



The value of prevention

An Evidence Check rapid review



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Executive summary

This Evidence Check is a rapid review that focuses on identifying and demonstrating the value of prevention in an Australian context. It focuses on 4 key risk factors causally linked with poor health in Australia: overweight and obesity, unhealthy diet, physical inactivity, and tobacco use.

Prevention involves acting early to reduce or prevent harm or illness. Prevention includes primordial or primary prevention (reducing risk before disease or health impacts have occurred), secondary prevention (responding to early stages of disease), and tertiary prevention (managing and reducing disease progression). Prevention is a priority in Australia because of the burden and cost of a range of diseases and risk factors, which have significant repercussions for health and health equity.

Aims and methods

This review summarises the health burden and economic costs of 4 risk factors (overweight and obesity, unhealthy diet, physical inactivity and tobacco use), and identifies the relevant evidence about the health, social, economic and other benefits of population-level strategies at the primordial or primary level of prevention that protect the health of the community through reducing exposure to these risk factors before disease occurs.

The review questions were:

1. What are the economic and health costs of high body mass, poor diet, insufficient physical activity and tobacco use?
2. What are the health, social and economic benefits of primary prevention strategies which address high body mass, poor diet, insufficient physical activity and tobacco use; and which strategies are most cost-effective?

Searches were undertaken of the peer-reviewed (published) literature and relevant grey literature documents published between 2015 and 2020. Two systematic searches were undertaken, one for each review question, using 4 scientific databases for both searches. A total of 8 searches were undertaken for the peer-reviewed literature. For the grey literature, advanced searching was undertaken using Google for key government and organisational websites.

For review question 1, literature was identified that provided the attributable health burden and/or economic costs associated with one or more of the 4 risk factors in the Australian population. For review question 2, literature was identified that provided the effectiveness of strategies and interventions addressing one or more of the 4 risk factors, including their benefits and costs. This included both literature from an Australian context as well as overseas jurisdictions similar to Australia such as New Zealand, UK and Canada.

Due to the nature of the review questions and the vast body of literature, only systematic reviews and particular types of grey literature documents were prioritised for review question 1. For review question 2, umbrella reviews (reviews of reviews or 'meta-reviews') and meta-syntheses (reviews of meta-analyses) were prioritised, along with grey literature documents including reports, non-published reviews and evaluations.

Findings

A large number of results were identified for both review questions during the searching process, including a total of 150 grey literature documents and 15,206 results for peer-reviewed studies. After screening of titles, abstracts and full text, a total of 86 peer-reviewed studies and grey literature documents were included in this review, 14 studies for review question 1 and 72 for review question 2.

Review question 1

For review question 1, 14 reviews, syntheses and reports were included (peer-reviewed n=5, grey n=9). The majority of the reviews focused on the health burden of one or more of the identified risk factors, including the most recent Australian Burden of Disease Study.

According to the Australian Burden of Disease Study 2015, the health burden of the 4 risk factors (overweight and obesity, unhealthy diet, physical inactivity, and tobacco use) is substantial. Tobacco use was the modifiable risk factor with which the largest health burden was associated, which was 20,933 deaths and 9.3% of the overall health burden (in terms of Disability-Adjusted Life Years or 'DALYs') in 2015. Overweight and obesity was associated with 14,165 deaths and 8.4% of DALYs. Dietary factors were associated with 19,876 deaths and 7.3% of DALYs. Physical inactivity was associated with 7,079 deaths and 2.5% of overall health burden in terms of DALYs. The health burden of these 4 risk factors cannot be combined due to the joint causal responsibility they share with several diseases.

The evidence identified by this review also indicates that in Australia there are significant costs associated with each of the 4 key risk factors, representing a large economic burden to individuals, communities, businesses, governments and society. For example, one systematic review identified 18 studies estimating the economic burden of lifestyle risk factors. The range of economic cost estimates for each preventable risk factor included: individual dietary risk factors up to \$561m, tobacco use up to \$10.5bn, high BMI \$840m - \$14.9bn, and physical inactivity up to \$15.6bn (all costs in 2016-17 Australian dollars). The variability in results is largely due to differences in input data used and study methods (for example, choices around which costs were included). The costs of overweight, obesity and tobacco use were more commonly costed than physical inactivity.

The available evidence identified that the 4 risk factors of overweight and obesity, unhealthy diet, physical inactivity, and tobacco use represent a significant health burden for the Australian population, causing tens of thousands of premature deaths per year and years lived in poor health. Tobacco use generally represents the highest burden of disease, though the other risk factors also have a significant burden.

The included studies also identified the economic costs of these risk factors. These costs included costs to the health system, such as hospitalisations and charges to Medicare, as well as broader economic or societal costs from reduced employment, absenteeism and presenteeism.

The evidence suggests that even small changes in the prevalence of these risk factors are likely to lead to a significant reduction in the health burden for individuals and the healthcare system, as well as a reduction in economic and societal costs for communities, businesses and governments.

Review question 2

For review question 2, 72 reviews and reports were included (peer-reviewed, n=42, grey n=30). Half of the included reviews and reports looked at the benefits and outcomes from multiple primary prevention strategies. Common types of strategies examined were settings-based health promotion (particularly targeting children) and built and natural environment and transport strategies.

While many identified outcomes in the literature were health benefits (either physical, behavioural or mental health), there were also social and other outcomes that could be considered co-beneficial, including environmental benefits (such as a reduction in temperature, air pollution or carbon emissions). These other benefits could demonstrate additional value of preventive strategies. Cost-effectiveness and economic benefits of preventive interventions were also identified and included where these were reported on by the study authors; this was the case in 9 cost-effectiveness reviews.

The results of this review indicate that investing in population-wide preventive strategies at the primordial or primary prevention level will likely be beneficial for health. Most of the benefits identified in this review were health benefits, particularly physical benefits such as improving physical activity levels, improving diet, reducing or prevent tobacco use, and reducing overweight and obesity. Strategies that were particularly effective tended to be those that involved the implementation of multiple strategies, and/or were multi-component interventions implemented at different levels of the system or setting.

Some preventive strategies produced a wider range of benefits beyond health, including mental wellbeing benefits, social benefits and environmental benefits. Non-health 'co-benefits' were particularly apparent for strategies such as built environment and transport interventions.

Preventive strategies are also likely to be cost-effective and economically beneficial. Cost-effective interventions and those producing evidence of economic benefit tended to be more regulatory in nature, such as taxation, changes to the physical (built or natural) environment, food reformulation to reduce salt levels, and provision of active transport infrastructure. Tobacco taxation was highly effective and cost-effective. However, other interventions were also economically beneficial, such as obesity prevention interventions in children and mass media campaigns.

Conclusion

This review confirmed that the 4 risk factors of overweight and obesity, unhealthy diet, physical inactivity, and tobacco use represent a significant health burden for the Australian population, causing a large proportion of preventable disease and years lived in poor health. These risk factors also contribute a significant economic burden for individuals, governments, businesses and communities, with economic cost estimates ranging from \$561m for individual dietary factors, to up to \$15.6b for physical inactivity.

The review also found that primary prevention strategies addressing overweight and obesity, unhealthy diet, physical inactivity, and tobacco use are valuable interventions for governments and communities to implement, with numerous health benefits. Some of these strategies also have multiple benefits in other non-health areas. Many of the included interventions may be highly cost-effective for governments and may generate economic benefits.

Despite a large body of literature, there are many evidence gaps remaining, particularly in terms of reporting on non-health co-benefits of prevention and collecting data for economic evaluations to demonstrate the economic benefits of prevention.

To demonstrate the full value of prevention, researchers and policymakers need to ensure they are measuring a range of health and non-health outcomes, including physical health, mental health, social, environmental and/or economic outcomes. Economic costs and benefits of preventive strategies also need to be routinely collected to enable more rigorous economic evaluations and costings of interventions. Taking a systems or complexity approach to the design, implementation and evaluation of preventive strategies may assist with developing effective interventions and identifying the full range of benefits for populations.

Purpose of this review

The purpose of this Evidence Check is to provide a summary of the evidence base on the value of prevention for the Centre for Population Health at the NSW Ministry of Health. The review builds on previous work that has considered the health and other benefits of prevention¹ and the cost-effectiveness of preventive health interventions particularly in terms of chronic disease prevention.²⁻⁵

The focus of this review is on 4 key risk factors:

- Overweight and obesity
- Unhealthy diet
- Physical inactivity
- Tobacco use and smoking.

This review summarises the health burden and economic costs of these risk factors, and identifies the relevant evidence about the health, social, economic and other benefits of population-level strategies at the primordial or primary level of prevention that protect the health of the community through reducing exposure to these risk factors.

The review will assist investigators and partners of The Australian Prevention Partnership Centre to help build a case for continued and expanded investment in prevention within and across state and territory jurisdictions as well as at a national level.

Background

What is prevention?

'Prevention' can be defined as any action taken to protect and promote the health of populations.⁶ Prevention aims to prevent poor health, illness, injury and early death from occurring, and increase the likelihood that people will stay healthy and well for as long as possible.⁷ Effective preventive actions and strategies decrease the risk of experiencing a disease, condition or injury.^{6,8} Prevention also supports people to effectively manage existing diseases or conditions so their health does not worsen.

Preventive actions and strategies can be categorised into 4 levels (**Figure 1**) though it should be noted that primordial prevention can be included as part of primary prevention.^{6,9-12} Different preventive strategies require different levels of 'agency' on the part of individuals to achieve change.¹³ For example, primordial prevention strategies tend to be population-level strategies that usually require government or community intervention to expose the whole population to health-promoting conditions and environments, such as providing fluoridated drinking water, addressing socioeconomic factors causing poor health, or providing active transport infrastructure.

Primary prevention interventions aim to change risky behaviours or risk factors before health impacts occur, such as through mass media campaigns, education, and other strategies such as vaccination. In comparison, secondary and tertiary levels of prevention require greater effort on the part of individuals and tend to be targeted at high-risk groups, such as engaging in screening for cancer (secondary prevention) or chronic disease management programs (tertiary prevention).¹²

Many preventive health strategies and interventions, particularly at the primordial or primary level, lie outside the remit of the health system and require multi-level, multi-sectoral action. Prevention therefore requires a range of individuals, communities, organisations and governments to work together in a coordinated way from different perspectives.¹⁴ A systems approach to prevention can help to respond to complex challenges such as preventing chronic disease, and can help identify which preventive interventions or strategies may be effective at promoting systems-level changes that support better health for all.¹⁵

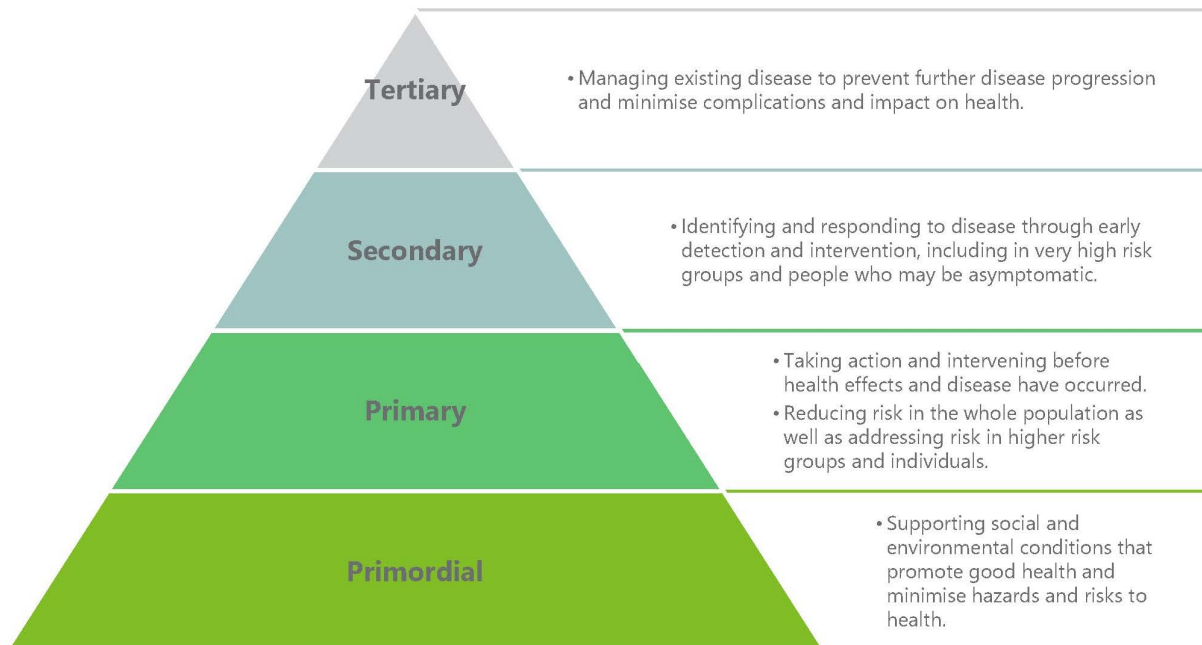


Figure 1: Levels of prevention

Primary prevention strategies

Primary prevention strategies, which are the focus of this report, encompass a diverse range of interventions that include both population-based and individual-based interventions. For the purposes of this review, 'primary prevention strategies' include both primordial and primary levels of prevention. **Table 1** shows a summary of the types of chronic disease prevention strategies commonly defined as 'primary prevention' in the relevant public health literature.^{4,6,16}

Note that many public health and preventive interventions can involve multiple types of strategies – for example, offering an individual-level healthy lifestyle program while at the same time running a population-level mass media health promotion campaign. Similarly, while fiscal interventions usually require some type of legislative change or regulation, for the purposes of this review they have been grouped separately.

Primary prevention strategy	Examples
Regulation and policies	<ul style="list-style-type: none"> • Plain packaging of tobacco products • Front-of-pack food labelling regulations • Limitations on advertising unhealthy food and drink to children • Smoke-free laws and policies • Healthy canteen policies • Healthy eating and physical activity guidelines
Fiscal	<ul style="list-style-type: none"> • Tobacco product excise • Alcohol beverage excise • Sugar-sweetened beverage tax • Subsidies or discounts for healthy food
Social marketing and mass media campaigns	<ul style="list-style-type: none"> • Obesity prevention and healthy lifestyle campaigns • Anti-smoking campaigns to prevent uptake of smoking and to encourage smoking cessation
Healthy lifestyle & individual behaviour change programs	<ul style="list-style-type: none"> • Coaching or counselling service (telephone, text-based or online) • Nutrition education programs • Health promotion apps • Breastfeeding promotion • Smoking cessation programs
Settings-based health promotion	<ul style="list-style-type: none"> • Healthy weight programs in maternity settings for pregnant women • Physical activity and nutrition interventions in school settings, after school care or early childhood care settings • Workplace sedentary behaviour interventions • Embedding prevention strategies in primary and clinical care settings
Built and natural environment and transport	<ul style="list-style-type: none"> • Active transport infrastructure such as walking and cycling paths • Urban or land-use planning and zoning changes
Behavioural economics and 'nudge'	<ul style="list-style-type: none"> • Portion size reductions • Placement of healthier food options in supermarkets • Financial incentives to influence purchasing decisions such as taxes and subsidies on food and beverage products • Financial incentives to influence individual behaviour such as paying people to lose weight • Making healthy choices the 'default' option on restaurant menus, meal kits and takeaway apps

Table 1: Primary prevention strategies

Methods

Review approach

An Evidence Check style of rapid review was used to identify and review the relevant peer-reviewed and grey literature evidence. Evidence Checks are an evidence synthesis method that utilises systematic searching protocols to provide a broad overview of the evidence base to assist policymakers and practitioners in evidence-informed decision making in health.^{17,18} This review was conducted following PRISMA guidelines.¹⁹

A knowledge brokering session was conducted between the commissioning agency, the Sax Institute and The Australian Prevention Partnership Centre to discuss and confirm the scope and approach of the Evidence Check. After consultation, it was agreed this review would focus on 4 risk factors of particular interest to the commissioning agency, and the relevant primary prevention strategies that address those risk factors at a population-wide level.

Review questions

Review question 1

What are the economic and health costs of high body mass, poor diet, insufficient physical activity and tobacco use?

Review question 2

What are the health, social and economic benefits of primary prevention strategies which address high body mass, poor diet, insufficient physical activity and tobacco use; and which strategies are most cost-effective?

Search strategies

Searches were undertaken of the peer-reviewed (published) literature and relevant grey literature documents. Two systematic searches were undertaken, one for each review question, using 4 scientific databases for both searches. These databases were MEDLINE, CINAHL, EconLIT and Embase. This meant that a total of 8 searches were undertaken for the peer-reviewed literature. For the grey literature, advanced searching was undertaken using Google for key government and organisational websites.

For review question 1, literature was identified that provided the attributable health burden and/or economic costs associated with one or more of the 4 risk factors in the Australian population.

For review question 2, literature was identified that reported the effectiveness of strategies and interventions addressing one or more of the 4 risk factors, including their benefits and costs. This included literature from an Australian context, as well as overseas jurisdictions similar to Australia such as New Zealand, the United Kingdom and Canada. Those strategies included 'upstream' preventive interventions occurring at the primordial or primary level of intervention which are population-wide or 'universal' in nature (i.e. as opposed to individual-level counselling or education):

- Laws, legislation, government regulation (including food reformulation or labelling), policies and guidelines
- Fiscal interventions such as taxation
- Social marketing and mass media campaigns
- Settings-based health promotion and healthy lifestyle programs
- Built environment, urban planning and active transport interventions
- Behavioural economics or 'nudge' interventions.

The search strategies undertaken can be found in **Appendix A**. A copy of the database searches can be found in **Supplementary material 1**.

Inclusion and exclusion criteria

The full inclusion and exclusion criteria can be found in **Appendix B**.

Due to the broad nature of the review questions and the vast body of literature pertaining to these questions, certain additional restrictions were employed to manage the feasibility of this rapid review:

- Types of studies (peer-reviewed literature)
 - Review question 1 – systematic reviews
 - Review question 2 – umbrella reviews (reviews of systematic reviews) and meta-syntheses (reviews of meta-analyses)
- Types of documents (grey literature)
 - Systematic-like reviews, including rapid reviews
 - Reports
 - Evaluations.

Screening and data extraction

Screening process

For the peer-reviewed literature, titles and abstracts were identified and screened by two authors using EPPI-Reviewer. A full text review was then undertaken for review question 1.

Due to the substantial number of literature search results for review question 2, an additional process of prioritisation occurred after reviewing titles and abstracts, and before the completion of the full text review. This prioritisation process comprised of two authors individually reviewing each title and abstract, and allocating it to a particular thematic category. These categories were developed by EH and PC during the screening stage to facilitate identification of the most relevant studies in a short timeframe:

- Umbrella reviews
- Tobacco
- Overweight & obesity
- Diet
- Physical activity
- Multiple risk factors & general lifestyle
- Breastfeeding
- Behavioural economics, nudge, financial incentives
- Built environment
- Children, school-based, adolescents
- E-health, digital, technology, social media
- Indigenous populations
- Cost-effectiveness, economic evaluations
- Implementation barriers & enablers.

For the grey literature, titles and executive summaries were identified and screened by one author, and the final decision on inclusion or exclusion were made by EH or PH during data extraction.

Data extraction was undertaken using Microsoft Excel, with the following information for both peer-reviewed and grey literature.

Review question 1

- Author
- Year of publication
- Title of publication
- Country of publication or study
- Publication / study type
- Risk factor(s)
- Number of included studies
- Attributable health burden
- Attributable economic burden
- Mental health & other social burdens
- Evidence quality

Review question 2

- Author
- Year of publication
- Title
- Publication / study type
- Country of publication or study
- Risk factor(s)
- Primary prevention strategy
- Setting
- Health benefits
- Mental health benefits
- Social benefits
- Economic benefits (including cost-effectiveness)
- Other benefits (e.g. Environment)
- Cost-effectiveness
- Benefits for specific groups
- Evidence quality (according to authors' assessment)
- Other details, such as number of studies or reviews included.

Types of benefits

A broad range of outcomes were identified prior to data extraction and synthesis, which could be considered 'benefits' from preventive interventions that target the 4 risk factors. While a number of these outcomes are health benefits (either physical, behavioural or mental health), there are also social and other outcomes that could be considered co-beneficial, such as environmental benefits. These benefits were identified and extracted during the data extraction and synthesis processes. Cost-effectiveness and economic benefits of preventive interventions were also identified and included where these were reported on by the study authors.

Health benefits

Physical or behavioural health benefits of interventions include:

- Increase in physical activity levels
- Reduction in sedentary behaviour
- Improved dietary patterns (e.g. increased fruit and vegetable consumption; reduced sugar-sweetened beverage consumption; reduced salt consumption; reduced sugar or fat consumption; reduced consumption of energy-dense, nutrient poor foods and drinks)
- Reduction in body weight or BMI
- Reduction in waist circumference
- Reduction in cholesterol
- Reduction in prevalence of overweight and/or obesity
- Reduction in injuries.

Mental wellbeing benefits

Mental health and wellbeing benefits of interventions include:

- Improved mental or psychological wellbeing
- Reduction in mental health problems
- Reduction in levels of depression or anxiety
- Reduction in stress
- Reduction in substance misuse
- Improvements in cognitive function.

Social and other benefits

Non-health benefits include social and other benefits (some of which can also be classified as 'economic benefits' using different approaches), as well as environmental benefits:

- Improvements in health and social equity, or reduction in inequities between groups
- Improvements in safety and amenity
- Improvements in social participation
- Increased employment and education
- Improved behaviour in school
- Reduction in road traffic collisions and accidents
- Reduction in carbon emissions
- Reduction in air pollution and improvement in air quality
- Reduction in crime or violence.

Economic benefits and cost-effectiveness measures

Some studies and reports identified the economic benefits from preventive interventions. These benefits were usually identified as part of an economic evaluation, such as a cost-effectiveness analysis (CEA), cost utility analysis (CUA), cost benefit analysis (CBA), or some other type of economic evaluation or analysis.

Economic benefits were usually reported as monetary values (such as Australian or US dollars). Cost-effective measures were reported as Incremental Cost Effectiveness Ratios (ICERs), for example the cost per Quality Adjusted Life Year (QALY) gained or DALY averted.

Other additional measures of economic benefit were also included, such as healthcare cost savings, or reduction in presenteeism, absenteeism and other economic productivity measures such as years of production or income lost due to premature mortality. Other economic outcomes or benefits included macroeconomic impacts such as changes in employment and effects on Gross Domestic Product.

Evidence synthesis

On completion of data extraction, a narrative synthesis was conducted by two reviewers (EH and PC).

Quality assessment

Due to the large number of search results, the complex and heterogeneous body of literature reviewed and the review timeframe, a full quality assessment was not done for the studies. Instead, for umbrella reviews and systematic reviews, the type of quality assessment framework used and the level of quality of evidence reported by the authors was noted. For grey literature, the AACODS checklist²⁰ was used to assess the general quality of the report or document for the purpose of including the document in the review.

During data extraction stage, it was noted whether the authors had assessed the evidence quality and/or included any limitations and further information about collection, analysis and interpretation of data. This included any limitations or assumptions provided in regard to modelling and economic evaluations.

Findings

A large number of studies and documents were identified for both review questions during the searching process, including a total of 150 grey literature documents and 15,206 results for the peer-reviewed studies. After screening of titles, abstracts and full text, a total of 86 peer-reviewed studies and grey literature documents have been included in this review.

See **Appendix C** for PRISMA flow diagrams for peer-reviewed and grey literature sources for both review questions. See **Appendix D** for the full list and details of all included studies. See **Supplementary material 2** for the data tables of all studies for both review questions.

Review question 1 – health burden and economic costs

Summary of studies

14 studies were included in the review (peer-reviewed n=5, grey n=9) (**Table 2**). A summary of the main characteristics and findings of each study is available in Appendix 5.

The peer-reviewed literature encompassed 5 systematic reviews. These reviews included the health burden of the 4 risk factors – 3 of these were based on systematic reviews that included burden of disease data, as well as one involving a meta-analysis using individual participant data (looking at BMI and all-cause mortality). Two of the 5 systematic reviews looked at the economic costs associated with preventable risk factors, including overweight and obesity.

A total of 9 grey literature documents were included. Five documents were reports from non-government organisations and research institutes, 4 documents were government reports from the Australian Institute of Health and Welfare and the WA Government.

Type of study or document	No. of included studies
Government report	5
Other report	4
Systematic review	4
Systematic review and meta-analysis	1
Total	14

Table 2: Summary of type of study, review question 1

Most studies or documents looked at the health burden or economic costs of overweight or obesity, or all (or a combination) of the risk factors (**Table 3**). Four studies or documents considered the health costs of one or more risk factors – this included Australian Burden of Disease estimates²¹ and two systematic reviews.^{22,23} No study or document analysed only the health burden or economic costs associated with unhealthy diet in Australia.

Risk factor	No. of studies	Proportion of included studies
Multiple risk factors	4	29%

Risk factor	No. of studies	Proportion of included studies
Overweight and obesity	7	50%
Physical inactivity	1	7%
Tobacco use	2	14%
Total	14	100%

Table 3: Summary of risk factors, review question 1

Health burden and economic costs of risk factors

Multiple risk factors

The health burden of all 4 risk factors (overweight and obesity, unhealthy diet, physical inactivity, and tobacco use) is a substantial proportion of the preventable burden of disease in Australia. These figures have been examined in the most recent Australian Burden of Disease Study²¹ (ABoDS) from 2015, and one systematic review.²³ The economic costs of these risk factors in Australia are also significant and have been covered by one systematic review.²² Further details about each of the studies is included below.

Health burden

The 2015 Australian Burden of Disease Study outlines the fatal and non-fatal burden of disease for the Australian population, using Disability-Adjusted Life Years (DALYs)*.²¹ One DALY represents the loss of 1 year of healthy life from premature death ('years of life lost' – YLL) or living with illness ('years lived with disability' – YLD). Strong evidence of a causal association is required for a risk factor to be included in these estimates. A large proportion of Australia's disease burden is likely preventable, for example through acting on these 4 risk factors. The attributable health burden in DALYs* by risk factor includes tobacco use 9.3%; overweight & obesity 8.4%; dietary risks 7.3%; physical inactivity 2.5%. It should also be noted that these 4 risk factors are directly and indirectly related to other major risk factors, such as high blood pressure and high blood plasma glucose. Deaths attributed to each risk factor were tobacco use 20,933; dietary risks 19,876; physical inactivity 7,079; overweight & obesity 14,165. The health burden of these 4 risk factors cannot be combined due to the joint causal responsibility they share with several diseases. Approximately a third of all health burden can be attributed to all modifiable risk factors including environmental, behavioural and metabolic factors.

Crosland et al.²³ systematically reviewed studies on the health burden in Australia attributable to lifestyle risk factors. Eleven studies were included. Included studies found that approximately one-third of DALYs were attributed to all modifiable risk factors (behavioural, metabolic and environmental). The estimated range of DALYs attributed to each risk factor was diet 7.2– 9.7%; tobacco 7.9– 9.0%; high BMI, 5.5– 8.3%; physical inactivity 1.2– 5.5%. Alcohol as a risk factor for disease also had a high burden of disease, 5.1– 12.2%. These estimates are similar to the ABoDS estimates.

Economic costs

In terms of the economic costs of multiple risk factors, Crosland et al.²² systematically reviewed studies on the economic costs of disease attributable to lifestyle risk factors in Australia. Twenty-five papers were included, deriving from 18 studies. The range of economic cost estimates for each preventable risk factor was diet (individual dietary risk factors) up to \$561m, tobacco use up to \$10.5bn, high BMI \$840m–\$14.9bn, and physical inactivity up

* Disability-adjusted life year (DALY) is a measure commonly used in public health research to represent both premature death (years of life lost) and losses in quality of life (years lived with disability). Therefore, it represents the total health burden experienced by a population because it encapsulates both mortality and morbidity in a single measure.

to \$15.6bn (all costs in 2016–17 Australian dollars). Much of the variability in results was due to differences in input data used and study methods. Studies that placed a value on statistical life years (VSLY) arrived at higher estimates than those that did not. There are, however, some significant limitations with this data. Firstly, there is a need for updated evidence on the joint economic impact of risk factors (the most recent was from 2010). Secondly, there are major gaps in the underlying evidence, for example on dietary risk factors, and on the links between risk factors and labour force outcomes such as participation, absenteeism and presenteeism.

Overweight and obesity

This review found that the health burden and costs of overweight and obesity have been well identified in the peer-reviewed and grey literature. There are strong epidemiological links between excess body weight and many costly diseases and conditions. The overall findings were that overweight and obesity caused 14,165 deaths and 8.4% of overall health burden (DALYs) in 2015 in Australia.²⁴ Estimates of the economic burden associated with high body mass were also significant, with obesity costing the Australian economy \$8.6 billion in 2011–12.²⁵ These findings are outlined in further detail below.

Health burden

The AIHW²⁴ estimated the attributable health burden in terms of deaths and DALYs due to overweight and obesity in Australia, based on the ABDS 2011. Obese children are at a higher risk of breathing difficulties, fractures, hypertension, insulin resistance, and early markers of cardiovascular disease. Overweight and obese children are also more likely to become obese adults, and to develop chronic conditions at younger ages, including cardiovascular disease and type 2 diabetes. Overweight and obesity among adults increases the likelihood of developing many chronic conditions, including some cancers, cardiovascular disease, asthma, back pain and problems, chronic kidney disease, dementia, diabetes gallbladder disease, gout and osteoarthritis. The life expectancy of those with class I obesity (30.00–34.99 kg/m²) was reduced by 2–4 years, and by 8–10 years for those with class III obesity (40.00–44.99 kg/m²).

Furthermore, the AIHW²⁴ estimated a number of health inequities in Australia in regard to the burden of overweight and obesity. Compared with non-Indigenous Australians, Aboriginal and Torres Strait Islander adults are more likely to be overweight or obese, and Aboriginal and Torres Strait Islander children and adolescents are more likely to be obese. Australians who live outside of major cities, or who are in the lower socioeconomic groups, are more likely to be overweight or obese than others.

In addition to the national Burden of Disease estimates for Australia, the Western Australian Government also released a report on the burden of overweight and obesity for the WA population.²⁶ In 2015, there were 1,174 deaths attributable to excess body mass, making up 8.1% of all deaths in WA. Adult males were more likely to die at a younger age (40 to 69 years) due to conditions linked with excess body mass than females, in 2015. The majority (63.9%) of deaths attributable to excess body mass in 2015 were due to ischaemic heart disease (29.9%); Alzheimer's disease and other dementias (13.1%); diabetes mellitus (11.2%); and chronic kidney disease due to diabetes mellitus, hypertension and other causes excluding glomerulonephritis (9.6%) as principal causes of death. The number of adult deaths attributable to excess body mass are projected to increase by 32% (376) in 2026 from 1,174 deaths in 2015, if current trends in overweight and obesity continue.

While not a burden of disease estimate, the NSW Ministry of Health²⁷ summarised that in 2017–18 in NSW, overweight or obese adults were 3 times more likely to report diabetes, 2.7 times more likely to report hypertension and 2 times more likely to report arthritis. There were 66,869 hospitalisations attributed to high body mass. In NSW in 2017, there were 3,758 deaths attributable to high body mass. In 2018, it was estimated that 11.1% of persons aged 16 years and over in NSW were diabetic or had high blood glucose (including both type 1 and type 2 diabetes). Between 2009 and 2018, the prevalence of diabetes increased significantly from 8.3% to 11.1%. In 2018, around 1 in 7 mothers (14.5%) who gave birth in NSW had diabetes. There was a large increase in the reported rate of gestational diabetes between 2015 and 2016.

In terms of peer-reviewed scientific literature, Di Angelantonio et al.²⁸ combined the results of 189 studies with a total of 3.9 million people (in a meta-analysis) to determine the association of BMI with death due to any reason. To limit confounding (factors not related to obesity or otherwise accounted for in the analysis) and reverse causality (people losing weight after becoming ill with a disease related to obesity), analysis was restricted to never-smokers without specific known chronic diseases at baseline and omitted the first 5 years of follow-up. For

BMI over 25.0, all-cause mortality increased approximately log-linearly with BMI. The hazard ratio per 5 BMI units over 25.0 was 1.31 (95%CI 1.29-1.33) across all studies; in Australia/NZ studies it was 1.31 (1.27-1.35). However, for males, HR per 5 BMI units over 25.0 was 1.51 (95%CI 1.46-1.56), compared to females' HR of 1.30 (1.26-1.33). In other words, this study found that people who are obese have a 30% greater chance of dying at any point in time compared with people who are of normal weight, and that this risk of dying increases the more obese people are.

Sanders et al.²⁹ conducted a systematic review of 47 studies on childhood overweight and obesity to determine its association with physical and psychological health comorbidities. The population group was Australian children aged 0 to 18 years. Studies with sample size greater than 1,000 showed prevalence of overweight and obesity was 19–27.6% for children 0-12 years and 13.7–26.2% for adolescents aged 12-17 years, 13-19.6% (cf. ABS estimate from 2011-12 Health Survey was 22.8-26.6% for age 2-17).

Sanders et al.²⁹ found evidence for negative effects of overweight and obesity in children on cardio-metabolic risk factors (15 studies), non-alcohol fatty liver disease (5 of 5 studies), and asthma (4 of 6 studies). Evidence for sleep apnoea was conflicting. Single studies associated overweight and obesity with a range of other conditions, though international evidence was stronger for several of these, e.g. dental health. Overweight and obesity in childhood was also associated with poorer psychological outcomes, including poorer health-related quality of life (HRQoL) (12 studies), poorer mental health (9 studies), and reduced self-esteem (4 studies). Childhood obesity also increased the risk of development of comorbidities into adulthood, such as increased blood pressure, development of metabolic syndrome and type 2 diabetes.

Economic costs

The economic burden attributable to obesity in Australia was also covered by the AIHW.²⁴ In 2014–15, more than 124,600 procedures related to weight-loss surgery were billed to Medicare in public and private hospitals and in non-hospital settings. The total costs for these Medicare-billed procedures were about \$62.8 million, with about \$25.7 million in benefits paid by Medicare, and about \$37.1 million paid in out-of-pocket costs by patients and/or health insurers. These costs are only related to healthcare system costs at the level of the Australian Government; this is only a small part of costs related to obesity. Other studies apply a broader scope for the type of costs included (see Crosland et al. above and the estimates discussed over the next several paragraphs, which include the costs of obesity for state governments).

More recently, PwC²⁵ estimated that obesity cost the Australian economy \$8.6 billion in 2011–12 (in 2014–15 dollars). PwC's estimation included 'direct' costs to the health system of \$3.8 billion (such as increased hospital care and pharmaceutical costs) as well as 'indirect' costs of \$4.8 billion (such as absenteeism, presenteeism, increased government subsidies and foregone tax). PwC however did not account for further costs from reduced wellbeing and foregone earnings, noting that such costs are more challenging to quantify; PwC's costs of obesity are therefore likely to be a conservative estimate. The report estimated that, if no further action is taken to slow the rise in obesity, there will be \$87.7 billion in additional costs due to obesity over a 10-year period (2015–16 to 2024–25).

PwC²⁵ utilised the ABoDS 2003 estimates to consider the economic costs of obesity in Australia. Additional direct costs to the health system from obesity in adults totalled \$3.8 billion in 2014-15 dollars. This included \$255 million in GP services, \$125 million in allied health, \$297 million in specialist services, \$1.2 billion in hospital care, \$1.4 billion in pharmaceuticals, \$368 million in weight-loss interventions, and \$154 million in public interventions. State governments bear \$390 million of the total \$3.8 billion in direct costs. Additional indirect costs from obesity in adults (18+) in 2014–15 dollars totalled \$4.79 billion including \$477 million in absenteeism, \$544 million in presenteeism, \$323 million in government subsidies, and \$3.44 billion in foregone tax. PwC estimated a potential \$11.8 billion in foregone earnings because of individuals not employed to their full potential due to obesity. They also estimated an additional cost of \$133 million to the federal government in disability payments.

The WA burden of disease analysis also provided the economic costs of overweight and obesity to the WA economy.²⁶ In 2016, 9.3% of hospitalisations for adults and children in WA were attributable to excess body mass and cost the WA health system \$338 million (\$AUD 2015–16), or 6.1% of all hospitalisation costs. The greatest number of hospitalisations attributable to excess body mass in 2016 were for chronic kidney disease due to diabetes mellitus, glomerulonephritis, hypertension, and other causes, totalling 70,203 hospitalisations, or 70.4% of all hospitalisations attributable to excess body mass. The linked diseases responsible for the greatest hospitalisation costs attributable to excess body mass were (in decreasing order): ischaemic heart disease, obesity,

osteoarthritis of the knee, chronic kidney disease (all causes combined), gall bladder and biliary disease, and diabetes mellitus, totalling \$242.7 million or 72% of hospitalisation costs attributable to excess body mass in 2016. These are predicted to remain the costliest conditions attributable to excess body mass in 2026, whether current trends in overweight and obesity remain stable, are halted, or are reduced.

The WA report also noted that, if current trends in child and adult overweight and obesity continue, the number of hospitalisations attributable to excess body mass in 2026 is predicted to increase by 54%.²⁶ Hospitalisation costs will rise by 80%, to \$610.1 million. It should be noted that the Beswick report provides an estimate of inpatient admission costs only; costs from emergency department presentations, pharmaceutical costs, and outpatient health care costs are not included. The costs estimated in this study represent a portion of the total health system costs and do not include personal costs to individuals or costs to the community and economy, such as labour and productivity losses, so it is estimated that the costs of overweight and obesity are likely much higher than those included.

The NSW Ministry of Health²⁷ reported that, in 2008, the financial cost of obesity in Australia was estimated to be \$8.3 billion; these figures were quoted directly from an Access Economics study. Of these costs, \$3.6 billion was estimated to be related to productivity costs, \$2.0 billion related to health system costs and carer costs were in the order of \$1.9 billion. The cost of individuals' lost wellbeing was valued at \$49.9 billion, bringing the total cost of obesity to \$58.2 billion across Australia. Of this, \$19.0 billion was apportioned to NSW. The report quotes OECD estimates that overweight and obesity accounts for 8.6% of health expenditure in Australia. Obese individuals have been found to have medical costs that are approximately 30% greater than those of a healthy weight. Overweight and obesity, and related chronic diseases, also have a negative impact on the labour market and the economy through lack of employment, absenteeism and presenteeism. It is estimated that overweight and obesity lowers labour market outputs by the equivalent of 371,000 full-time workers per year.

Teager et al.³⁰ noted in their report a 17% increase in obesity rate of children and young people aged 2–17 since 2011–12 in Australia. They estimated the annual cost of late intervention in children and young people is \$1.3 billion on mental health and \$1.1 billion on physical health. Excess expenditure on mental health was included in economic estimates, which also included drug and alcohol-related expenditure and costs.

Hoque et al.³¹ reviewed studies of economic costs of underweight, overweight and obesity in adult populations in Asia-Pacific countries, finding 17 articles. Economic burden of overweight ranged from 1.5% to 9.8% of total healthcare expenditure. Among studies comparing hospital costs for normal weight to overweight and obese individuals, excess costs for overweight were 7.1% to 9.8%, and for obesity 17% to 22.3%. In an Australian study, direct costs of overweight and obesity to the health system were AUD\$10.7 billion per year in 2004–05, including hospital and ambulatory costs, pharmaceuticals and other costs. This systematic review concluded the direct cost of obesity was \$395 million and 2% of GDP (1989); the cost of obesity was 17% greater than health expenditure on normal weight individuals (2001); and the direct cost of overweight was \$6.5 billion and obesity \$14.5 billion – an excess cost of \$10.7 billion compared with the normal weight population. Indirect costs of overweight and obesity were \$21 billion (2005 study).

Tobacco use and smoking

The largest health burden associated with a modifiable risk factor in Australia is tobacco use. Tobacco use in Australia was associated with 20,933 deaths and 9.3% of the overall health burden (in terms of DALYs) in 2015.³² Even with reduced rates of smoking in the Australian population, tobacco use is estimated to cause up to AUD\$10.5 billion of economic costs per year.²²

Health burden

The AIHW³² estimated that tobacco use contributes to health burden more than any other risk factor and was responsible for 9.3% of the total burden of disease (DALYs) in Australia in 2015. Tobacco use contributed to 13% of deaths in Australia in 2015, equivalent to 20,933 deaths. Tobacco use was responsible for 14% of all fatal burden[†]

[†] Fatal burden is the burden from dying prematurely compared to optimal life expectancy. The measure usually used to represent fatal burden is years of life lost (YLLs).

and 5% of all non-fatal burden[‡]. 43% of the burden attributable to tobacco use was due to cancer and 28% was from lung cancer. Chronic obstructive pulmonary disease (COPD) accounted for 30% of the burden attributable to tobacco use, with the burden higher in females (38%) than males (25%). Cardiovascular diseases were responsible for 17% of the burden due to tobacco use primarily related to coronary heart disease (10%) and stroke (3%).

According to the AIHW³² analysis, the burden from tobacco use also varied according to where a person lived, their socioeconomic group and mental health status. Age-standardised rates were higher in: the Northern Territory (2.1 times as high) than in all of Australia; the lowest socioeconomic areas (2.6 times as high) than in the highest socioeconomic areas; remote and very remote areas combined (1.8 times as high) than in major cities; people with a mental health condition (1.5 times as high) than in people without a mental health condition.

Economic costs

Whetton et al.³³ summarised that, in the 2015–16 financial year, there were 20,032 deaths from smoking-related causes and 1.7 million smoking-related hospital inpatient episodes in Australia.

The net tangible costs of smoking in 2015–16 were estimated to be \$19.2 billion (range \$16.3 billion to \$24.0 billion). The tangible costs (those that incur a financial impact) in the calculation included the reduction in economic output due to premature mortality, hospital separation costs, other medical and social care costs including the cost of informal care provided by family and friends, costs arising from workplace absenteeism and presenteeism, and spending on tobacco by dependent smokers. This broad range of costs were incurred by various actors throughout society such as Commonwealth and State/Territory governments who pay for health care costs, companies and employers who encounter reduced productivity due to people being away from work due to illness, and individuals who smoke due to the cost of the product itself and out-of-pocket costs that might be incurred in the process of seeing medical treatment.

In addition to the tangible costs of smoking, Whetton et al.³³ estimated very significant intangible costs (e.g. the value of life lost, pain and suffering), both from premature mortality and from the lost quality of life of those experiencing smoking attributable ill health. These intangible costs of smoking were estimated at \$117.7 billion in 2015–16 (range \$52.0 billion to \$375.8 billion) with the total cost of smoking being \$136.9 billion (range \$68.3 billion to \$399.7 billion). The most significant individual cost item within the tangible costs was the spending on tobacco by dependent smokers, which was estimated at \$5.5 billion, followed by workplace costs (\$5.0 billion) and the reduction in the present value of future economic output due to premature mortality (\$3.4 billion).

Physical inactivity

Physical inactivity, while not as significant a burden as overweight and obesity or tobacco use, was still associated with 7,079 deaths and 2.5% of DALYs in 2015.²¹ Physical inactivity causes up to \$15.6 billion of economic burden per year.²² Some estimates indicate it costs \$48 billion per year in indirect and direct costs.³⁴

Only 1 report looked at the health and economic costs of physical inactivity only in Australia. Barnsley et al.³⁴ analysed the ABoDS 2011 and reported that insufficient physical activity is responsible for 5% of all death and disability in Australia. Physical inactivity costs the health system \$3.7 billion and leads to death and disability costing \$48 billion per year. **Note that other estimates of the health and economic burden of physical inactivity are included in the studies of multiple risk factors specified above.**

Unhealthy diet

Unhealthy dietary risks combined contributed to 19,876 deaths and 7.3% of overall health burden (in terms of DALYs) in 2015.²¹ Other estimates were as high as 9.7% of overall health burden.²³

There were few studies that estimated the economic burden of an unhealthy diet. No report or study was identified that provided estimates of the health burden or economic costs of unhealthy diet only in Australia. **Note that other estimates of the health and economic burden of diet are included in the studies of multiple risk factors specified above.**²¹⁻²³

[‡] Non-fatal burden is the burden from living with ill-health as measured by years lived with disability (YLDs).

Review question 2 – benefits of primary prevention

Summary of studies

72 studies and reports were included in the analysis for this review question (peer-reviewed, n=42, grey n=30) (Table 4). A summary of the main characteristics and findings of each study is available in Appendix 6. Of the grey literature, 22 were reports or documents from Australia, 2 were international, 3 from New Zealand, 2 from the United Kingdom and 1 from the USA. The studies included were also a variety of publication types, including 29 umbrella reviews, 9 cost-effectiveness reviews, 13 reports and 7 previous Evidence Check reviews.

Publication type	No. of included studies
Book chapter	1
Evaluation	4
Report	13
Review	5
Review – Evidence Check	7
Systematic or umbrella review (Cost-effectiveness)	9
Systematic review (Indigenous populations)	4
Umbrella review	29
Total	72

Table 4: Summary of type of study, review question 2

The primary risk factor(s) targeted by the intervention or strategy were comprehensive across the 4 areas (Table 5). 19% of the included literature looked at one or more risk factors.

Primary risk factor targeted	No. of included studies	Proportion of included studies
Multiple risk factors	14	19%
Overweight and obesity	19	26%
Physical inactivity	15	21%
Tobacco use	11	15%
Unhealthy diet	13	18%
Total	72	100%

Table 5: Summary of risk factors, review question 2

Benefits for specific population groups

This review identified benefits of different strategies for specific population groups: children and young people; older adults; and First Nations or Indigenous peoples. The benefits for these groups are discussed under each strategy section, though a brief summary has been provided below.

Children, adolescent and young adult populations

A large number of reviews and studies summarised the benefits of interventions that targeted children and young people, including in school or early childcare settings. 18 studies looked at multiple strategies or settings-based health promotion strategies for children, adolescents and/or young adults.³⁵⁻⁵²

Over half (10/18) of these studies were focused solely on strategies to address overweight and obesity in children and young people. These studies suggested that settings-based health promotion interventions in schools were effective at producing health benefits such as a reduction in sedentary behaviour, increase in physical activity, reduction in screen time and improvement in dietary outcomes. However, there was limited or no impact in terms of reduction in weight or BMI.

A smaller number looked at tobacco and substance use (3 studies),^{43,44,50} unhealthy diet (2 studies),^{51,52} multiple risk factors (2 studies),^{35,45} and physical inactivity (1 study).⁴² These studies generally found evidence of health benefits from multi-level or multi-component interventions (i.e. interventions delivered in combination, targeting different levels of the 'system'), as well as interventions targeting both school or childcare settings and family or household settings. There is strong evidence for interventions across multiple settings that target multiple health risk factors in children, adolescents and young adults; school-based strategies can also positively impact on mental wellbeing.³⁵

Some additional benefits were also identified, such as that multi-component interventions in schools can reduce both bullying and smoking rates in adolescents.⁵⁰ The one study looking at the cost-effectiveness of physical activity interventions in children identified that the cost-effectiveness of different programs ranged from high (physical activity media campaign) to low (Walking School Bus).⁴²

Older adult populations

Two reviews considered the benefits of interventions targeting older adults. These were reviews of reviews looking at the benefits of physical activity interventions or general health promotion for older adults in the community.^{53,54} These reviews found there are physical health and mental health benefits to engaging older adults in community-based physical activity interventions, especially walking interventions.

First Nations or Indigenous populations

4 systematic reviews and 1 umbrella review focused on primary prevention strategies targeted at Aboriginal and Torres Strait Islander populations in Australia^{55,56} and/or other Indigenous and First Nations groups such as Māori and Pacific Islander populations⁴¹, pregnant Indigenous women in high-income countries⁵⁷ and Indigenous populations in Canada.⁵⁸

In Australia, multiple strategies involving a range of nutrition interventions produced some health benefits for Aboriginal and Torres Strait Islander Australians, such as increased fruit and vegetable consumption, reduced cholesterol and some short-term changes in BMI.^{55,56} Another study also indicated some evidence of benefit from tobacco control measures, particularly multi-component interventions (as opposed to single interventions).⁵⁹

Other studies that looked at interventions targeting Indigenous or First Nations populations from other countries found physical health benefits from multiple strategies addressing childhood obesity,⁴¹ and physical health benefits such as increased physical activity, reduced BMI and reduced blood pressure from physical activity interventions.⁵⁸ However another study noted that for nutrition interventions there is limited evidence of positive effect on dietary outcomes or childhood obesity.⁵⁷

The term 'Indigenous' or 'First Nations' are used in text to signify studies conducted in Australia, New Zealand, Canada and other nations with Indigenous populations. Where referencing studies of populations only in Australia, 'Aboriginal and Torres Strait Islander' is used.

Primary prevention interventions and strategies

The types of strategies covered by the literature were diverse. In terms of types of primary prevention strategy or intervention identified in the literature, 49% encompassed multiple strategies (**Table 6**). Multiple strategies were those that reviewed several different types of primary prevention interventions or strategies. Where the review covered interventions at the secondary or tertiary level of prevention, the data extraction and synthesis focused on the primary prevention intervention findings.

Primary prevention strategy or intervention	No. of studies	Proportion of included studies
Multiple strategies	35	49%
Regulation and policies	2	3%
Fiscal	7	10%
Built environment and transport	9	12%
Settings-based health promotion	11	15%
Social marketing and mass media campaigns	2	3%
Healthy lifestyle	6	8%
Total	72	100%

Table 6: Summary of type of intervention, review question 2

Multiple strategies

Of the included literature in this report, 35 (49%) were classified as reviewing or providing evidence of effectiveness of multiple strategies to address one or more of the 4 risk factors of interest. This meant that the study looked at several types of strategies, including some or all of the strategies identified separately in this section, for example, looking at the health benefits of policies, mass media campaigns and community education to reduce dietary salt consumption. We have briefly summarised this literature here by risk factor, though more detail about strategies can also be found in the later sections.

Overall, this literature suggests that the strongest body of evidence of health benefits is for interventions across multiple settings, with multiple components, targeting one or more risk factors. Combined strategies and interventions are particularly effective for obesity prevention interventions targeting children. A small number of included studies identified other benefits to these strategies, such as mental wellbeing and social benefits.³⁵⁻³⁷

This literature also suggests that most preventive health strategies are cost-effective and have numerous economic benefits beyond health benefits. This is particularly the case for multiple strategies in tobacco control, for which the strongest evidence of cost-effectiveness is apparent, but also applies to interventions targeting physical activity, diet and obesity, with the cost savings from many of these interventions far outweighing the cost of implementation. The types of interventions that are particularly cost-effective tend to be population-wide, regulatory strategies, such as mandatory salt reduction and reformulation,

restrictions on advertising unhealthy food to children, tobacco control restrictions, and fiscal interventions such as taxation of unhealthy or harmful products like tobacco, alcohol and sugary drinks.

Multiple risk factors

Of the studies with multiple strategies 5/35 looked at the benefits of different interventions for multiple risk factors. Three of these were rapid reviews or Evidence Checks.^{35,60,61} The other 2 studies were an umbrella review on health inequalities⁶² and a systematic review of economic evaluations of public health interventions for physical activity and diet.⁶³

Pikora et al.³⁵ reviewed 119 studies looking at chronic disease prevention interventions in children and young adults. They found strong evidence for interventions conducted in multiple settings (e.g. schools, family and community) that target multiple health risk factors (e.g. nutrition education, physical activity promotion and discourage sedentary behaviours). Multi-component interventions in diet delivered across multiple settings, as well as classroom and school-based interventions to address physical activity in children, were also effective, as were school-based interventions and tobacco control interventions. They also noted other benefits to school-based and multi-component strategies, such as reductions in bullying and helping young people develop social skills and influence.

Rowbotham et al.⁶⁰ reviewed 48 studies on whole-of-population strategies for preventing chronic disease, finding the strongest evidence of health benefits included: multi-component interventions targeting dietary intake in the workplace; group-based exercise programs and self-monitoring of physical activity in the workplace and broader community; counselling and support programs for smoking cessation in the workplace and community; and support for employees to change behaviour to manage weight. There was some moderate evidence of benefit for regulation and policy approaches; taxation on SSBs and unhealthy foods; stair use prompts; smoking bans; financial incentives; social media and social marketing campaigns.

Harris et al.⁶¹ reviewed 99 studies on the effectiveness of healthy lifestyle interventions in alcohol, physical activity, diet and overweight and obesity. They found strong evidence that digital health interventions can improve physical inactivity, diet and reduce weight, while health coaching and behavioural interventions have moderate evidence of improving physical activity, diet and weight. Workplace interventions also have strong evidence of effectiveness for improving physical activity and reducing sedentary behaviour. There is moderate evidence for behavioural or community education programs improving diet and reducing weight. In addition, there is some emerging evidence that: built environment and active transport interventions can improve physical activity; and behavioural economics or nudge interventions (such as changing serving sizes) can improve diet. There was insufficient evidence of food labelling on improving dietary behaviours. The quality of evidence was moderate to high for most interventions and risk factors except alcohol.

Thomson et al.⁶² looked at 29 systematic reviews of public health policies on health inequalities in high-income countries. Their focus was on fiscal interventions such as taxation and subsidies; regulation and policy interventions; built environment and transport; and education and community programs. They found that most preventive interventions had positive impacts for health equity. However, most reviews were of low to moderate quality.

Gebreslassie et al.⁶³ reviewed economic evaluations of strategies such as mass media campaigns, active transport, pedometers, exercise referral, brief advice, fiscal incentives, retail policy, food labelling and formulation, lifestyle interventions. Their focus was on cost-effectiveness of the different strategies. They found that most public health interventions (universal or targeted) were cost-effective. The authors found that environmental interventions and mass media campaigns to promote physical activity demonstrated good value for money. They also found that 40 out of 48 universal dietary interventions were cost-effective; specifically, that taxing unhealthy food was cost-effective whereas subsidising fruit and vegetables was not. Interventions directed at food manufacturers was particularly cost-effective. Restriction of unhealthy food advertising to children was cost-effective. The majority of studies took a healthcare perspective and did not look at broader societal costs such as productivity and indirect costs.

Tobacco use

Of the included literature, 6/35 studies focused on multiple strategies targeting tobacco use and smoking. Of these, 3 were umbrella reviews of strategies, including 1 on government tobacco control policies⁶⁴ and 2 focused on young people and tobacco use.^{43,44} There was 1 systematic review of tobacco control in Indigenous populations⁵⁹ and the other 2 studies were grey literature documents reviewing the economic benefits to tobacco control strategies.^{65,66}

Hoffman et al.⁶⁴ summarised the health benefits of different approaches to tobacco control and included 59 reviews in their umbrella review, of which 38 were rated as moderate or strong level of evidence quality. These strategies included smoke-free policies, financial incentives, health warning labels, mass media campaigns and tobacco taxes. Media campaigns could reduce smoking behaviour in combination with other more regulatory interventions.

For young people and tobacco use, Mannocci et al.⁴³ reviewed 13 systematic reviews and meta-analyses on public health strategies to reduce the demand of tobacco amongst young people. Interventions shown to be effective at preventing young people from starting smoking were: school education; family-based interventions; price and tax measures. Approaches combining several interventions were more likely to be effective.

Stockings et al.⁴⁴ reviewed a significant body of literature about prevention, early intervention, harm reduction and substance use in young people. They included 414 systematic reviews, 67 of which were focused on tobacco. There were health benefits for young people from taxation, bans on advertising and public consumption bans of smoking or tobacco use. Education with skills training and cognitive behavioural therapy (CBT) could also provide some benefit to young people. However, it was unclear how the quality of the reviews was assessed.

Chamberlain et al.⁵⁹ reviewed 21 systematic reviews looking at tobacco control interventions for Indigenous peoples in different countries, including tobacco price increases, mass media campaigns and smoke-free environments. The main health benefits identified were a reduction in smoking rates as well as an increase in tobacco cessation (quit) rates. They found benefits to effective tobacco control interventions that are multi-component or multi-faceted, with Indigenous leadership or collaboration and cultural awareness (e.g. tailored campaigns/programs, though other reviews suggest non-tailored messages can be as effective). Multi-faceted smoking cessation strategies were more effective than single interventions but had lower evidence of effectiveness compared to non-Indigenous populations. There were also some benefits in terms of self-efficacy and self-esteem for Indigenous school students from tobacco control interventions. However, overall there was limited evidence available about the effectiveness of tobacco control strategies in Indigenous populations, and most of the reviews were at moderate to high risk of bias.

A book chapter by Greenhalgh et al.⁶⁵ proposed that, in almost every case, tobacco control programs and policies are either cost saving or highly cost-effective. Price-based policy measures (such as increased tobacco taxes) are the most effective strategy for reducing tobacco use and its associated costs. Non-price-based measures (such as smoking restrictions in workplaces, public places, bans on tobacco advertising, and raising the legal age of smokers) have also proven to be both effective and cost saving through benefits such as a reduction in smoking prevalence, reduction in second-hand smoke, savings from smoking-related medical expenditures, heart diseases averted, costs averted by a reduction in smoking-induced fires, and gains in productivity. The cost-effectiveness ratio of implementing non-price-based smoking cessation legislation ranges from US\$2 to US\$112 per life year gained, while reducing smoking prevalence by up to 30%–82% in the long term (over a 50-year period). This chapter included a study that found that tobacco control interventions implemented up to the year 2000 saved the Australian economy \$8.06 billion (in 2000 dollars) and the government saved \$2 for every \$1 it spent on public health programs to reduce smoking. Another included study concluded that achieving a target of 10% prevalence by 2025 in Victoria would result in a decline in tangible costs of 14.5%, \$535 million and intangible costs associated with loss of life of \$863.4 million or 15%. Reducing smoking prevalence to 5% in Victoria would lead to a reduction in associated tangible costs of 55.6%, or \$2 billion.

Overweight and obesity

There were 12/35 studies on multiple strategies targeting overweight and obesity. This included 3 umbrella reviews,^{39,40,67} 2 cost-effectiveness systematic reviews,^{38,68} and 6 grey literature reports, reviews or evaluations.^{25,36,37,69-71} A systematic review on Indigenous populations was also identified.⁴¹

An umbrella review of 66 meta-analyses on prevention and treatment of childhood and adolescent obesity found that combined interventions addressing both diet and physical activity appeared most effective, particularly school-based interventions, which could reduce BMI and absolute body weight as well as improving diet and increasing physical activity.³⁹ Combined lifestyle interventions produced significant health benefits irrespective of age group. Nutrition education could reduce BMI in overweight and obese children. Aerobic and resistance training activities could reduce body fat percentage in children to a greater extent compared to other physical activity interventions, however may not impact on BMI or body weight.

Reilly et al.⁴⁰ performed a rapid review of 23 systematic reviews on physical activity interventions in early life, finding that health benefits were modest and short-term. Multi-component interventions (targeting physical activity, sedentary behaviour and/or diet) were most effective at reducing weight or body fat in children. Effective interventions for obesity prevention targeted multiple levels: not only individuals but also the physical, social and policy environments, such as parent involvement and interventions targeting the parents themselves.

Roberts et al.⁶⁷ reviewed 53 systematic reviews on population-wide diabetes and obesity prevention programs and performed a meta-analysis of impact on BMI. A number of health benefits were identified, including improved dietary outcomes and reduced BMI from fiscal interventions and subsidies and food labelling; and increased physical activity levels from built environment interventions, such as park and playground renovations, and stair use signage. They also found that multi-component interventions were associated with a reduction in BMI, though there was insufficient evidence of impact of any interventions on the prevalence of overweight, obesity, or type 2 diabetes.

Littlewood et al.⁴¹ found modest results of childhood obesity prevention interventions with Māori and Pacific Islander populations, with minimal benefits. Interventions and results were heterogeneous, and no study reported a significant outcome in weight-related measurements. However, some improvements were seen in cardio-metabolic outcomes.

In the grey literature, Bell et al.³⁶ conducted an evaluation of South Australia's Obesity Prevention and Lifestyle Program (OPAL), a multi-setting, multi-sectoral community-based systems-wide program designed to increase the percentage of young people aged 0-18 years in South Australia who are of a healthy weight. They found some health benefits in terms of healthy weight levels, fruit intake, physical activity and reduction in screen time, as well as improved quality of life amongst participants.

Ananthapavan et al.⁶⁹ summarised the effectiveness and cost-effectiveness of 16 obesity prevention policies in Australia, including fiscal interventions; regulation and policies; labelling; settings-based health promotion; and mass media campaigns. The gain in health adjusted life years (HALYs) ranged from 237 to 471,165 years, depending on the strategy, with the most gains from a uniform volumetric tax on alcohol. They also identified the equity implications of each strategy type. Eleven of the 16 interventions resulted in dominant ICERs, meaning they are likely to result in health benefits as well as being cost saving. Those interventions with the greatest health gains were also expected to result in the greatest health care cost savings. For example, a uniform volumetric tax on alcohol was estimated to result in \$4.8 billion in health care cost savings, a sugar-sweetened beverages (SSBs) tax was estimated to result in \$1.7 billion in healthcare cost savings and restricting television advertising of unhealthy foods was expected to result in \$784 million in healthcare cost savings. The cost of implementing these interventions was far outweighed by the cost savings. The authors found a quarter (4/16) had a high or medium strength of evidence of effectiveness at reducing BMI, including 2 school-based interventions to reduce sedentary behaviour and increase physical activity. 10/16 interventions had a medium strength of evidence re: improving physical activity and/or diet. Regulatory interventions (e.g. taxes and advertising restrictions) tended to be dominant interventions, that is, producing both health and economic benefits.

Sacks et al.³⁷ looked at 89 systematic reviews and 16 additional studies on population-level strategies to support healthy weight. They found that food systems interventions (including regulation and policies, food environment interventions and pricing changes) generate improved dietary outcomes. Increasing the price of alcohol has a significant effect in terms of obesity prevention. Multi-component interventions in schools and workplaces can increase physical activity levels. School garden programs and cooking education can also improve diet in children but have no effect on BMI or weight. Financial incentives can improve physical activity levels. This review also found that workplace interventions targeting diet and physical activity can improve mental wellbeing, reduce stress and improve cognitive performance. Similarly, school gardens can improve mental wellbeing, as can classroom-based sedentary behaviour and physical activity interventions. This review also identified some interventions as having evidence of cost-effectiveness, including marketing restrictions for unhealthy foods; nutrition labelling; tax on sugar-sweetened beverages; changes to physical activity environments; some mass media campaigns; financial incentives for improving weight, diet or physical activity; and increasing the price of alcohol. A carbon tax on food may also generate health and environmental benefits, such as improved diet and reduce carbon and greenhouse gas emissions.

A Global Obesity Centre (GLOBE) et al.⁷⁰ report identified a number of different strategies to reduce obesity and increase health benefits in the Australian population, such as mandatory food labelling, an active transport strategy, public education campaigns, a 20% tax on sugar-sweetened beverages, and reformulation of discretionary foods.

PwC²⁵ recommended investment in a set of obesity prevention and treatment interventions, which could result in significant reductions in obesity prevalence and provide a net benefit of AUD\$10.3 billion over 10 years.

The Queensland Government⁷¹ summarised Cochrane reviews about childhood obesity prevention, finding that for those 0-6 years and 6-11 years, multi-component interventions are more successful in reducing BMI and body weight compared to single interventions. For 6-11 years and 12-17 years, behaviour change interventions can reduce BMI and body weight. Obesity prevention interventions and strategies can also improve children's overall quality of life.

McKinnon et al.⁶⁸ conducted a systematic review of economic analyses on obesity-related policy and environmental interventions and proposed there was a lack of CBA or CEAs of obesity-related policy and environmental interventions, though 25/27 of the included studies found that the interventions were economically beneficial. This review also identified economic benefits to built environment and transport interventions, such as reduced healthcare costs associated with cycling network and infrastructure, and light rail transit. One of the studies included in this review found that restrictions on food and beverage television advertising to children would yield \$300 million in healthcare cost savings. This review also reported a variety of population health benefits across countries and interventions.

Zanganeh et al.³⁸ conducted a systematic review of economic evaluations of childhood and adolescent obesity interventions. A total of 39 studies were included and the vast majority reported results that were cost-effective, with some illustrating cost savings results. A number of these evaluations related to the Australian context. Interventions found likely to be cost-effective were 7 physical activity promotion strategies, removing TV advertising of energy-dense nutrition-poor food and beverages (which was cost saving), and a 'be active eat well' program of both diet and physical activity. Interventions not found to be cost-effective included several programs aiming to increase physical activity including the 'walking school bus' program. However, these results may have been due to issues such as high cost of delivery. Only a small number of the included studies were categorised as poor evidence quality.

Unhealthy diet

Of the included studies, 8/35 studies considered the benefits of multiple strategies to address unhealthy diet. 3 of these were umbrella reviews,⁷²⁻⁷⁴ 2 were systematic reviews in Indigenous populations,^{56,57} 2 were cost-effectiveness systematic reviews,^{75,76} and 1 was a grey literature report on salt reduction strategies in Australia.⁷⁷

Gwynn et al.⁵⁶ identified that multi-sectoral, multi-setting strategies offer greatest promise of impact or benefit for Aboriginal and Torres Strait Islander populations in Australia, but there is a need for better implementation and evaluation of interventions.

Ashman et al.⁵⁷ found that some dietary and nutrition strategies have evidence of improving nutrition-related outcomes for pregnant Indigenous women and their children, including breastfeeding rates, birth weight and reduction in alcohol use. There was limited evidence of programs regarding dietary outcomes, childhood obesity or other outcomes. Features of more successful programs included individual advice/support, strong community collaboration (Indigenous-led), utilising Indigenous workers, home visits, and community-based and multi-component interventions.

In the grey literature, Health Technology Analysts Pty Ltd⁷⁷ in their analysis on salt reduction for The George Institute for Global Health, modelled the health and economic benefits for multiple strategies of mandatory salt reduction legislation, voluntary salt reduction, and community health programs in Australia. By reducing salt intake by 1 g/day across Australia, life years saved was estimated to be 1,364 per year, with an estimated 2,626 strokes and 2,526 CHD events avoided. They also conducted an SROI (Social Return on Investment) to estimate the economic benefits of salt reduction programs across Australia, including productivity costs and benefits (participation, presenteeism and absenteeism). SROI was found to be 2.4:1 (community program), 5.7:1 (voluntary reformulation strategies) and 10.1:1 (mandatory salt reduction). The authors estimated between \$120m-\$154m in reduced costs to society due to saved lives and strokes and avoided coronary heart disease events. The cost of

different programs per person per year was \$0.49 for mandatory reduction; \$0.81 for voluntary reduction and \$1.60-\$2.37 for a community program.

Hope et al.⁷⁵ found evidence from 14 CUA studies that salt reduction interventions, particularly multiple strategies at different levels of the food system, are cost-effective and offer good value for money for population health benefit. The authors in one study estimated that a total of 610,000 DALYs would be averted over the cohort's lifetime if everyone reduced their salt intake to recommended limits. Mandating more moderate use of salt in breads, margarines and cereals produced the greatest gains in population health. The authors of the review concluded that most interventions were low cost but produce long-term improvements in population health. They found that all studies were of good, very good or excellent quality.

Schorling et al.⁷⁶ also conducted a systematic review of salt reduction interventions to prevent hypertension and cardiovascular disease and included evidence from New Zealand, England, United Kingdom, Australia, Canada and European countries. The review authors concluded that 59 out of 62 scenarios were cost saving and the Incremental Cost Effectiveness Ratios (ICERs) were particularly low for taxes, salt reduction by manufacturers and product labelling. They also found that targeted (individual-level) dietary advice was not cost-effective compared with population-wide approaches.

Physical inactivity

Of the included studies, 4/35 studies focused on multiple strategies to address physical inactivity. 2 were cost-effectiveness studies.^{42,78} The other 2 studies included a grey literature report⁷⁹ and an umbrella review.⁸⁰

Abu-Omar et al.⁷⁸ conducted an umbrella review of systematic reviews of cost-effectiveness analyses for physical activity interventions and found that most school-based physical activity interventions are cost-effective. Other cost-effective approaches include: the promotion of active transport (for children and adolescents), pedometer interventions and brief interventions in the healthcare setting (in adults), fall prevention (in older people), and environmental approaches and mass media campaigns (in the general population). The authors found that 14 out of the 18 included systematic reviews had high methodological quality based on a standard quality assessment tool.

Korber⁴² reviewed economic evaluations of health promotion programs for children and adolescents, which included a range of physical activity strategies. The main health benefits identified in included studies were increase in physical activity; reduction in BMI and/or waist circumference; reduction in cases of overweight and obesity; reduction in body fat; increase in energy expenditure; and increase in QALYs or DALYs. There was a wide range in cost-effectiveness results due to the varied nature of included interventions. Most studies were of good quality.

The Heart Foundation⁷⁹ identified a range of health, mental wellbeing, social and economic benefits to multiple types of strategies that promote physical activity. For example, they found associations between improvement of physical activity levels, reduction of cardiovascular diseases and type 2 diabetes from walkable neighbourhoods, green space, and active transport. Financial incentives and mass media campaigns can also assist in increasing physical activity levels. Workplace interventions, such as displaying stair signage, can be effective at reducing sedentary behaviour levels. There were also mental wellbeing benefits identified from sport and recreation interventions and participation, with children and young people particularly benefiting from reduced psychological distress due to regular participation in physical activity. The Heart Foundation's review also indicated that walkable neighbourhoods had environmental benefits, such as reduced air pollution, and active transport increases social connection and safety in the community.

Craike et al.⁸⁰ looked at physical activity interventions for low SES groups and found some positive benefits. Effects were larger in the 7 interventions targeting physical activity only compared to the 5 interventions targeting multiple behaviours including physical activity. Other high-quality reviews found no change in physical activity outcomes except for positive sport participation rates for school children. Two studies were cost-effectiveness reviews of physical activity interventions.

Regulation and policies

Two studies looked at the benefits of regulation and policies to improve health and prevent disease. One study was an evaluation of Australia's tobacco plain packaging regulation.⁸¹ The other study was an

umbrella review of physical inactivity policies.⁸² Overall, this literature indicated there are significant health and economic benefits to population-level regulatory and policy-based strategies in the area of tobacco control. There is also evidence of benefit for policies that promote greater physical activity, particularly if they are multi-level policies targeting different aspects of the system, such as implementation of active transport infrastructure combined with mass media campaigns. For the purposes of this review, regulations and policies that were fiscal in nature (such as taxation or subsidies) as well as built environment interventions requiring policy-level change, are covered in later sections.

Tobacco use

The 2016 evaluation⁸¹ of tobacco plain packaging found there were clear health benefits to the legislation. For example, the reduction in the number of smokers would save 30,318 life years if evenly distributed over the 10-year time frame from implementation, and even a 0.5% reduction in those who are estimated to take up smoking in the next year would translate to an additional 160 life years saved. There was also a decreased burden of disease projected for males and females because of current and past reduced risk factor exposure including current and past exposure to tobacco use and to second-hand smoke. Risk factor exposure decreased 11% (47,508 DALYs) over 12 years. The plain packaging evaluation also noted other benefits such as cleaner streets due to reduced smoking rates, and additional economic benefits such as a cost avoided per working smoker of \$337.48 per year and increased productivity per working quitter at an estimated \$84.37 per year. A 0.07 percentage point drop in smoking prevalence would be equivalent to \$273 million in monetised health benefits (30,318 life years saved) over 10 years.

Reviews with multiple strategies often included policy and regulatory change as a type of preventive strategy with benefits. For example, Hoffman et al.⁶⁴ found the health benefits from smoke-free policies reduced risk of admission for coronary events, other heart diseases, cerebrovascular accidents and respiratory diseases. The reductions were greatest with comprehensive policies that banned smoking in workplaces, restaurants, and bars. Workplace smoke-free policies also led to a reduction in smoking prevalence, reduced cigarette consumption by 2.2 cigarettes per day, increased quit attempts by 4.1% and increased successful cessation by 6.4%. Health warning labels decreased smoking behaviour, reduced tobacco use and increased motivation to quit, quitting likelihood and likelihood of abstinence after quitting.

Physical inactivity

Gelius et al.⁸² conducted an umbrella review of effective policies to promote physical activity and found a range of health benefits in areas such as built environment and transport policy. Policies that provide cycling and walking infrastructure (such as dedicated cycle routes and separation from traffic) can be effective at promoting physical activity. Multi-level policy interventions were effective if they promoted infrastructure improvements and were supported by mass media campaigns, increased density, mixed land use, greater connectivity, and more lighting. Road and parking price policies can have positive effects on walking and cycling levels. Policies that enable supportive infrastructure for dog walking also increases physical activity.

This umbrella review⁸² also found strong evidence for policies focusing on mass media campaigns directed at children and that social marketing messages about walking can increase physical activity. Centralised government programs can promote child physical activity, such as through school settings, which has moderate effects on physical activity. Daily mandatory PE lessons can increase students' moderate to vigorous physical activity by >20 min per day. Extracurricular physical activity before or after school increases physical activity >25 minutes per day. Outside school setting, an increase in moderate to vigorous physical activity in childcare settings was found due to open play areas and staff education and training. Promoting active transport as part of multi-component interventions can also be effective for children physical activity levels. Gelius (2020) noted very few reviews had a 'strong' level of evidence, with challenge of confounding bias for many systems or environment-level interventions for physical activity promotion.

Fiscal

Seven studies considered the benefits of fiscal preventive interventions such as taxation or excise on harmful products like tobacco, alcohol and sugar-sweetened beverages, or subsidies/incentives for healthier behaviours (including disincentives for less healthy behaviours).

The established evidence base is very strong for tobacco taxation, particularly in high-income countries. Tobacco taxation is extremely effective and cost-effective as an intervention, with significant health and economic benefits to fiscal interventions targeting tobacco.

There is also evidence that alcohol taxation is cost-effective and can help address obesity. However, there is less evidence of benefits for taxation of other products such as sugar-sweetened beverages, or of fiscal interventions and subsidies targeting physical activity.

Multiple risk factors

The Task Force on Fiscal Policy for Health⁸³ found that more than 10 million premature deaths each year could be prevented by reducing consumption of 3 products: tobacco, alcohol and sugary beverages. Taxing these 3 products is justified by strong economic arguments regarding market failures, negative externalities, and fiscal efficiency. If all countries increased taxes to raise prices by 20–50% of current levels over 50 years, for tobacco this would result in 10.8–27.2 million deaths averted and 212–535.7 million years of life gained; for alcohol 9.4–21.9 million deaths averted and 238.7–557.8 million years of life gained, and, for sugary drinks, 0.8–2.2 million deaths averted and 23.7–57.8 million years of life gained. The economic benefits of taxation were in addition to the health benefits. The same increases in taxes would result in savings of \$1.6–\$3 trillion for tobacco, \$8.9–\$16.7 trillion for alcohol and \$0.7–\$1.4 trillion for sugar-sweetened beverages. They also noted that there are other benefits to such fiscal interventions, such as improving equity. For example, large excise taxes on tobacco, alcohol and sugary beverages are essential to reaching the targets set by the Sustainable Development Goals related to ensuring healthy lives, ending poverty, and promoting full and productive employment.

Thomson et al.⁶² found that taxes on unhealthy food and drinks and food subsidy programs for low-income families were effective at reducing health inequalities in high-income countries but may not impact on weight outcomes; tobacco taxes reduced smoking rates without increasing inequalities.

Tobacco use

The World Health Organization⁸⁴ indicates that tax increases that lead to a 10% rise in retail tobacco product prices will cut consumption by 2% to 8%. Most of the health and economic benefits from reducing tobacco use accrue to the most disadvantaged social groups, who benefit the most in terms of avoiding death and disease associated with tobacco use. WHO emphasises that tobacco taxation offers a win-win, cost-effective policy option for governments, where raising tobacco taxes will both generate economic benefits (extra government revenue) and health benefits (reduced consumption of a deadly product).

The evaluation by Ernst & Young⁸⁵ of the tobacco excise increases in New Zealand found that 9 years of increasing tobacco excise by CPI+10% annually has resulted in a decrease in smoking rates across all demographic groups. The largest decline was in the proportion of youth who have ever smoked or are daily smokers; for 15–17 year-olds, the decline went from 13.7% in 2006–07 to 3.2% in 2016–17. On a per-capita basis, tobacco sales (in volumes) have fallen 44% since 2004, from 1103 to 623 cigarettes worth of tobacco per person per year. The authors predicted that continued 10% increases in the tobacco excise could reduce daily smoking prevalence to 8.7% in 2025, compared to 9.9% without any increases from 2011 onwards.

Other studies also indicated the importance of tobacco taxation. Hoffman et al.⁶⁴ demonstrated that taxes on tobacco reduced smoking behaviour, with decreases in cigarette consumption and smoking prevalence and increases in smoking cessation. Price increases appear to be most beneficial among adolescents, young adults, and low SES groups.

Overweight and obesity

In comparison to tobacco taxation, there is less robust and more mixed evidence about the benefits of taxation for other health harming products such as sugar-sweetened beverages.

Duckett et al.⁸⁶ reported that a 40c/100g of sugar excise tax would generate a drop of about 15% in consumption and likely result in a 2% decrease in the prevalence of obesity, while noting the \$500 million revenue from a sugar-sweetened beverage tax would have social or broader co-benefits (i.e. could be spent on obesity prevention programs and interventions).

Bes-Rastrollo et al.⁸⁷ found that excise taxes on sugar-sweetened beverages were associated with reduced consumption of these beverages, and that there is an inverse association between sugar-sweetened beverage taxation and weight gain or obesity, though estimate of effect is small.

Global Obesity Centre (GLOBE) et al.⁷⁰ also noted a 20% tax on sugary drinks could raise AUD\$400 million a year to be reinvested in public health and preventive programs.

Wilson et al.⁸⁸ provided evidence that a 20% sugar-sweetened beverage tax could save 12,000 DALYs and result in a small reduction of weight and BMI. Further, such a sugar-sweetened beverage tax could result in 175,300 HALYs gained over Australian population lifetime with sugar intake reducing by 11%, while other evidence indications for reductions in type 2 diabetes, stroke, cardiovascular disease, and incidence of tooth decay. The healthcare cost savings of a sugar-sweetened beverage tax could be of between AU\$609m to AU\$1,733 million. However, they noted a lack of real-world evidence showing sugar-sweetened beverage taxes have a positive impact on health outcomes. There is also a lack of strong evidence indicating there is a cost benefit from a sugar tax.

Some studies looking at the impact of multiple strategies on health also included fiscal interventions. Ananthapavan et al.⁶⁹ found volumetric alcohol taxation could assist with a reduction in population-level overweight and obesity; they also found a sugar-sweetened beverage tax had a positive benefit for equity of health outcomes, with higher health gains in the lower SES groups.

Unhealthy diet

Mounsey et al.⁸⁹ reviewed the macroeconomic impacts of diet-related fiscal policy for chronic disease prevention, finding there was no robust evidence for negative impacts (such as reduced GDP or employment levels), and there may be possible benefits in terms of potential increases in employment. However, the body of evidence was extremely limited and had quality assurance challenges in terms of industry funding of reports.

Physical inactivity

Gelius et al.⁸² found there was insufficient evidence for policies that providing subsidies to promote physical activity, and other fiscal interventions (such as congestion pricing).

Built and natural environment and transport

There were 9 studies looking at the impact of built and natural environment and transport strategies on health and other outcomes.⁹⁰⁻⁹⁸ These included interventions such as provision of green space, active transport interventions, neighbourhood changes and other modifications to the built and natural environment. Several reviews looking at multiple strategies also included built environment and transport interventions, which have been covered in this section.

Given the multiple benefits identified in this literature, the studies have been summarised and discussed based on type of benefit, rather than risk factors i.e. health, mental wellbeing, social, economic, and environmental benefits.

In summary, the literature examining the impact of strategies focused on the built and natural environment and transport suggests that there are numerous health benefits to such strategies, particularly in terms of increasing rates of physical activity, which has flow-on benefits for chronic diseases and conditions. Many built environment strategies, such as access to green space and increased neighbourhood walkability, are also associated with improved mental wellbeing outcomes.

Furthermore, these strategies are associated with several non-health co-benefits, including improved safety, reduced crime, increased social connection, reduced social isolation, and reduced carbon emissions. For economic benefits, the greatest amount of evidence is in active transport strategies such as cycling, which has evidence from Australia, the United Kingdom and Europe of significant monetised benefits.

Overall, this literature suggests that strategies targeting the built and natural environment and transport could have many health benefits as well as other types of benefits including mental wellbeing, social, environmental and economic benefits; however, more high-quality evidence is needed.

Multiple benefits

Bird et al.⁹¹ provided a comprehensive umbrella review of the evidence on built and natural environment interventions to address multiple risk factors. They identified a significant range of physical and mental health benefits, as well as social and other benefits:

- Modifying neighbourhood design was associated with reductions in BMI, risk of cardiovascular disease events, type 2 diabetes, stroke, musculoskeletal conditions, some cancers, improved mental wellbeing and reduced road traffic collisions.
- Modifying the type of housing (most through public housing interventions) was associated with improvements in asthma outcomes, reduction in mortality, reductions in falls and related injuries, reductions in health inequalities among low SES populations, improved mental health and wellbeing, reductions in substance misuse and mental disorders, and improvement in quality of life. Modifying housing was also associated with increased employment and improved safety perceptions.
- Modifying the natural environment was associated with: reduction in risk of COPD, health birth weight, reduction in myocardial infarction, reduction in infant mortality, reduction in risk of out-of-hospital cardiac arrest, reduction lung cancer, reduction in ischaemic heart disease, reduction cardiovascular disease mortality risk, reduction in obesity among adults, improved birth outcomes, improved respiratory functioning children, improved physical health outcomes, improved mental health outcomes and improved cognitive function.
- Modifying transport was associated with reductions in BMI, reductions in risk of pedestrian injury, reduction in road traffic collisions, improved cardiovascular outcomes, improved physical activity, and improved social participation among older adults.

However, the review by Bird et al.⁹¹ found the quality of the empirical evidence of the included studies was mixed as the majority relied on findings from descriptive studies, which meant only associations could be identified (rather than causal pathways).

Health benefits

The most common types of health benefits associated with built environment and transport strategies were increased physical activity, improved body weight and reduced rates of chronic disease.

The Heart Foundation⁷⁹ identified that walkable neighbourhoods, green space and trees, active transport and public transport could increase physical activity, reduce cardiovascular disease and type 2 diabetes, and other chronic diseases.

Mandic et al.⁹⁵ found neighbourhoods with higher walkability have a lower prevalence of diabetes and obesity. Active transport more generally is associated with improved fitness, healthy body weight, and better health outcomes, including reduced health inequalities.

van den Bosch et al.⁹⁷ reviewed the evidence for nature-based solutions (NBS) and public health. NBS broadly included 'green infrastructure' interventions, such as provision of green spaces (such as parks and forests), ecosystem restoration, greening of areas and building surfaces, and climate change mitigation and adaptation measures (such as planting more trees and constructing wetlands or providing more 'blue space'). The authors found inconsistent to weak associations of NBS with increases in physical activity, though some positive association with reduced obesity (but evidence is weak or inconsistent). In comparison, there was moderate to strong evidence for positive association between green spaces and all-cause and cardiovascular disease mortality (but none for lung cancer).

Bowen et al.⁹² found that proximity to green space increased likelihood of physical activity, and higher levels of green space access were associated with reduced BMI in children. Chronic disease and diabetes were also lower in regular park users, and some evidence of reduced mortality due to respiratory and cardiovascular disease with green space access.

Frontier Economics⁹³ noted that greater access to green space is likely to increase physical activity by 5% to 20% across the Australian population.

Other umbrella reviews, such as Thomson et al.⁶² indicated that built environment and transport interventions such as cycling infrastructure could reduce traffic injuries, and 20mph speed zones reduced road casualties.

Gouldson et al.⁹⁴ estimated that the value of health benefits from investments in cycling infrastructure can amount to more than 5 times the investment needs, while the health benefits from cycling could be worth US\$35-136

billion in health benefits per year in Europe. They also noted that where public transport networks are well developed, transport-related injuries are more than 80% lower.

A review of the ride to work scheme in the United Kingdom⁹⁶ found that active transport can: increase levels of physical activity; reduce the incidence of type 2 diabetes and lower mortality rates amongst those already with type 2 diabetes; reduce obesity rates; and reduce rates of colon cancer. 86% of users in the cycle to work scheme said they had gained health benefits including improved fitness, weight loss, reduction in stress and improved asthma. Less evidence about benefits of cycling on cardiovascular disease outcomes, though active commuting significantly reduces risk of cardiovascular disease events for women.

However, there are significant challenges in identifying the causal pathways between different nature-based interventions and health outcomes; there is some evidence for effects, but not enough information known about size of effect and dose-response.⁹⁷

Mental wellbeing benefits

Mental wellbeing benefits from built environment and transport interventions were also apparent in the literature. van den Bosch et al.⁹⁷ found evidence for positive impact on emotional wellbeing and stress from NBS, though mixed evidence for access to green space for mental health.

Astell-Burt et al.⁹⁰ identified evidence that access to green space, walkability and amenity of neighbourhoods can have a positive impact on psychological distress levels, but this could be influenced by socioeconomic disadvantage. There was a lower risk of psychological distress for people >45 years who had green space within 1 km of the home address.

Bowen et al.⁹² found that stress reduced with exposure to natural environments and forests with a 3km radius effect and there was improved emotional wellbeing from green space access. The study found decreased anxiety and improved cognition for exposure to nature and improvement in depression for women based on closeness to green space and park usage.

Other findings include that Australians accessing greenspace for 30 minutes or more during a week could reduce the population prevalence of depression and high blood pressure by up to 7% and 9% respectively.⁹³ Active transport could also help children and young people experience improved mental wellbeing and behaviour through more physical activity, and increased self-esteem.⁹⁵

Again, the level of evidence associated with these types of interventions is mixed. Astell-Burt et al.⁹⁰ noted that while wellbeing is linked to neighbourhoods with lots of green space and high walkability, the quality of green space is poorly defined and there is no standardised measurement of which components provide what type of health benefit. There is a need for higher quality evidence from longitudinal studies, clearly defined built environment indicators, and use of geospatial mapping.

Social benefits

For social benefits, Astell-Burt et al.⁹⁰ found 3 built environment indicators (green space, amenity, and walkability) are associated with higher levels of social capital or cohesion. Local built environment, such as neighbourhood deterioration, can have an impact of levels of local crime, which can improve sense of safety, amenity and increase wellbeing.

Bowen et al.⁹² found that exposure to natural settings after school and on the weekend can reduce ADHD symptoms in children; and that exposure to natural environments increases in children's confidence and self-esteem. Interventions such as community gardens can also reduce loneliness and increase social support, while outdoor public spaces can improve social cohesion and social interaction in public housing areas. Green infrastructure can reduce vandalism, violence, and crime, and improve safety.

There were also equity benefits identified in some built environment and transport interventions, such as active transport provision, which can improve access to employment and education; active transport can facilitate social interactions with peers, help to build connection, and improve neighbourhood safety and security.⁹⁵ Safer neighbourhoods promote more walking, and active transport can increase equity while also increasing social connections in the community.⁷⁹

It should be noted there are significant limitations with this body of evidence, given that these types of benefits tended to be poorly defined, and the identified relationship between the strategies and outcomes is associational (rather than causal).

Economic benefits

For the economic benefits associated with built environment and transport strategies, the main types of benefits identified in this review were monetised benefits associated with green spaces and active transport infrastructure. There is a reasonable amount of evidence in this area.

Bowen et al.⁹² found evidence of potential savings due to provision of urban parks in the United Kingdom. This was estimated to be £1.6m–8.7m per annum, including savings to the National Health Service (NHS) of £0.3m–1.8m per annum. Economic benefits of footpaths in United Kingdom were estimated at up to £1m per annum. If green space reduced physical inactivity by 1%, this would result in £1.44 billion savings per annum. Estimated reduction in the number deaths and cases of chronic heart disease, stroke and colon cancer could result in approximately £1.05 billion, £299 million, and £98 million respectively in healthcare savings each year. Investment in 12 community forests resulted in £122,000 per annum economic benefits, and reduction in air pollution levels of £116,000 per annum. Evidence from Belgium also identified the annual economic health value of a cycling project was 47,041 Euros, while in the United States, healthcare savings for residents in 11 cities due to parks and recreation spaces was US\$4.3m–\$90.2m.

In Australia, Frontier Economics⁹³ estimated that reduced mortality and morbidity attributable to increase in physical activity can result in improved economic outcomes (productivity benefits and reduction in healthcare expenditure). They analysed 3 case studies using a Cost of Illness (CoI) approach and a Willingness to Pay (WTP) approach, finding that the total benefits for large-scale greenfield development with water infrastructure was \$141m per population (CoI) and \$723m (WTP). This suggests there are health and economic benefits for water-based infrastructure.

Swift et al.⁹⁶ found that in the United Kingdom, an increase of cycling to 10% by 2025 and 25% by 2050 would result in £42 billion per annum of cumulative benefits. Doubling the number of cycling trips in 10 years would result in annual net benefits of £6.4 billion by 2050 and BCR 5.5:1. BCR of investing in cycling and walking is 13:1 to 19:1. Average cost benefit ratio of cycling initiatives across 12 sites in the United Kingdom was 5.9:1. This report also identified that investments in cycling in the United States in the range of USD\$138 to \$605 million will result in healthcare cost savings of \$388 to \$594 million, fuel savings of \$143 to \$218 million, and savings in value of statistical lives of \$7 to \$12 billion. Generating an additional 9,200 cyclists a year through cycle to work schemes would amount to £72 million in benefits.

Zapata-Diomedes et al.⁹⁸ in their Evidence Check rapid review found the monetary value of the health-related benefits associated with each additional kilometre walked varied between AUD\$1.04 and \$2.08 in Australia. The monetary value of health-related benefits attributable to an additional kilometre cycled ranged from less than \$0.02 to \$1.12. Economic outcomes were found to be greatest for increasing destinations within the neighbourhood, which are associated with health-related benefits worth an average \$14.65 per adult annually (range \$0.42 to \$42.50), depending on destination and context. The health-related economic benefits of changes in urban form are modest at an individual level, but at a population level these figures are significant.

Environmental benefits

In terms of other benefits such as environmental benefits, the level of evidence was identified as being stronger than many of the health or social benefits, perhaps due to a clearer causal link between environmental outcomes and built environment or transport interventions.

van den Bosch et al.⁹⁷ found moderate to strong evidence for the impact of NBS on heat and temperature, and moderate evidence moderate evidence that vegetation can reduce negative perception of noise.

Mandic et al.⁹⁵ found that active transport interventions and strategies resulted in a positive reduction in air pollution and emissions while also increasing physical activity levels. National Heart Foundation of Australia⁷⁹ also found that walkable neighbourhoods were associated with a reduction in air pollution.

Bowen et al.⁹² identified a strong body of evidence that green infrastructure assists with adaptation due to climate change, such as heat and air quality, with flow-on benefits for health.

Frontier Economics⁹³ similarly noted that improved access to green spaces and waterways could increase physical health due to more active recreation, reduction in temperatures and heat, and lower air pollution.

Settings-based health promotion

11 studies reviewed or evaluated the benefits of settings-based health promotion interventions, programs, or strategies. These are programs run within specific settings, such as school, early childhood or childcare, and maternity services. 6 of these studies were focused on school settings,⁴⁶⁻⁵¹ with another 2 focused on childcare settings.^{45,52} 2 were reviews on workplace interventions^{99,100} and only 1 review was in maternity settings.¹⁰¹

This literature suggests that multi-component, multi-level interventions tend to be more effective compared to single interventions in deriving health benefits for different populations, such as reduced BMI, improved diet, and a reduction in sedentary behaviour. These interventions may also have other non-health benefits; however few studies included such benefits. These interventions were generally not reviewed using economic evaluations or cost-effectiveness data.

School settings

For school-based health promotion interventions, 4/6 of these focused on overweight and obesity in children. These reviews noted the mixed evidence of benefit when only looking at weight-related health benefits.

Cauchi et al.⁴⁸ included 63 systematic reviews of childhood obesity prevention interventions and identified several interventions likely to be effective in preventing or reducing overweight and obesity in children (especially if part of long-term comprehensive efforts). These interventions included: increased physical activity sessions; purchase of PE equipment; improvements in nutritional quality of the food supply in schools; creation of environments and cultural practices that support consumption of healthier food at home; and capacity building or professional development for teachers to implement health promotion strategies and activities. The review also found the most consistently successful strategies for children in schools were those targeting sedentary behaviour. However, 84% of the included reviews were either low or medium quality in terms of evidence.

Goldthorpe et al.⁴⁹ in their umbrella review of 10 systematic reviews also found a range of health benefits from school-based obesity prevention interventions in children. These benefits included a small reduction in BMI, reduction in screen time and sedentary behaviour, reduction in sugar consumption and overall energy intake, improvement in fruit and vegetable consumption, and some small effects on behavioural and cognitive outcomes for children. Experiential learning, such as gardening and cooking classes, also produced a moderate effect size and benefit on dietary habits of school students.

Toumbourou et al.⁴⁶ in their Evidence Check review on healthy lifestyle choices in children identified that school-based obesity prevention had significant health benefits such as increased physical activity and improved diet, though effect sizes for weight change/BMI reduction were small. Multi-setting and multi-component obesity prevention interventions had larger effect sizes e.g. combined diet and physical activity components of interventions in the school, home, and broader community. They also found a greater health benefits for 0–5 year-olds and 5–12 year-olds compared to 13–18 year-olds, and greater benefits from obesity prevention programs running for 1–4 years.

Amini et al.⁴⁷ found that school-based obesity prevention interventions have mixed effectiveness on reducing BMI or other weight-related outcomes. Multi-component interventions which target both nutrition and physical activity behaviours in children will have health benefits compared to other interventions but may not always reduce weight or adiposity. Non-targeted, primary prevention interventions are more effective and target a greater number of students but may be less effective for high-risk students.

The other 2 studies for school-based health promotion included an evaluation report from the WA School Breakfast and Nutrition Education Program⁵¹ and an umbrella review of school-based interventions to promote adolescent health.⁵⁰

The evaluation by Byrne et al.⁵¹ looked at the impact of a state-wide school breakfast program in terms of improving diet of school students in Western Australia. They found positive benefit for students' attitudes and knowledge about healthy food and nutrition, for both primary and secondary school students. In addition to this,

the evaluation identified several positive social and other benefits, such as a positive influence on readiness for learning, task concentration, attendance, punctuality, productivity and social skills. The program also contributed to positive relationships between staff, students and community; increased connection to the school; and students' sense of calmness and improved behaviour benefits (e.g. less antisocial behaviour) contributing to a positive 'tone' in the school. Importantly, this program had benefits for equity as it targeted vulnerable youth and students at educational risk due to a range of factors including poverty.

The umbrella review by Shackleton et al.⁵⁰ looked at 30 reviews, the majority of which were low to medium quality. The health benefits identified in their review included a reduction in smoking rates amongst adolescents for multi-component school interventions and multi-sectoral interventions targeting both school environment and family/home environment. They also found that, while single interventions focused on tobacco as well as multiple risk behaviour interventions can reduce smoking, the former were less effective at preventing smoking initiation. There were additional benefits to multi-component interventions that addressed violence and substance use, as they reduced both bullying rates as well as smoking rates amongst adolescents.

Childcare and early childhood settings

Two reviews looked at childcare-based health promotion interventions for young children.

Stacey et al.⁴⁵ analysed the results of 22 systematic reviews on childcare policies and practices for diet and physical activity. They found the highest level of evidence of benefit was for physical activity interventions, including modifying physical environment to promote structured physical activity and providing staff training to promote children's physical activity. There was a mixed level of evidence of benefit for dietary interventions in childcare settings, including parental nutrition interventions and changing childcare nutrition policies to improve diet. Only 2/22 systematic reviews were identified as having a high level of evidence quality.

Matwiejczyk et al.⁵² reviewed 12 systematic reviews on effective interventions to promote healthy eating in childcare settings. They found that most reviews of dietary intake in childcare settings found some level of improvement, such as increased fruit and vegetable intake in children. However, reviews of obesity prevention interventions report mixed or non-significant results. Stronger evidence of benefit was associated with multi-level or multi-component interventions, interventions addressing physical activity, and engaged parents.

In other reviews looking at multiple strategies, Reilly et al.⁴⁰ also identified that childcare centre-based intervention targeting physical activity and screen time can reduce BMI in young children; furthermore, improving fundamental movement skills in childcare and early education settings can increase physical activity and reduce BMI.

Workplace settings

Two umbrella reviews looked at the impact of workplace health promotion interventions on health outcomes.

Proper et al.⁹⁹ reviewed 23 systematic reviews. Most reviews were of low quality. Workplace interventions targeting physical activity and/or diet can result in health benefits such as reduced body weight, BMI, waist circumference or body fat, though effect sizes were modest. Workplace interventions may also be effective at preventing type 2 diabetes and reducing cardiovascular disease risk factors; however benefits were more inconsistent compared to weight-related outcomes. Workplace interventions involving resistance training can prevent musculoskeletal disorders, and active transport and exercise training can promote physical activity and fitness in the workplace (but may not affect obesity rates). Furthermore, this review identified some mental wellbeing benefits from workplace interventions, such as e-health and CBT strategies (prevention of mental illness), and physical activity interventions can improve depression outcomes for workers.

White et al.¹⁰⁰ focused on physical activity and exercise interventions in the workplace, synthesising the findings of 18 systematic reviews. Their primary outcomes of focus were work-related outcomes. As a result, they identified several benefits including that simple physical activity interventions have a positive effect on work absence rates, and that for general workers, short or simple fitness programs can provide similar benefit to more complex ones. They also found for general workers that physical activity interventions reduced both sick leave and workplace absence, but benefits for workplace productivity were extremely limited, as were financial benefits. The quality of the evidence and lack of high-quality randomised controlled trials was also noted.

Maternity settings

Only 1 review was included for maternity setting interventions targeting healthy mothers on health-related behaviours.

Bell et al.¹⁰¹ found that 2 programs showed a reduction in maternal smoking; other programs showed a decreasing trend or improved reporting of smoking, as well as a reduction in alcohol consumption and improvement in breastfeeding rates at 6 months. Integrated maternity services demonstrated evidence of benefit in a reduction in low birthweight and preterm birth. In addition, this review identified child development benefits from a small number of maternity programs.

Bell et al.¹⁰¹ also included 3 programs that had been evaluated in terms of their cost-effectiveness, which showed a trend towards cost savings. One program targeting disadvantages families found a net benefit to the economy of AUD\$3.1 million, equivalent to a benefit cost ratio of approximately 1.2. Coordinated and integrated maternity care programs showed a consistent cost saving effect of at least \$2 for every \$1 spent, either in return on investment or compared with comparison group. Midwifery-led continuity of care indicated a cost-saving effect. However, no costs were provided specific to risk factors, and, overall, the authors did not make a formal assessment of evidence quality.

Social marketing and mass media campaigns

Only 2 studies focused solely on reviewing the effectiveness or cost-effectiveness of mass media campaigns and social marketing interventions.^{102,103} Some studies looking at multiple strategies also reviewed the impact of these strategies.

In summary, this evidence suggests that social marketing and mass media campaigns can have health benefits such as addressing tobacco use and physical activity. There is much less evidence for other behaviours such as improving diet or reducing or preventing obesity. The literature on multiple strategies also suggests mass media campaigns can be complementary to other types of interventions and strategies and enhance implementation and effectiveness.

Mass media campaigns also have evidence of economic benefits in terms of being cost-effective and providing good value for money. However, wider non-health benefits to such campaigns are not generally included in evaluations or reviews.

Multiple risk factors

Stead et al.¹⁰² provided an extensive umbrella review that included 4 reviews of reviews on different topics in public health. Review A found that mass media campaigns can reduce sedentary behaviour and contribute to smoking cessation. The largest quantity of evidence is for campaigns that address tobacco use and physical activity levels, with much less evidence for campaigns to change dietary or drinking behaviours. Review C found that mass media campaigns can be cost-effective for tobacco control, however, evidence on cost-effectiveness was extremely limited for all health topics except smoking, with most of the evidence from the United Kingdom and United States.

Tobacco use

Atusingwize et al.¹⁰³ identified numerous health benefits from tobacco control mass media campaigns, such as reductions in smoking, uptake of cessation, reductions in rates of lung cancer, and stroke. QALYs gained from tobacco control mass media campaigns ranged from 178,290 to 407,000. In one study, LYs gained were 323,000, with another study suggesting 55,000 deaths were averted from a tobacco control campaign. All 10 studies in this review found the cost-effectiveness of evaluated campaigns to be favourable and that they offer good value for money. For example, one of the included studies found \$740 million in healthcare cost savings due to the Australian National Tobacco Campaign. However, this review indicated that interventions were often poorly described in terms of campaign content and intensity, and cost information was frequently inadequate; such gaps in the evidence mean evaluating the benefits of campaigns is difficult.

Other risk factors

Several reviews looking at multiple strategies included mass media campaigns. These reviews suggested that campaigns complemented other types of strategies (such as more regulatory strategies). Examples given included mass media campaigns about physical activity to support changes in the built environment⁸² and campaigns about smoking in combination with other tobacco control interventions.⁶⁴ Some of these studies also found that mass media campaigns can be cost-effective for increasing physical activity levels.^{63,78,79,82} Korber⁴² found that mass

media campaigns for health promotion in children and young people represent good value for money and are the least costly out of all the interventions they compared.

In the included literature for this review, there is a more limited body of evidence of health benefits from campaigns regarding diet⁷² or obesity.^{37,62} Other studies suggested that mass media campaigns may not have direct benefit on health behaviours, but can have benefit in other ways, such as increasing knowledge about health behaviours and promoting a sense of self-efficacy and self-esteem; these benefits may be important for effective implementation of campaigns, particularly in groups such as Indigenous people.⁵⁹ It should also be noted that education and campaigns for health behaviours have little impact on reducing health inequities, and may inadvertently benefit higher socioeconomic groups.⁶²

Healthy lifestyle

Included in this category were healthy lifestyle and individual behaviour change programs offered universally or at scale to the general population or specific high-risk groups, rather than to people already experiencing ill health (such as people with type 2 diabetes). These programs included mobile technology interventions ('mHealth'),^{104,105} lifestyle interventions for older persons,^{53,54} and some healthy lifestyle interventions targeting Indigenous populations.^{55,58}

The evidence on the cost-effectiveness and benefits of healthy lifestyle and individual behaviour change indicates they can provide a range of health benefits including improved diet, increased physical activity, weight loss and smoking cessation.

Physical activity-based lifestyle interventions also have evidence of other types of benefits, such as mental wellbeing benefits and improved social connections with others, particularly for older populations.

However, no cost-effectiveness information was available from the included literature.

Multiple risk factors

An umbrella review¹⁰⁴ of 44 systematic reviews found that mobile technologies (mHealth) offer positive benefits for weight management (weight loss; reduction in BMI) and increase in physical activity. Some evidence of benefit of mobile technologies included improving fruit and vegetable intake, and reducing consumption of sugar, fat, and energy-dense foods. However, they noted inconsistent terminology and definitions for technology-based interventions, and a weak body of evidence for Web 2.0 interventions compared to mHealth.

Hall et al.¹⁰⁵ also looked at 15 mHealth systematic reviews, specifically interventions involving mobile text messaging for chronic disease prevention. A third of the studies found text messaging to have a positive benefit for health outcomes and behaviours including smoking cessation, physical activity, weight loss and a reduction in blood pressure. A meta-analysis of 5 studies with 9,100 participants found mHealth interventions increased long-term smoking cessation rates compared with control programs.

Other studies that reviewed multiple strategies included some healthy lifestyle interventions for multiple risk factors. Harris et al.⁶¹ reviewed the effectiveness of healthy lifestyle interventions to prevent or reduce cancer found a strong level of evidence that digital health interventions, such as providing motivational information and individualised tailoring and feedback, can improve physical activity, diet, and weight. Health coaching and behavioural interventions can also modify physical activity, diet, and weight, as can behavioural or community education programs, though this evidence was of moderate quality.

Physical inactivity

For older adult groups, Zubala et al.⁵³ reviewed systematic reviews that promoted physical activity interventions for older adults in the community. They found that all reviews reported positive effects for physical activity. The largest effect was for walking interventions, with sustained effects beyond 6 months. Multi-modal and multi-component interventions can increase physical activity levels of older adults in the community and walking interventions seemed to be particularly beneficial in this group. This review also identified mental wellbeing benefits for physical activity interventions in this group, including psychological outcomes such as self-efficacy, quality of life and improved depressive symptoms, though noting that benefits of interventions in terms of psychological wellbeing may be identifiable in the longer term (e.g. 6 or 12 months) rather than the short-term. It suggested that physical activity interventions have dual benefits for older adults in terms of promoting both increased physical activity as

well as mental wellbeing, with positive effects found for multi-modal interventions. But self-reported physical activity measurements and other factors meant only a small number of reviews had a low risk of bias.

Comans et al.⁵⁴ in their Evidence Check review on health promotion for older adults also identified that some evidence that physical activity and exercise interventions can improve older people's physical performance (i.e. measures of physical fitness and ability to do certain physical activities) and improve cognitive function in older adults >70 years. There were also social benefits to group activities with or without physical activity.

Pelletier et al.⁵⁸ also reviewed physical activity interventions to improve physical fitness and health outcomes among Indigenous adults living in Canada. They found an increase in physical activity from 2 interventions, while other benefits included a reduction in waist circumference following a walking intervention, and decreased blood pressure from a walking intervention and mixed exercise program. Again, quality of evidence was weak-moderate, with no RCTs and problems with using unvalidated and/or self-reported tools to collect data.

Unhealthy diet

Browne et al.⁵⁵ looked at food and nutrition lifestyle programs for Aboriginal and Torres Strait Islander Australians. Cooking skills workshops, group education sessions and store interventions had the greatest impact on producing improvements in chronic disease risk factors (e.g. cholesterol levels, triglycerides, blood pressure, weight, waist, HbA1c, blood glucose). Community involvement in program design was strongly associated with a positive effect on BMI. Other key factors included community involvement in implementation, the involvement of an Aboriginal health worker, and environmental changes. Food and nutrition programs that are initiated and designed by local Aboriginal and Torres Strait Islander people were most likely to have health benefits.

Behavioural economics and 'nudge'

While no umbrella reviews or other studies were identified that looked only at the benefits of behavioural economics or 'nudge' interventions, some of these strategies were included in reviews that considered the impact of multiple strategies.

This evidence suggests there are some health benefits from small-scale changes to 'nudge' people to healthier choices such as quitting smoking, choosing healthier food options or taking the stairs at work, however the body of literature is limited.

It should also be noted that while fiscal intervention such as taxes and subsidies can be considered a type of behavioural economic intervention, these are detailed in an earlier section.

Tobacco use

Hoffman et al.⁶⁴ found that offering financial incentives to smokers to quit had health benefits in terms of smoking cessation. In pregnant women, financial incentives increased smoking cessation and were the most important component of multi-component programs that promote cessation.

Multiple risk factors

Sacks et al.³⁷ suggested that financial incentives have some evidence for weight loss, improving diet and physical activity levels.

Unhealthy diet

Harris et al.⁶¹ identified some emerging evidence that behavioural economics or nudge interventions such as changing serving size of foods positively impact on diet. Perez-Cueto⁷⁴ noted that nudges within the food environment can improve diet quality.

Physical inactivity

Other 'nudge' interventions included stair signage and point-of-choice prompts, which had moderate level of effectiveness of benefit to reduce sedentary behaviour and increase physical activity.^{60,67} National Heart Foundation of Australia⁷⁹ also identified that stair signage in workplaces can be low cost and effective at reducing sedentary behaviour.

Discussion and conclusions

This review summarises the health burden and costs of 4 risk factors, and identifies which interventions and strategies may provide health, social, economic, and other benefits. The review was based on umbrella reviews, systematic reviews, and similar types of high-level grey literature syntheses. The review was guided by 2 research questions. A summary of the evidence and the resulting implications for further research are provided below.

Summary of evidence

Review question 1: What are the economic and health costs of high body mass, poor diet, insufficient physical activity, and tobacco use?

The available evidence identified that the 4 risk factors of physical inactivity, overweight and obesity, tobacco use and unhealthy diet represent a significant health burden for the Australian population, causing tens of thousands of premature deaths per year and years lived in poor health. Tobacco use generally represents the highest burden of disease, though the other risk factors also have a significant burden.

The included studies also identified the economic costs of these risk factors. These costs included costs to the health system, such as hospitalisations and charges to Medicare, as well as broader economic or societal costs from reduced employment, absenteeism and presenteeism.

The evidence suggests that even small changes in the prevalence of these risk factors are likely to lead to a significant reduction in the health burden for individuals and the healthcare system, as well as a reduction in economic and societal costs for communities, businesses, and governments.

Reduction and prevention of these risk factors is of critical importance for both health and economic reasons. Healthcare expenditure spent on preventable disease represents an opportunity cost of money that could be spent elsewhere in the healthcare sector. Similarly, the years of productive life lost in individuals due to premature death or retirement from the workforce are years lost that represent an opportunity cost to the whole of society, which could otherwise be directed towards boosting productivity and the output of the Australian economy.

Health costs (health burden)

The 4 risk factors of interest for this review represent a substantial proportion of the preventable disease burden in Australia. Though the attributable health burden by DALYs did vary across the risk factors, tobacco use generates the highest amount of burden (up to 9.3%), while the other risk factors also generate a high amount of health burden: overweight and obesity/high BMI (up to 8.4%); unhealthy diet (up to 9.7%); and physical inactivity (up to 5.5%).

The health burden of overweight and obesity was well identified in the included literature. There were many links and associations identified between high body mass and chronic diseases and conditions, including several different cancers. This increases the overall burden of disease for the risk factor.

Economic costs

In addition to the health burden, there were substantial economic costs associated with these 4 risk factors. The range of economic cost estimates (in 2017 Australian dollars) for each risk factor were: individual dietary risk factors (up to \$561m); tobacco use (up to \$10.5bn); high BMI (\$840m–\$14.9bn); and physical inactivity (up to \$15.6bn).

The costs of overweight, obesity and tobacco use were more commonly costed than physical inactivity or diet. The economic costs of overweight and obesity were significant because of the cost to the healthcare system (such as through an increase in hospitalisations, pharmaceuticals, and Medicare) as well as broader costs to the economy from an increase in absenteeism and presenteeism.

Review question 2: What are the health, social and economic benefits of primary prevention strategies which address high body mass, poor diet, insufficient physical activity and tobacco use; and which strategies are most cost-effective?

The results of this review indicate that investing in population-wide preventive strategies at the primordial or primary prevention level will likely be beneficial for health. Most of the benefits identified in this review were health benefits, particularly physical benefits such as improving physical activity levels, improving diet, reducing or preventing tobacco use, and reducing overweight and obesity. Strategies that were particularly effective tended to be those that involved the implementation of multiple strategies, and/or were multi-component interventions at different levels of the system or setting.

Some preventive strategies produced a wider range of benefits beyond health, including mental wellbeing benefits, social benefits and environmental benefits. Non-health 'co-benefits' were particularly apparent for strategies such as built or natural environment and transport interventions.

Preventive strategies are also likely to be cost-effective and economically beneficial. Cost-effective interventions and those producing evidence of economic benefit tended to be more regulatory in nature, such as taxation, changes to the physical (built or natural) environment, food reformulation to reduce salt levels, and provision of active transport infrastructure. Tobacco taxation was considered to be highly effective and cost-effective. However other interventions were also economically beneficial, such as obesity prevention interventions in children, and mass media campaigns.

Health benefits (including mental wellbeing benefits)

The types of health benefits identified in this literature included improvements physical health, such as increases in physical activity levels, reduction in obesity prevalence or BMI, and improvement in diet quality (such as increased fruit and vegetable consumption or decrease in less healthy foods). Mental wellbeing benefits included a reduction in psychological distress, reduced stress, prevention of mental illness, improvement in self-esteem, and higher scores in quality of life.

The greatest amount of evidence for health benefits was for interventions that considered the effects of multiple strategies for multiple risk factors. Many of the umbrella reviews considered the benefits of a range of different strategies that target different mechanisms and casual pathways. Combining multiple strategies and approaches reflects the complexity of chronic disease and demonstrates that successful preventive action is needed across multiple levels and sectors of the system.

Tobacco control interventions particularly demonstrated health benefits, usually defined as reduction in smoking rates. These interventions included regulation and policies (e.g. smoking bans), fiscal interventions such as tobacco excise, mass media campaigns, and healthy lifestyle programs to promote smoking cessation. Given the significant health burden of tobacco use, investing in tobacco control at the primary prevention level, such as stopping people (especially children and young people) from taking up smoking, is one of the most effective public health strategies with a very strong body of evidence of health benefit.

There was also evidence of health benefits from multiple strategies targeting several different settings and behaviours at once. Obesity prevention strategies in schools were commonly identified in the literature, with several umbrella reviews and grey literature sources evaluating the health benefits of such interventions. Many of these studies indicated that successful interventions were those that combined school-based interventions with other interventions targeting the family and/or community. However, it is interesting to note that it was more common for studies to identify more 'proximal' health benefits from these strategies, such as reduced screen time or sedentary behaviour, or improvements in fruit and vegetable consumption. A small number of studies also suggested there were mental wellbeing benefits to those strategies.

Health benefits were also identified in the literature on built and natural environment and transport interventions. For example, creating more walkable neighbourhoods, investing in cycling infrastructure, and increasing access to green space were all associated with health benefits such as a reduction in mortality rates, reduced rates of chronic disease, increased physical activity and lower BMI. Many of these interventions also had mental wellbeing benefits,

including a reduction in stress and improvement in rates of depression. This was particularly the case for interventions that promoted more physical activity, such as active transport and walking.

Social and other benefits (including environmental benefits)

The social and other benefits identified in this review included social cohesion, social connection, reduction in loneliness, reduction in crime and violence, or improvement in local area amenity. Other benefits identified included environmental benefits. The two types of strategies for which social and other benefits tended to be identified were settings-based health promotion and built and natural environment and transport interventions.

It was more common for obesity prevention interventions, particularly those in school settings, to provide evidence of social benefits. For example, feedback from teachers and parents about a children's obesity prevention intervention was that it changed the 'tone' of the school environment. Other studies also cited the importance of school-based interventions for building social skills and self-esteem in young people.

Interventions targeting the built and natural environment or transport system tended to describe a range of environmental benefits in addition to health benefits. These environmental benefits included reduced air pollution levels, carbon emissions, and reduced heat; these tended to be associated with green and blue spaces, vegetation (including tree canopy) and active transport and walkability. Some literature also suggested that walkable neighbourhoods, built environment interventions and active transport could promote greater social cohesion, safety and public amenity.

Economic benefits and cost-effectiveness

While the search strategy for this review adopted a broad definition of 'economic benefits', in the literature this was mostly interpreted to mean costed or monetised benefits gained because of an intervention, with these benefits usually provided through economic evaluations of interventions (such as cost-effectiveness analyses). These benefits ranged from macroeconomic benefits to societal benefits, or healthcare system cost savings.

Most preventive strategies at the primordial or primary level were found to be economically beneficial. Regulatory interventions (such as taxation of harmful products, or strategies such as food reformulation) tended to be dominant interventions in terms of cost-effectiveness or economic and health benefits. These strategies therefore represent good value for money in terms of efficient investment by governments. The types of strategies included in this review for which this was the case were tobacco taxation, mandatory salt reduction, reformulation of the food supply, and built environment and transport interventions.

Other strategies that demonstrated evidence of economic benefit included mass media campaigns to promote healthier behaviours, and interventions targeting children, such as restricting unhealthy food advertising to children. There was also evidence that childhood and adolescent obesity prevention interventions were cost-effective or cost saving.

Implications for further research

Demonstrating the value of prevention through measuring co-benefits

To clearly demonstrate and articulate the value of prevention, researchers and policymakers need to ensure they are reporting and measuring the full range of outcomes and co-benefits, including health and non-health benefits and co-benefits.

While most of the benefits identified in this review were related to physical health outcomes, several other benefits were identified. However, these benefits tended to be less frequently identified in reviews and syntheses, and were not generally included as outcomes, either in the reviews or primary studies. This represents a significant challenge for health researchers and governments to quantify and measure these benefits alongside health benefits, for example including co-benefits as primary or secondary outcomes in evaluations of public health interventions and studies.

Identifying the value and co-benefits of preventive strategies beyond physical health benefits is a focus of rapidly expanding fields of research in public health and medical research. The most well-established areas are in the

mental health co-benefits of healthy lifestyle interventions,¹⁰⁶ the health, economic and environmental co-benefits of investing in active transport and built environment interventions,¹⁰⁷⁻¹⁰⁹ the environmental co-benefits of healthier, more sustainable food systems,¹¹⁰ and the co-benefits of obesity prevention and climate change mitigation.¹¹¹ Including other outcomes outside of physical health outcomes when designing, implementing and evaluating preventive health interventions will add significantly to the evidence base and may provide further compelling evidence as to the full value of prevention. Similarly, non-health interventions could include health outcomes and data to demonstrate evidence of benefit to health.

Using systems thinking and approaches to prevention

Understanding and demonstrating that prevention can have benefits for areas outside of health reflects systems thinking or complexity approaches to chronic disease and prevention.

There is a range of complex drivers for the 4 risk factors on which this review focused. These drivers occur at different levels of the 'system'. Many of these risk factors are interrelated, for example physical inactivity, unhealthy diet and obesity. Addressing the complex web of causality that leads to certain health behaviours, outcomes and risk factors is therefore challenging.

Systems approaches can help to identify and articulate which interventions could be effective at addressing not just one risk factor, but also several other risk factors for poor health. Taking a systems approach could assist in terms of designing, implementing and evaluating multi-level, multi-component interventions for different populations and settings.

However, complex interventions that target multiple risk factors at once and are implemented in a real-world situation also means RCT-quality and meta-analysis quality evidence is likely not feasible. Much of the evidence required for improved policy and practice in prevention may therefore rely on natural experiments and other types of non-randomised, non-controlled experimental studies.¹¹² Researchers, policymakers and practitioners may need to consider what is a sufficient body of evidence to justify and enable the case for public health and preventive action.¹¹³

Systems approaches could also help to identify and measure the different types of benefits of prevention to individuals, communities, businesses and governments. For example, a systems approach to physical activity could help identify the benefits of different interventions across sectors such as transport, including health and environmental co-benefits like improvements in air quality.¹¹⁴

Collecting costs and benefits of prevention for economic evaluations

Economic costs and benefits need to be a routine part of data collection for implementation and evaluations of preventive strategies.

Only a small number of included reviews and reports provided economic costs or benefits of various interventions, including cost-effectiveness analyses and other economic evaluations. In addition, only 9 cost-effectiveness or economic evaluation reviews were identified, although this may reflect the number of systematic reviews that have been conducted, rather than the number or quality of cost-effectiveness analyses that exist in the literature (though systematic reviews do tend to reflect the body of primary studies available).

While cost-effectiveness and economic evaluations are usually conducted only for interventions that have demonstrated efficacy, this is an opportunity for future research. More high-quality research is needed in this area to demonstrate the economic benefits and cost-effectiveness of preventive strategies. In addition, economic evaluations of existing and hypothetical preventive interventions could assist government agencies and departments who are increasingly required to provide cost benefit and economic justification to new programs or policies.

Economic data and evidence of economic costs and benefits therefore need to be collected, and other types of benefits need to be clearly defined and measured. When a new intervention is implemented in prevention, how the benefits or costs will be measured or accounted for needs to be determined during the design of the intervention and research. While it is increasingly common to engage statisticians early in a project or research planning stage, it is less common for health economists to be consulted. Consulting a health economist is particularly important if

a group or government department needs to account for non-health benefits of preventive interventions, as there are different economic approaches that can be used to help demonstrate and cost these benefits, such as Cost Benefit Analysis (CBA), Social Return on Investment (SROI), or Cost Consequence Analysis (CCA). The specific type of economic analysis that should be used in a given situation is dependent on the decision context, type of intervention and research question, and the most relevant analytic approach needs to be chosen in order to demonstrate the full value and benefits of prevention.

There was also an evidence gap in terms of quantifying the health and economic burden of poor diet, and effective strategies to change dietary behaviours. There are epidemiological challenges of attributing causal links between disease and aspects of dietary patterns, as people's dietary behaviours are highly complex. This also makes it challenging to develop effective preventive interventions, though this review notes there is a body of evidence regarding salt reduction strategies, including economic evaluation and modelling. This is an area worth further exploration to help determine which public health interventions can reduce the significant burden and cost associated with unhealthy diet.

Limitations

There are several limitations to this review. This was a rapid review and, while systematic searching methods were employed, it is not the same in terms of evidence grading as a systematic review. The prioritisation of umbrella reviews and systematic reviews due to the breadth of literature may also mean that some studies were missed. For example, though it was included in the search strategy, no umbrella reviews or reports were identified about the benefits from behavioural economics or 'nudge' interventions. It may be that the wrong search terminology was used for this, but we also note such interventions and strategies are poorly defined.

In terms of identifying all the benefits associated with prevention, a review such as this is dependent on what is reported in the primary documents and systematic reviews. Evidence on non-health or social benefits may exist but have been missed by the focus of the present study on high-level evidence and inclusion criteria of umbrella reviews for review question 2.

The request to include grey literature is associated with a few challenges, given that grey literature documents and sources are found in a variety of locations across multiple organisational websites, both country-specific and international. As a result, there may be other grey literature documents that could have been relevant for this review but were not identified during the searching or screening process.

Due to the large number of results and extensive areas covered by the review, a full quality assessment for each study or report was not performed; instead, a summary of the study's assessment of evidence quality was provided, including any assessment frameworks used and whether limitations were provided. This assessment of the quality of the underlying evidence is also likely to be of more relevance to the reader than an assessment of the quality of an umbrella review, for example.

The available evidence in this review was also heterogeneous, making synthesis and comparison difficult, particularly when comparing different strategies and interventions. Few meta-analyses were identified because of this heterogeneity of data and the different interventions, strategies and settings. Providing definitive answers on which interventions or strategies are best is therefore difficult for such a broad review.

Glossary of terms

Abbreviation	Term
ABDS	Australian Burden of Disease Study
BCR	Benefit Cost Ratio
BMI	Body Mass Index
CBA	Cost Benefit Analysis
CEA	Cost Effectiveness Analysis
CoI	Cost of Illness
CUA	Cost Utility Analysis
DALY	Disability Adjusted Life Year
ICER	Incremental Cost Effectiveness Ratio
QALY	Quality Adjusted Life Year
QoL	Quality of Life
RCT	Randomised Controlled Trial
RoI	Return on Investment
SROI	Social return on investment
Umbrella review	A systematic review of systematic reviews
WTP	Willingness To Pay

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Appendices

Appendix A: Search strategies

Key concepts

Review question 1

Concept 1 <i>Costs (health & economic)</i>	Concept 2 <i>Risk factor</i>	Concept 3 <i>Risk factor</i>	Concept 4 <i>Risk factor</i>	Concept 5 <i>Risk factor</i>
Economic cost	High body mass	Poor diet	Physical inactivity	Tobacco use
Costing	Obesity	Diet	Physical activity	Tobacco smoking
Financial	Overweight	Nutrition	Sedentary behaviour	Tobacco use cessation
Cost of illness	BMI		Exercise	Smoking
Value	Body mass index			
Burden of disease				
Health burden				
Health impact				

Review question 2

Concept 1 <i>Health, social & economic benefits</i>	Concept 2 <i>primary prevention strategies</i>	Concept 3 <i>Risk factor</i>	Concept 4 <i>Risk factor</i>	Concept 5 <i>Risk factor</i>	Concept 6 <i>Risk factor</i>
Evaluation	Prevention	High body mass	Poor diet	Physical inactivity	Tobacco use
Effectiveness	Social marketing	Obesity	Diet	Physical activity	Tobacco smoking
Impact	Mass media campaign	Overweight	Nutrition	Sedentary behaviour	Tobacco use cessation
Value	Policy	BMI		Exercise	Smoking
Social good	Regulation	Body mass index			
Social impact	Legislation				
Sustainable development	Taxes				
Cost effectiveness	Health promotion				
Economic	Food labelling				
Value for money	Urban / city planning				
Cost benefit	Built environment				
Cost analysis	Healthy lifestyle				
Costing	Active transport / active travel				
	Behavioural economics				
	Breastfeeding				

Peer-reviewed literature search strategy

Databases used

- MEDLINE Complete via EBSCOhost
- Econlit via EBSCOhost
- CINAHL via EBSCOhost
- Embase

Example of database search (MEDLINE Complete via EBSCOHost, 23 June 2020)

Review question 1

Search ID	Search	Options	Results
S35	S30 AND S31 AND S32	Limiters - Date of Publication: 20100701-20200631; English Language Search modes - Boolean/Phrase	(6,536)
S34	S30 AND S31 AND S32	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	(11,080)
S33	S31 AND S32	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	(385,546)
S32	S19 OR S20 OR S21 OR S22 OR S23 OR S24 OR S25 OR S26 OR S27 OR S28 OR S29	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	(3,092,955)
S31	S1 OR S2 OR S3 OR S4 OR S5 OR S6 OR S7 OR S8 OR S9 OR S10 OR S11 OR S12 OR S13 OR S14 OR S15 OR S16 OR S17 OR S18	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	(2,272,892)
S30	TI Australia* OR AB Australia* OR CY Australia OR MH Australia	Search modes - Boolean/Phrase	(396,422)
S29	(MH "Global Burden of Disease")	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	(593)
S28	TI prevent* OR AB prevent*	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	(1,404,742)
S27	TI economic OR AB economic	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	(215,291)
S26	TI financ* OR AB financ*	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	(103,561)
S25	TI burden OR AB burden	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	(208,194)

S24	TI cost OR AB cost	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	(544,432)
S23	TI ("health impact" OR "social impact") OR AB ("health impact" OR "social impact")	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	(10,659)
S22	(MH "Mortality+") OR (MH "Morbidity+") OR (MH "Life Expectancy")	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	(904,794)
S21	(MH "Health Impact Assessment")	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	(671)
S20	(MH "Costs and Cost Analysis+")	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	(235,945)
S19	(MH "Primary Prevention")	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	(18,401)
S18	TI ("sedentary behav*") OR AB ("sedentary behav*")	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	(6,195)
S17	TI ("physical* activ*" OR "physical* inactiv*") OR AB ("physical* activ*" OR "physical* inactiv*")	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	(119,532)
S16	(MH "Health Risk Behaviors") OR (MH "Health Behavior")	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	(50,187)
S15	(MH "Sedentary Behavior")	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	(9,187)
S14	(MH "Exercise") OR (MH "Walking+") OR (MH "Running+")	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	(174,295)
S13	TI (obesity OR obese OR overweight) OR AB (obesity OR obese OR overweight)	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	(313,772)
S12	TI ("body mass index" OR bmi) OR AB ("body mass index" OR bmi)	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	(241,382)
S11	TI "high body mass" OR AB "high body mass"	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	(2,759)
S10	(MH "Body Weight+")	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	(460,421)
S9	TI nutrition OR AB nutrition	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	(153,583)
S8	TI diet OR AB diet	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	(354,511)
S7	(MH "Diet, Food, and Nutrition+")	Expanders - Apply equivalent subjects	(1,078,675)

		Search modes - Boolean/Phrase	
S6	(MH "Diet+")	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	(278,545)
S5	TI smoking OR AB smoking	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	(221,553)
S4	TI tobacco OR AB tobacco	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	(100,513)
S3	(MH smoking) OR (MH "Smoking Prevention") OR (MH "Smoking Reduction") OR (MH "Cigarette Smoking")	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	(148,437)
S2	(MH "Tobacco Use Cessation") OR (MH "Tobacco Use Disorder") OR (MH "Smoking Cessation")	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	(35,769)
S1	(MH "Tobacco Use") OR (MH "Tobacco Smoking")	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	(2,700)

Review question 2

Search ID	Search	Options	Results
S55	S54	Limiters - Date of Publication: 20100701-20200631; English Language Search modes - Boolean/Phrase	(3,592)
S54	S53	Limiters - Review Articles Search modes - Boolean/Phrase	(7,123)
S53	S50 AND S51 AND S52	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	(33,230)
S52	S20 OR S21 OR S44 OR S45 OR S46 OR S47 OR S48 OR S49	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	(2,353,166)
S51	S19 OR S22 OR S23 OR S24 OR S25 OR S27 OR S28 OR S29 OR S30 OR S31 OR S32 OR S33 OR S34 OR S35 OR S36 OR S37 OR S38 OR S39 OR S40 OR S41 OR S42 OR S43	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	(960,532)
S50	S1 OR S2 OR S3 OR S4 OR S5 OR S6 OR S7 OR S8 OR S9 OR S10 OR S11 OR S12 OR S13 OR S14 OR S15 OR S16 OR S17 OR S18	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	(2,273,598)
S49	(MH "Sustainable Development")	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	(701)
S48	TI "value for money" OR AB "value for money"	Search modes - Boolean/Phrase	(1,664)
S47	TI effectiveness OR AB effectiveness	Search modes - Boolean/Phrase	(442,500)
S46	TI ("social good" OR "social impact") OR AB ("social good" OR "social impact")	Search modes - Boolean/Phrase	(2,142)
S45	TI (cost OR financ* OR economic) OR AB (cost OR financ* OR economic)	Search modes - Boolean/Phrase	(774,315)
S44	TI evaluation OR AB evaluation	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	(1,244,933)
S43	(MH "Breast Feeding")	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	(37,433)
S42	TI ("active transport") OR AB ("active transport")	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	(7,486)
S41	TI ("social marketing") OR AB ("social marketing")	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	(1,664)

S40	TI ("mass media campaign") OR AB ("mass media campaign")	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	(308)
S39	(MH "Mass Media+")	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	(45,351)
S38	(MH "Social Marketing")	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	(2,384)
S37	TI ((health OR disease) N3 (policy OR policies OR regulation* OR legislation OR law*)) OR AB ((health OR disease) N3 (policy OR policies OR regulation* OR legislation OR law*))	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	(62,154)
S36	TI (prevention OR preventative) OR AB (prevention OR preventative)	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	(549,877)
S35	(MH "Legislation, Food")	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	(2,423)
S34	(MH "Legislation")	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	(0)
S33	(MH "Health Promotion+")	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	(76,396)
S32	(MH "Food Packaging")	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	(4,678)
S31	(MH "Food Labeling")	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	(3,733)
S30	(MH "Built Environment") OR (MH "Environment Design")	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	(6,733)
S29	TI ("urban planning") OR AB ("urban planning")	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	(987)
S28	(MH "City Planning") OR (MH "Social Planning") OR (MH "Health Planning")	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	(25,950)
S27	(MH "Economics") OR (MH "Resource Allocation") OR (MH "Health Care Rationing") OR (MH "Economics, Behavioral") OR (MH "Economics, Medical")	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	(53,034)
S26	(MH "Taxes")	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	(6,642)
S25	(MH "Government Regulation")	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	(21,153)

S24	(MH "Smoke-Free Policy")	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	(890)
S23	(MH "Fiscal Policy") OR (MH "Social Control Policies")	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	(813)
S22	(MH "Policy") OR (MH "Nutrition Policy") OR (MH "Health Policy") OR (MH "Health Care Reform") OR (MH "Public Policy")	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	(136,763)
S21	(MH "Health Impact Assessment")	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	(671)
S20	(MH "Costs and Cost Analysis+")	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	(235,945)
S19	(MH "Primary Prevention")	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	(18,401)
S18	TI ("physical* activ*" OR "physical* inactiv*") OR AB ("physical* activ*" OR "physical* inactiv*")	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	(119,532)
S17	(MH "Health Risk Behaviors") OR (MH "Health Behavior")	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	(50,187)
S16	(MH "Sedentary Behavior")	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	(9,187)
S15	(MH "Exercise") OR (MH "Walking+") OR (MH "Running+")	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	(174,295)
S14	TI (obesity OR obese OR overweight) OR AB (obesity OR obese OR overweight)	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	(313,772)
S13	TI ("body mass index" OR bmi) OR AB ("body mass index" OR bmi)	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	(241,382)
S12	TI "high body mass" OR AB "high body mass"	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	(2,759)
S11	(MH "Body Weight+")	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	(460,421)
S10	TI ("sedentary behav*") OR AB ("sedentary behav*")	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	(6,195)
S9	TI nutrition OR AB nutrition	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	(153,583)
S8	TI diet OR AB diet	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	(354,511)

S7	(MH "Diet, Food, and Nutrition+")	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	(1,078,675)
S6	(MH "Diet+")	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	
S5	TI smoking OR AB smoking	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	
S4	TI tobacco OR AB tobacco	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	
S3	(MH smoking) OR (MH "Smoking Prevention") OR (MH "Smoking Reduction") OR (MH "Cigarette Smoking")	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	
S2	(MH "Tobacco Use Cessation") OR (MH "Tobacco Use Disorder") OR (MH "Smoking Cessation")	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	
S1	(MH "Tobacco Use") OR (MH "Tobacco Smoking")	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	

Grey literature search strategy

Databases and websites used

- Google Advanced www.google.com.au/advanced_search?hl=en
- WHO IRIS (Institutional Repository for Information Sharing) apps.who.int/iris/
- Australia
 - Capital Monitor (accessible through university libraries – Australian legislation, policy & research)
 - Analysis & Policy Observatory (APO) apo.org.au/subject/57741
 - Federal government departments and statutory agencies (such as ABS and AIHW)
 - State and territory governments and statutory agencies (such as VicHealth)
 - Consultancies – PwC; EY; BCG; McKinsey; KPMG; Access Economics
 - Health-related major organisations & NFPs: The Australian Prevention Partnership Centre; Sax Institute; The George Institute; Obesity Policy Coalition; Cancer Council Australia; Heart Foundation; Consumers' Health Forum; Foundation for Alcohol Research and Education; Major private health insurers (eg. Medibank; Bupa); health professional groups – RACGP; AMA; Public Health Association of Australia, Health Promotion Association of Australia
- NZ
 - New Zealand Ministry of Health – Grey Matter newsletter <https://www.health.govt.nz/news-media/grey-matter-newsletter>
 - Ministry of Health
 - Public Health Association of NZ
- Canada
 - Canadian Best Practices Portal – Public Health Agency of Canada <https://cbpp-pcpe.phac-aspc.gc.ca/>
 - Prevention Policies Directory - Canadian Partnership Against Cancer <https://www.partnershipagaincancer.ca/tools/prevention-policies-directory/>
 - Public Health Agency of Canada
 - Canadian Public Health Association
- UK
 - NICE Evidence search <https://www.evidence.nhs.uk/>
 - OpenGrey Europe <http://www.opengrey.eu/>
 - NICE
 - Public Health England
 - Wellcome Trust
 - Obesity Health Alliance
- International
 - WHO
 - OECD
 - World Cancer Research Fund
 - NCD Alliance.

Search terms

Review question 1

16 June 2020 (search 1)

economic OR costs OR cost OR costing OR financial OR "cost effective" OR "cost benefit" OR "cost analysis" OR "cost of illness" OR "value for money" OR "burden of disease"

AND

tobacco OR smoking OR diet OR nutrition OR obesity OR overweight OR BMI OR "physical inactivity" OR "physical activity" OR "sedentary behaviour"

23 June 2020 (search 2)

Economic OR cost OR financial OR "cost of illness" OR value OR "value for money"

OR

"burden of disease" OR "health burden" OR "health impact"

AND

tobacco OR smoking OR diet OR nutrition OR obesity OR overweight OR BMI OR "high body mass" OR "physical inactivity" OR "physical activity" OR "sedentary behaviour"

Filters

- 2010-2020
- Australia

Review question 2

16 June 2020 (search 1)

evaluation OR evaluate

AND

policy OR policies OR law OR legislation OR regulation OR tax OR excise OR "behavioural economics" OR "nutrition labelling" OR "health promotion" OR "health campaign" OR "mass media campaign" OR "social marketing" OR "built environment" OR "urban planning" OR "liveability" OR "active transport" OR "active travel" OR cycling OR walkability

AND

tobacco OR smoking OR "tobacco control" OR diet OR nutrition OR obesity OR "physical inactivity" OR "sedentary behaviour" OR breastfeeding

23 June 2020 (search 2)

economic OR cost OR "cost analysis" OR "cost effective" OR "cost benefit" OR "return on investment" OR "economic model"

OR

Evaluation OR effectiveness OR "Social impact" OR "social good" OR "sustainable development"

AND

prevention OR policy OR law OR legislation OR regulation OR tax OR excise OR "behavioural economics" OR "health promotion" OR "health campaign" OR "mass media campaign" OR "social marketing"

AND

tobacco OR smoking OR "tobacco control" OR diet OR nutrition OR obesity OR overweight OR "physical inactivity" OR "sedentary behaviour" OR breastfeeding

Specific searches, add:

- "built environment" OR "urban planning" OR "liveability" OR "active transport" OR "active travel" OR cycling OR walkability AND obesity OR overweight OR "physical inactivity" OR "sedentary behaviour"
- "nutrition labelling" OR "food labelling" AND diet OR nutrition OR obesity OR overweight
- "tobacco control" OR "smoke free policy" OR "smoke free laws"

Filters

- 2010-2020
- Australia, NZ, UK, Canada
- filetype:pdf
- Title, keyword, abstract searching.

Appendix B: Inclusion and exclusion criteria

Review question 1

What are the economic and health costs of high body mass, poor diet, insufficient physical activity and tobacco use?

	Inclusion	Exclusion
Date	2015–2020	<2015
Language	English	Non-English language
Country	Australia	Other countries not listed
Publication or study type	Scientific literature: <ul style="list-style-type: none"> • Systematic review • Umbrella review • Meta-analysis Grey literature: <ul style="list-style-type: none"> • Burden of Disease study • Evidence Check/review • Report 	Other publication types not listed, including other types of non-systematic reviews
Risk factors	<ul style="list-style-type: none"> • Poor/unhealthy diet • Physical inactivity and sedentary behaviour • Overweight, obesity, BMI • Tobacco use and smoking 	Any other risk factors not listed
Population	<ul style="list-style-type: none"> • Adults • Children 	
Primary outcomes	The publication or study must include at least one of these outcomes or measures: <ul style="list-style-type: none"> • Proportion of economic costs attributable to at least one (or more) of the 4 risk factors. These costs include: <ul style="list-style-type: none"> ○ Healthcare costs ○ Productivity costs ○ Non-healthcare costs and other government expenditure (e.g. Welfare) • Proportion of morbidity or mortality (health costs or health burden) attributable to at least one (or more) of the 4 risk factors. This includes: <ul style="list-style-type: none"> ○ Morbidity measures – DALYs, YLLs, QALYs, HALYs ○ Mortality – e.g. number of deaths. 	<ul style="list-style-type: none"> • Prevalence of risk factors • Association or relationship between the risk factors and other outcomes

Review question 2

What are the health, social and economic benefits of primary prevention strategies which address high body mass, poor diet, insufficient physical activity and tobacco use; and which strategies are most cost-effective?

	Inclusion	Exclusion
Date	2015–2020	<2015
Language	English	Non-English language
Country	Scientific literature: <ul style="list-style-type: none"> High-income countries Grey literature: <ul style="list-style-type: none"> Australia Canada New Zealand United Kingdom International organisations 	<ul style="list-style-type: none"> Other countries not listed. Low- and middle-income countries.
Publication or study type	Scientific literature: (in order of priority as per the evidence hierarchy) <ul style="list-style-type: none"> Umbrella review (review of systematic reviews) and/or meta-review (review of meta-analyses) Systematic review and/or meta-analysis Grey literature: <ul style="list-style-type: none"> Review Evaluation Report 	Other publication types not listed, including protocols and non-systematic reviews
Risk factors	<ul style="list-style-type: none"> Poor/unhealthy diet Physical inactivity and sedentary behaviour Overweight, obesity, BMI Tobacco use and smoking 	Other risk factors not listed
Population	<ul style="list-style-type: none"> Adults Children Adolescents Older adults Pregnant women Employees General population Indigenous populations 	<ul style="list-style-type: none"> Healthcare workers and professionals People already with conditions or at high risk e.g. Obese persons; women with gestational diabetes; people with diagnosed pre-diabetes; existing smokers Specific sub-populations e.g. People with a mental illness or disability

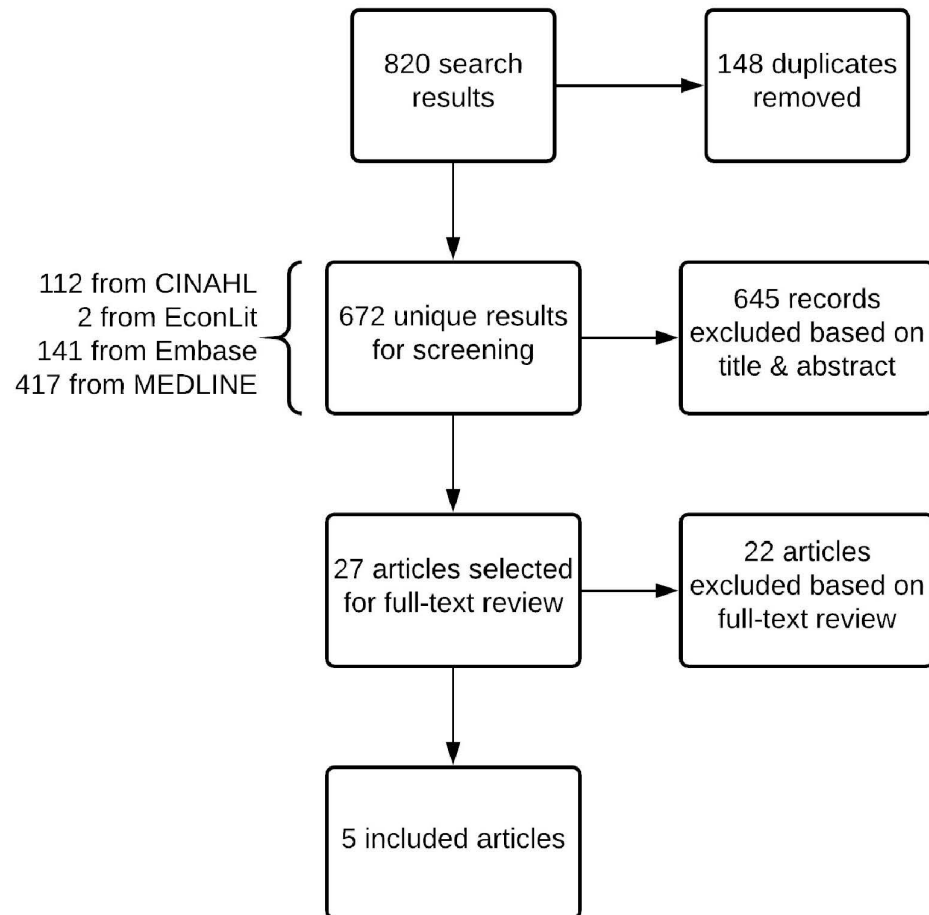
	Inclusion	Exclusion
Intervention	<p>One of the listed population-wide primary prevention interventions that addresses at least 1 or more of the 4 risk factors at a population level (i.e. In the whole population / already healthy or low risk population):</p> <ul style="list-style-type: none"> • Prevention • Social marketing • Mass media campaign • Policy • Regulation • Legislation • Taxation • Health promotion • Food labelling • Urban / city planning • Built environment • Healthy lifestyle programs • Active transport / active travel e.g. walking, cycling • Behavioural economics • Breastfeeding promotion • School-based programs or early childhood-based programs • e-Health and mHealth interventions • Any other setting-based program 	<ul style="list-style-type: none"> • Treatment • Secondary prevention (including screening) • Tertiary prevention • Smoking cessation • Weight loss or weight management • Pharmacotherapy • Surgery • Falls prevention • Healthcare or primary care interventions • Dietary or nutritional interventions e.g. Supplementation; putting people on specific clinical diets or feeding patterns
Primary outcomes	<p>The effectiveness, impact or benefit of the intervention which could include:</p> <ul style="list-style-type: none"> • Health benefits – including physical and mental health and benefits to the health system • Social benefits – including education, crime, welfare, productivity • Economic benefits – including cost-effectiveness, return on investment, cost benefit • Other benefits – such as environmental benefits • Any other measure of effectiveness or impact 	<ul style="list-style-type: none"> • Implementation or feasibility of interventions • Methodological reviews of interventions

Appendix C: PRISMA flow diagrams

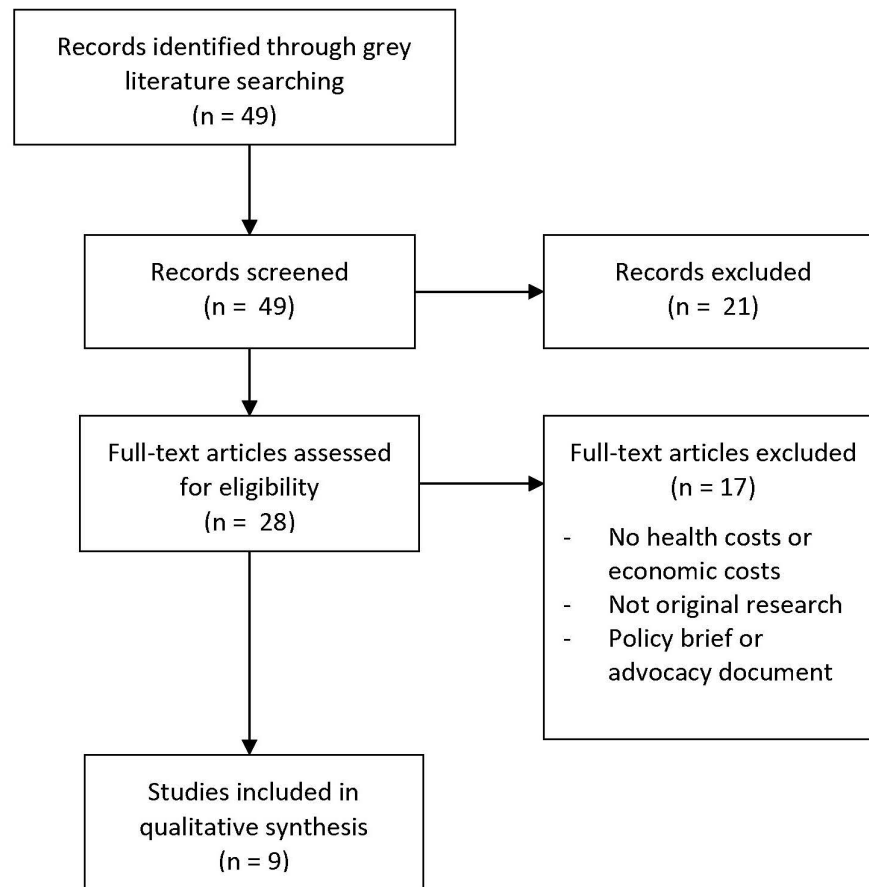
Review question 1

What are the economic and health costs of high body mass, poor diet, insufficient physical activity and tobacco use?

Peer-reviewed literature



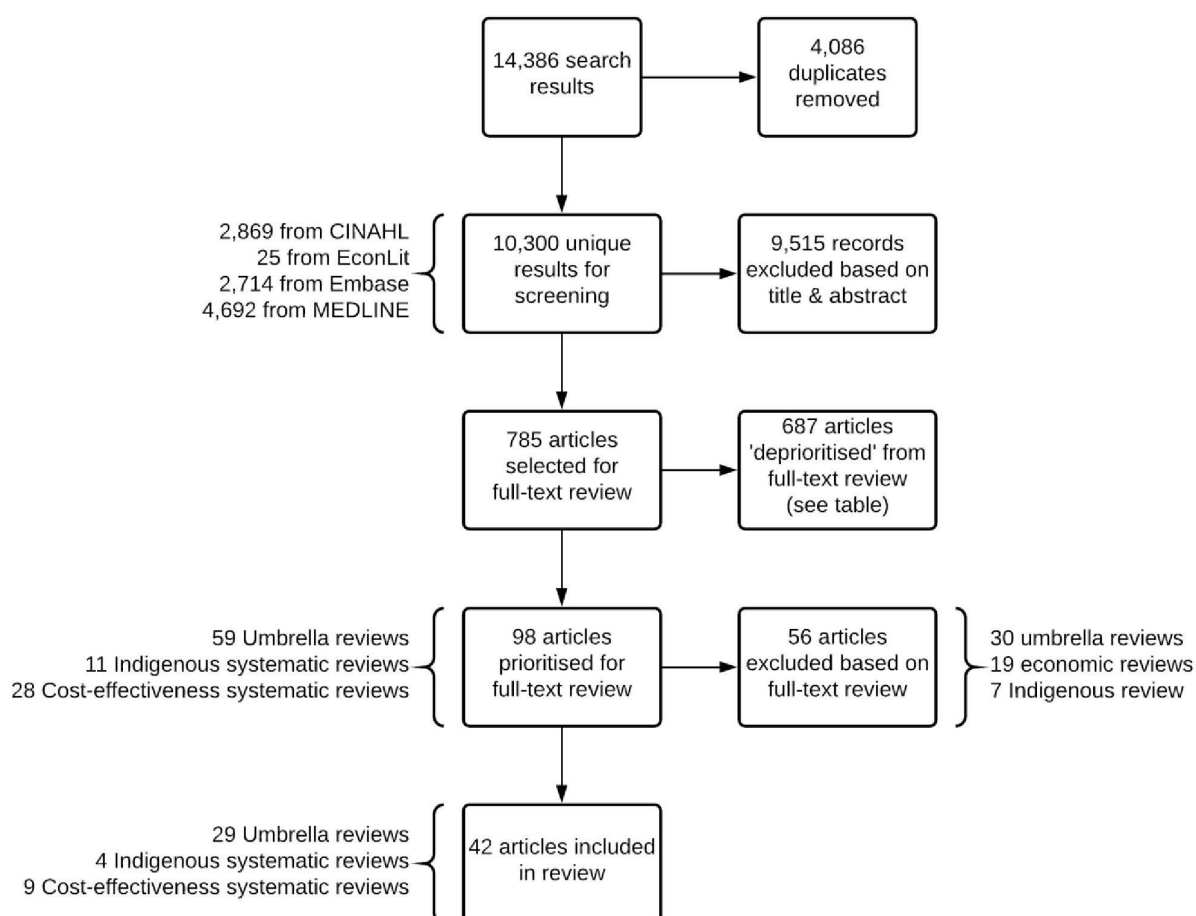
Grey literature



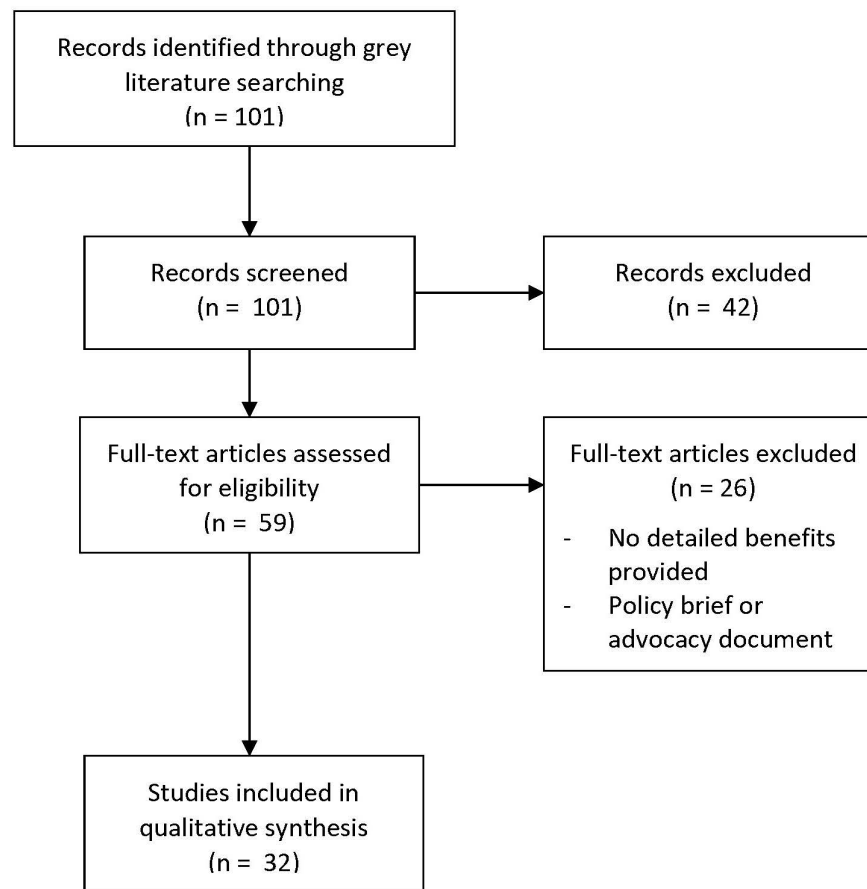
Review question 2

What are the health, social and economic benefits of primary prevention strategies which address high body mass, poor diet, insufficient physical activity and tobacco use; and which strategies are most cost-effective?

Peer-reviewed literature



Grey literature



Appendix D: Included studies

Review question 1

Study ID	Publication type	Risk factor	No. of included studies
AIHW 2017	Government report	Overweight and obesity	Not specified
AIHW 2019a (ABDS 2015)	Government report	Multiple risk factors	Original analysis
AIHW 2019b (ABDS 2015)	Government report	Tobacco use	Original analysis
Barnsley 2017	Report	Physical inactivity	Original analysis
Beswick 2020	Government report	Overweight and obesity	Original analysis
Crosland 2019a	Systematic review	Multiple risk factors	11
Crosland 2019b	Systematic review	Multiple risk factors	18
Di Angelantonio 2016	Systematic review with meta-analysis	Overweight and obesity	239
Hoque 2016	Systematic review	Overweight and obesity	17 in total; 3 on Australia
NSW MoH 2020	Government report	Overweight and obesity	Original analysis
PwC 2015	Report	Overweight and obesity	Original analysis
Sanders 2015	Systematic review	Overweight and obesity	47
Teager 2019	Report	Multiple risk factors	Original analysis
Whetton 2019	Report	Tobacco use	Original analysis

Review question 2

Study ID	Title	Publication type	No. reviews or studies included	Primary risk factor targeted	Primary prevention strategy
Abu-Omar 2017	The cost-effectiveness of physical activity interventions: A systematic review of reviews	Umbrella review (CE)	18	Physical inactivity	Multiple strategies
Amini 2015	Effect of School-based Interventions to Control Childhood Obesity: A Review of Reviews	Umbrella review	8	Overweight and obesity	Settings-based health promotion
Ananthapavan 2018	Assessing Cost-Effectiveness of Obesity Prevention Policies in Australia 2018 (ACE-Obesity Policy)	Report	Original analysis	Overweight and obesity	Multiple strategies
Ashman 2017	Factors Associated with Effective Nutrition Interventions for Pregnant Indigenous Women: A Systematic Review	Systematic review (Indigenous populations)	27	Unhealthy diet	Multiple strategies
Astell-Burt 2015	The effect of urban form on wellbeing: an Evidence Check rapid review brokered by the Sax Institute for the NSW Centre for Population Health	Review – Evidence Check	103	Physical inactivity	Built environment and transport
Atusingwize 2015	Economic evaluations of tobacco control mass media campaigns: a systematic review	Systematic review (CE)	10	Tobacco use	Mass media campaigns
Australian Government Department of Health 2016	Post-Implementation Review Tobacco Plain Packaging 2016	Evaluation	Original analysis	Tobacco use	Regulation and policies
Bardus 2016	Mobile and Web 2.0 interventions for weight management: an overview of review evidence and its methodological quality	Umbrella review	44	Overweight and obesity	Healthy lifestyle
Bell 2016	The Obesity Prevention and Lifestyle (OPAL) program evaluation	Evaluation	Original analysis	Overweight and obesity	Multiple strategies

Study ID	Title	Publication type	No. reviews or studies included	Primary risk factor targeted	Primary prevention strategy
Bell 2018	Healthy mothers and babies – a life-course approach: an Evidence Check rapid review brokered by the Sax Institute for the NSW Ministry of Health	Review – Evidence Check	22 programs, 10 reviews	Multiple risk factors	Settings-based health promotion
Bes-Rastrollo 2016	Impact of sugar taxation on body weight control: a comprehensive literature review	Umbrella review	71	Overweight and obesity	Fiscal
Bird 2018	Built and natural environment planning principles for promoting health: an umbrella review	Umbrella review	117	Multiple risk factors	Built environment and transport
Bowen 2015	The evidence base for linkages between green infrastructure, public health and economic benefit	Review	>50	Multiple risk factors	Built environment and transport
Browne 2018	Food and nutrition programs for Aboriginal and Torres Strait Islander Australians: an overview of systematic reviews	Umbrella review	12	Unhealthy diet	Healthy lifestyle
Byrne 2018	Evaluation of the Foodbank WA School Breakfast and Nutrition Education Program: Final Report	Evaluation	Original analysis	Unhealthy diet	Settings-based health promotion
Cauchi 2016	Environmental components of childhood obesity prevention interventions: an overview of systematic reviews	Umbrella review	63	Overweight and obesity	Settings-based health promotion
Chamberlain 2017	Evidence for a comprehensive approach to Aboriginal tobacco control to maintain the decline in smoking: an overview of reviews among Indigenous peoples	Umbrella review	21	Tobacco use	Multiple strategies
Comans 2019	Community-based health promotion for older adults: an Evidence Check rapid review brokered by the Sax Institute	Review – Evidence Check	26	Physical inactivity	Healthy lifestyle

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Craike 2018	Interventions to improve physical activity among socioeconomically disadvantaged groups: an umbrella review	Umbrella review	17	Physical inactivity	Multiple strategies
Duckett 2016	A sugary drinks tax: recovering the community costs of obesity	Report	Original analysis	Overweight and obesity	Fiscal
Ernst & Young 2018	Evaluation of the tobacco excise increases as a contributor to Smokefree 2025	Evaluation	N/A	Tobacco use	Fiscal
Frontier Economics 2019	Health benefits from water centric livable communities: a report prepared for the Water Services Association of Australia (WSAA)	Report	Approx. 100	Physical inactivity	Built environment and transport
Gebreslassie 2020	Economic evaluations of public health interventions for physical activity and healthy diet: A systematic review	Systematic review (CE)	32	Multiple risk factors	Multiple strategies
Gelius 2020	What are effective policies for promoting physical activity? A systematic review of reviews	Umbrella review	23	Physical inactivity	Regulation and policies
Global Obesity Centre (GLOBE) and Obesity Policy Coalition 2017	Tipping the Scales: Australian Obesity Prevention Consensus	Report	N/A	Overweight and obesity	Multiple strategies
Goldthorpe 2019	Are primary / elementary school-based interventions effective in preventing / ameliorating excess weight gain? A systematic review of systematic reviews	Umbrella review	10	Overweight and obesity	Settings-based health promotion
Gouldson 2018	The Economic and Social Benefits of Low-Carbon Cities: A Systematic Review of the Evidence	Review	>700	Physical inactivity	Built environment and transport
Greenhalgh 2020	Economic evaluations of tobacco control interventions	Book chapter	Original analysis	Tobacco use	Multiple strategies

Study ID	Title	Publication type	No. reviews or studies included	Primary risk factor targeted	Primary prevention strategy
Gwynne 2019	Effect of nutrition interventions on diet-related and health outcomes of Aboriginal and Torres Strait Islander Australians: a systematic review	Systematic review (Indigenous populations)	26	Unhealthy diet	Multiple strategies
Hall 2015	Mobile Text Messaging for Health: A Systematic Review of Reviews	Umbrella review	15	Multiple risk factors	Healthy lifestyle
Harris 2019	Review of effectiveness of certain healthy lifestyle interventions to reduce alcohol consumption, increase levels of physical activity and healthy eating and reduce overweight and obesity	Review – Evidence Check	99	Multiple risk factors	Multiple strategies
Health Technology Analysts Pty Ltd 2020	The Potential Impact of Salt Reduction in Australia	Report	Original analysis	Unhealthy diet	Multiple strategies
Heart Foundation of Australia 2019	Blueprint for an active Australia: National Heart Foundation of Australia	Report	N/A	Physical inactivity	Multiple strategies
Hoffman 2015	Overview of systematic reviews on the health-related effects of government tobacco control policies	Umbrella review	59	Tobacco use	Multiple strategies
Hope 2017	A systematic review of economic evaluations of population-based sodium reduction interventions	Systematic review (CE)	14	Unhealthy diet	Multiple strategies
Hyseni 2017	The effects of policy actions to improve population dietary patterns and prevent diet-related non-communicable diseases: scoping review	Umbrella review	58	Unhealthy diet	Multiple strategies
Kirkpatrick 2018	Gaps in the Evidence on Population Interventions to Reduce Consumption of Sugars: A Review of Reviews	Umbrella review	12	Unhealthy diet	Multiple strategies

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Korber 2015	Quality assessment of economic evaluations of health promotion programs for children and adolescents—a systematic review using the example of physical activity	Systematic review (CE)	14	Physical inactivity	Multiple strategies
Littlewood 2020	Interventions to prevent or treat childhood obesity in Māori & Pacific Islanders: a systematic review	Systematic review (Indigenous populations)	6	Overweight and obesity	Multiple strategies
Mandic 2019	Turning the Tide - from Cars to Active Transport	Report	N/A	Physical inactivity	Built environment and transport
Mannocci 2019	What public health strategies work to reduce the tobacco demand among young people? An umbrella review of systematic reviews and meta-analyses	Umbrella review	13	Tobacco use	Multiple strategies
Matwiejczyk 2018	Characteristics of Effective Interventions Promoting Healthy Eating for Pre-Schoolers in Childcare Settings: An Umbrella Review	Umbrella review	12	Unhealthy diet	Settings-based health promotion
McKinnon 2016	Obesity-Related Policy/Environmental Interventions: A Systematic Review of Economic Analyses	Systematic review (CE)	27	Overweight and obesity	Multiple strategies
Mounsey 2020	The macroeconomic impacts of diet-related fiscal policy for NCD prevention: A systematic review	Systematic review (CE)	11	Unhealthy diet	Fiscal
Pelletier 2017	A systematic review of physical activity interventions to improve physical fitness and health outcomes among Indigenous adults living in Canada	Systematic review (Indigenous populations)	5	Physical inactivity	Healthy lifestyle
Perez-Cueto 2019	An Umbrella Review of Systematic Reviews on Food Choice and Nutrition Published between 2017 and-2019	Umbrella review	26	Unhealthy diet	Multiple strategies

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Pikora 2016	Chronic disease prevention interventions in children and young adults: A rapid review	Review	119	Multiple risk factors	Multiple strategies
Proper 2019	The effectiveness of workplace health promotion interventions on physical and mental health outcomes – a systematic review of reviews	Umbrella review	23	Multiple risk factors	Settings-based health promotion
Psaltopoulou 2019	Prevention and treatment of childhood and adolescent obesity: a systematic review of meta-analyses	Umbrella review	66	Overweight and obesity	Multiple strategies
PwC 2015	Weighing the cost of obesity: A case for action	Report	Original analysis	Overweight and obesity	Multiple strategies
Queensland Government 2017	An Integrated Approach for Tackling Childhood Overweight and Obesity in Queensland. An overview	Report	N/A	Overweight and obesity	Multiple strategies
Reilly 2019	Physical activity interventions in early life aimed at reducing later risk of obesity and related non-communicable diseases: A rapid review of systematic reviews	Umbrella review	23	Overweight and obesity	Multiple strategies
Roberts 2019	Efficacy of population-wide diabetes and obesity prevention programs: An overview of systematic reviews on proximal, intermediate, and distal outcomes and a meta-analysis of impact on BMI	Umbrella review	53	Overweight and obesity	Multiple strategies
Rowbotham 2017	Effective whole-of-population strategies for preventing chronic disease. A rapid evidence review	Review	48	Multiple risk factors	Multiple strategies
Sacks 2019	Population-level strategies to support healthy weight: an Evidence Check rapid review brokered by the Sax Institute	Review – Evidence Check	89 systematic reviews; 16 additional studies	Overweight and obesity	Multiple strategies

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Schorling 2017	Cost-effectiveness of salt reduction to prevent hypertension and CVD: a systematic review	Systematic review (CE)	14	Unhealthy diet	Multiple strategies
Shackleton 2016	School-Based Interventions Going Beyond Health Education to Promote Adolescent Health: Systematic Review of Reviews	Umbrella review	30	Tobacco use	Settings-based health promotion
Stacey 2017	Evidence of the Potential Effectiveness of Centre-Based Childcare Policies and Practices on Child Diet and Physical Activity: Consolidating Evidence from Systematic Reviews of Intervention Trials and Observational Studies	Umbrella review	22	Multiple risk factors	Settings-based health promotion
Stead 2019	Mass media to communicate public health messages in 6 health topic areas: a systematic review and other reviews of the evidence	Umbrella review	112	Multiple risk factors	Mass media campaigns
Stockings 2016	Prevention, early intervention, harm reduction, and treatment of substance use in young people	Umbrella review	414	Tobacco use	Multiple strategies
Swift 2016	Impact of the Cycle to Work Scheme: Evidence Report	Report	Original analysis	Physical inactivity	Built environment and transport
Task Force on Fiscal Policy for Health	Health Taxes to Save Lives: Employing Effective Excise Taxes on Tobacco, Alcohol, and Sugary Beverages	Report	Original analysis	Multiple risk factors	Fiscal
Thomson 2018	The effects of public health policies on health inequalities in high-income countries: an umbrella review	Umbrella review	29	Multiple risk factors	Multiple strategies

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Toumbourou 2016	Healthy lifestyle choices in children: an Evidence Check rapid review brokered by the Sax Institute for the NSW Ministry of Health	Review – Evidence Check	39	Overweight and obesity	Settings-based health promotion
US National Cancer Institute 2016	The Economics of Tobacco and Tobacco Control	Report	N/A	Tobacco use	Multiple strategies
Van den Bosch 2017	Urban natural environments as nature-based solutions for improved public health – A systematic review of reviews	Umbrella review	13	Multiple risk factors	Built environment and transport
White 2016	Physical Activity and Exercise Interventions in the Workplace Impacting Work Outcomes: A Stakeholder-Centered Best Evidence Synthesis of Systematic Reviews	Umbrella review	18	Physical inactivity	Settings-based health promotion
Wilson 2018	Sugar taxes: A review of the evidence	Review	47	Unhealthy diet	Fiscal
World Health Organization 2015	The economic and health benefits of tobacco taxation	Report	N/A	Tobacco use	Fiscal
Zanganeh 2019	A systematic review of methods, study quality, and results of economic evaluation for childhood and adolescent obesity intervention	Systematic review (CE)	39	Overweight and obesity	Multiple strategies
Zapata-Diomedes 2015	The effects of urban form on health: costs and benefits	Review – Evidence Check	39	Physical inactivity	Built environment and transport
Zubala 2017	Promotion of physical activity interventions for community dwelling older adults: A systematic review of reviews	Umbrella review	19	Physical inactivity	Healthy lifestyle