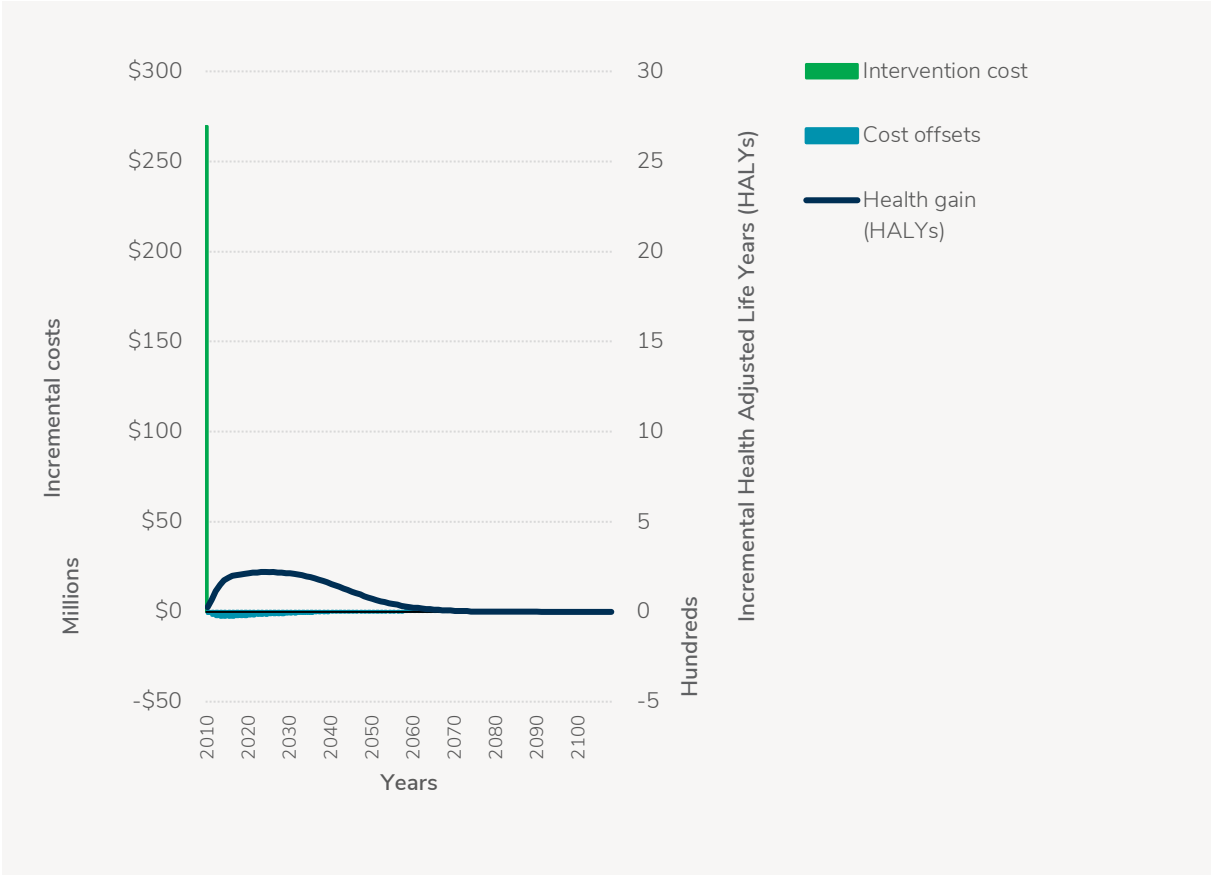


Figure 2 ***Costs, cost offsets and health gains over time (base case)***



Implementation considerations

Consideration	Details	Assessment
Strength of evidence	Low certainty of effect for BMI and body weight outcomes due to absence of relevant studies. No BMI impact was detected during the trial-based evaluation of *Stand Up Victoria*.	Low
	Medium certainty of effect for physical activity outcomes, with the effect estimate based on objectively measured data from a single RCT in the Australian context. The PA outcomes are consistent in direction with another RCT in the North American context.	Medium
Equity	The equity impact of this interventions is not known. The intervention will impact on all office-based workers for firms that take up the intervention.	Neutral
Acceptability	**Government:** The intervention aligns well with government policy to promote workplace occupational health and safety.	High
	Industry: Potential benefits that may accrue to industry include reductions in absenteeism and increased productivity. There is no evidence on likely acceptability to industry, and the relative affordability is likely to depend on the size of the organsation, amongst other factors.	Medium
	Public: The intervention offers the potential to promote the overall health of office-based workers. The intervention is likely to be supported by the public due to no additional out of pocket costs to the employee.	High
Feasibility	The intervention is likely to be feasible to implement, although it will require a relatively large investment from individual firms. The characterisitics of organisations that are likely to adopt the intervention are not well established. Economies of scale could be achieved through bulk orders or use of less expensive sit-stand workstations. Other potential savings could be explored (such as coaching via text message rather than the use of health coaches, substitution of videos for seminars etc).	Medium
Sustainability	The sustainability of effect depends on the ongoing organisational and cultural support provided for the intervention use. Once sit-stand workstations are installed in workplaces, the intervention effect would be potentially maintained.	Low
Other considerations	**Positive side effects:** The modelling only captured changes in BMI and physical activity. It did not capture changes to other cardiometabolic risk biomarkers that have showed promising potential health benefits (e.g., reductions in fasting glucose). **Negative side effects:** The intervention may be associated with some adverse events from the intervention (e.g., back injuries requiring medical attention).	

Notes: BMI: body mass index; PA: physical activity; RCT: randomised controlled trial

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Appendices

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