Assessing Cost-Effectiveness in Prevention

ACE–Prevention

September 2010

Theo Vos[1], Rob Carter[2], Jan Barendregt[1], Cathrine Mihalopoulos[2], Lennert Veerman[1], Anne Magnus[2], Linda Cobiac[1], Melanie Bertram[1], Angela Wallace[1]

For the ACE–Prevention team

FINAL REPORT




With the support of

[1] Centre for Burden of Disease and Cost-Effectiveness, School of Population Health, University of Queensland
[2] Deakin Health Economics, Strategic Research Centre–Population Health, Deakin University, Victoria

This report was produced jointly by the Centre for the Burden of Disease and Cost-Effectiveness, School of Population Health, University of Queensland, Brisbane and Deakin Health Economics, Strategic Research Centre–Population Health, Deakin University, Melbourne. The work was funded by the National Health and Medical Research Council (NHMRC Grant No.351558). The views expressed in this report are solely those of the authors and should not be attributed to the Department of Health and Ageing or the Minister for Health and Ageing.

The Aboriginal and Torres Strait Islander component of ACE-Prevention was supported by the Cooperative Research Centre for Aboriginal Health (CRCAH). In January 2010, the CRCAH was refunded by the CRC Program and renamed the Cooperative Research Centre for Aboriginal and Torres Strait Islander Health (CRCATSIH), and incorporated into The Lowitja Institute – Australia's National Institute for Aboriginal and Torres Strait Islander Health Research.

An electronic version of the full report and other summaries are available at: www.sph.uq.edu.au/bodce-ace-prevention

ISBN: 978-1-74272-006-7

Suggested citation: Vos T, Carter R, Barendregt J, Mihalopoulos C, Veerman JL, Magnus A, Cobiac L, Bertram MY, Wallace AL, ACE–Prevention Team (2010). Assessing Cost-Effectiveness in Prevention (ACE–Prevention): Final Report. University of Queensland, Brisbane and Deakin University, Melbourne.

Assessing Cost-Effectiveness in Prevention (ACE–Prevention)

Final Report

September 2010

Theo Vos
Rob Carter
Jan Barendregt
Cathrine Mihalopoulos
Lennert Veerman
Anne Magnus
Linda Cobiac
Melanie Bertram
Angela Wallace

For the ACE–Prevention team

NHMRC Grant No.351558

ACE–Prevention Final Report

Theo Vos, Jan Barendregt, Lennert Veerman, Linda Cobiac, Melanie Bertram, Angela Wallace

Centre for Burden of Disease and Cost-Effectiveness

School of Population Health, University of Queensland

Rob Carter, Cathrine Mihalopoulos, Anne Magnus

Deakin Health Economics, Strategic Research Centre–Population Health

Deakin University, Victoria

For the ACE–Prevention team

Foreword

An ageing population, population growth, technological advances and increasing expectations of the health system will continue to sharpen our focus on a system that delivers value for money.

Pressure to deliver more with Australian health budgets will continue to grow.

Ensuring our scarce health resources are directed to where they can be most effective in improving the health and quality of life of all Australians—particularly for those with the poorest health outcomes—is a crucial task for those managing our health systems.

This groundbreaking major five-year study, funded by the National Health and Medical Research Council (NHMRC), and run under the auspices of the Centre for Burden of Disease and Cost-Effectiveness at the University of Queensland and Deakin Health Economics at Deakin University, must be a foundation for a more effective system for health.

Expertly led by Professor Theo Vos of the University of Queensland, in association with Professor Rob Carter from Deakin University, this research underpins a comprehensive analysis of the value of many health advancement strategies to address the burden of preventable death and disease in Australia.

Importantly, the findings demonstrate how to achieve not only a more efficient system of health, but also a fairer system. The report's focus on deeply entrenched health inequalities facing Indigenous Australians paints a striking picture—we simply must do more to improve the physical and mental health of those experiencing social, economic or geographical disadvantage.

This report has evaluated the cost-effectiveness of 150 preventive health interventions, addressing areas such as mental health, diabetes, tobacco use, alcohol use, nutrition, body weight, physical activity, blood pressure, blood cholesterol and bone mineral density.

It challenges us to learn more from intervention experiences in tobacco control and sun safety, which have demonstrated enormous benefit in the past from well-targeted and sustained activity. Similar success is possible in areas such as alcohol use and obesity, which have received low levels of investment in past decades. Additional investment, however, should not be at the expense of continuing effort in the areas in which we are making inroads.

As the community and decision-makers become more aware of the need to allocate more resources to and take some tough decisions about prevention, it is vital that action be based on the best available evidence, not on speculation or anecdotal evidence. The importance of this landmark volume is that it shows the possibilities of evidence-based decision-making on prevention. It also clearly shows where more research is needed.

In addition to identifying what we must do *more* of, the report suggests what we should do *less* of, to achieve a healthier community and a health system that delivers better value for money.

This report is the largest and most rigorous evaluation of preventive strategies undertaken anywhere in the world, and challenges us to think more deeply about the value of health to society and the strategies to achieve a healthier and fairer society.

We invite you to use the learnings in this landmark report to guide your contribution to the debate on how we may design a system for health that values effectiveness, equity and efficiency, and how we can promote preventive action on the basis of the best available evidence.

Professor Mike Daube

President

Public Health Association of Australia

Todd Harper

Chief Executive Officer

Victorian Health Promotion Foundation

Contents

List of tables

List of figures

Acknowledgements

This project has received input from a number of people, whose time and commitment are greatly appreciated.

The authors would like to acknowledge contributions from all the researchers and doctoral and masters students on the project.

In the University of Queensland team: Daphni Chao, Hideki Higashi, Vittal Mogasale, Shahram Ghaffari, Siobhan Dickenson, Jun Feng, Farid Najafi, Megan Forster, Isaac Asamoah, Shamesh Naidoo, Greg Fowler, Utsana Tonmukayakul, Linda Kemp, Yong Yi Lee, Josh Byrnes and David Stein.

In the Deakin University team: Sophy Shih, Kiusiang Tay-Teo, Katherine Ong, Jonathan Anderson, Gary Sacks, Liliana Bulfone, Sandra Younie, Grace Kabaniha, Michael Otim, Simon Slota-Kan and Anita Lal.

The study was ably advised and guided throughout by a Project Steering Committee, an Indigenous Steering Committee and Technical Advisory Panels, the members of which are detailed on the following pages. The contributions of each group are gratefully acknowledged. Alan Lopez's guiding role as chairman also deserves special mention.

Administrative support has been vital and well provided by Sarah Calderwood, Amy Hunt, Amy McGloin, Trish Weston, Trish Sharkey, Itana Ponych, Naomi Herzog, Elena Stewart and Kaneeshka Prakash.

Project Steering Committee

Chief investigators

Name	Affiliation
Theo Vos	University of Queensland
Rob Carter	Deakin University
Alan Lopez	University of Queensland
Chris Doran	University of New South Wales
Andrew Wilson	Queensland University of Technology
Ian Anderson	University of Melbourne

Members

Name	Affiliation*
Peter Abernethy	National Heart Foundation of Australia
David Banham	Department of Health, South Australia
Bill Bellew	University of Queensland
Alan Coates	Cancer Council Australia
Jim Codde	Department of Health, Western Australia
Stephen Colagiuri	Diabetes Australia
Helen Dewey	National Stroke Research Institute
Helen Egan	Chronic Disease Prevention Alliance
Mark Elwood	National Cancer Control Initiative
John Goss	Commonwealth Department of Health and Ageing
Steve Guthridge	Department of Health and Ageing, Northern Territory
Michelle Haby	Department of Health, Victoria
Wayne Hall	University of Queensland
Todd Harper	Victorian Health Promotion Foundation
Brian Harrison	Commonwealth Department of Health and Ageing
David Hill	Cancer Council Victoria
Richard Juckes	Commonwealth Department of Health and Ageing
Erin Lalor	National Stroke Foundation
Timothy Mathew	Kidney Health Australia
Christopher McGowan	Primary Care Provider
John Ramsay	Department of Health and Human Services, Tasmania
Denise Robinson	New South Wales Health
Vijaya Sundararajan	Department of Health, Victoria
Boyd Swinburn	Deakin University
Roscoe Taylor	Department of Health and Human Services, Tasmania
Rob Walters	Australian Divisions of General Practice
Harvey Whiteford	University of Queensland
Tony Woollacott	Department of Health, South Australia

*The affiliations of the committee members shown are those for the time of their consultation and may no longer be current.

Indigenous Steering Committee

Members

Name	Affiliation*
Mick Gooda (Chair)	Cooperative Research Council for Aboriginal Health
Ian Anderson	University of Melbourne
Paula Arnol	Danila Dilba Biluru Butji Binnilutlum Health Service
Rachel Balmano	Department of Health and Ageing
Darren Benham	Office for Aboriginal and Torres Strait Islander Health
Alwin Chong	South Australian Aboriginal Health Council
Helen Egan	Chronic Disease Prevention Alliance
Melissa Haswell	University of New South Wales
Barbara Henry	Northern Territory Government
Shane Houston	Northern Territory Department of Health and Community Services
Margaret Kelaher	University of Melbourne
Dr Tricia Nagel	Menzies School of Health Research
Graeme Patterson	Office for Aboriginal and Torres Strait Islander Health
Jeff Richardson	Monash University
Kevin Rowley	University of Melbourne
David Thomas	Menzies School of Health Research
Komla Tsey	James Cook University
Dallas Young	James Cook University

*The affiliations of the committee members shown are those for the time of their consultation and may no longer be current.

Technical advisors

Topic area	Name	Affiliation*
Cancer	Suzanne Dobbinson	Cancer Council Victoria
	Dorota Gertig	Victorian Cervical Cytology Registry
		National HPV Vaccination Program Register
	Jen Makin	Cancer Council Victoria
	Craig Sinclair	Cancer Council Victoria
Cardiovascular disease	Steven Lim	University of Washington
	Anthony Rogers	University of Auckland
Nutrition and physical activity	Coral Colyer	National Heart Foundation of Australia
	Christina Stubbs	Queensland Health
Body mass	Boyd Swinburn	Deakin University
Diabetes	Jonathan Shaw	Baker IDI Heart and Diabetes Institute
Alcohol	Peter d'Abbs	James Cook University
	Donna Bull	Alcohol and other Drugs Council of Australia
	Tanya Chikritzhs	National Drug Research Institute
	Neil Donnelly	NSW Bureau of Crime and Statistics
	Wayne Hall	University of Queensland
	Robin Room	Turning Point
	Anthony Shakeshaft	National Drug and Alcohol Research Centre
	David Templeman	Alcohol and other Drugs Council of Australia
Tobacco	Majid Ezzati	Harvard School of Population Health
	Wayne Hall	University of Queensland
	Todd Harper	Victorian Health Promotion Foundation
	Alan Lopez	University of Queensland
Osteoarthritis	Scott Crawford	Prince Charles Hospital
Osteoporosis	John Eisman	Garvan Institute of Medical Research
	Phillip Sambrook	University of Sydney
Illicit drugs	Alan Clough	James Cook University
	Louisa Degenhardt	National Drug and Alcohol Research Centre
	Wayne Hall	University of Queensland
	George Patton	Royal Children's Hospital, Victoria
	Alison Ritter	National Drug and Alcohol Research Centre
	Robin Room	University of Melbourne
	Jenny Williams	University of Melbourne
Mental disorders	James Cui	Monash University

Topic area	Name	Affiliation*
	Pim Cuipers	Vrije Universiteit
	Barbara Hocking	SANE Australia
	Patrick McGorry	ORYGEN Youth Health
	Jane Pirkis	University of Melbourne
	Jaelea Skehan	Hunter Institute of Mental Health
	Ron Rappee	Macquarie University
	Filip Smit	Trimbos Institute (Utrecht, the Netherlands)
Kidney disease	Timothy Mathew	Kidney Health Australia
HIV	David Baker	East Sydney Doctors
	Levinia Crooks	Australasian Society for HIV Medicine
	Sean Emery	National Centre in HIV Epidemiology and Clinical Research, University of New South Wales
	Robert Finlayson	Taylor Square Private Clinic
	Andrew Grulich	National Centre in HIV Epidemiology and Clinical Research, University of New South Wales
	Jenny Hoy	Victorian HIV Service, Alfred Hospital
	Michael Kidd	Flinders University
	Cipri Martinez	Western Australia AIDS Council
	Marion Pitts	Australian Centre for Research in Sex Health and Society, Latrobe University
	Jo Watson	National Association of People Living with HIV/AIDS
	Bill Whittaker	National Association of People Living with HIV/AIDS
Indigenous health	Alex Brown	Baker IDI Heart and Diabetes Institute
	Sabina Knight	Centre for Remote Health
	Kevin Rowley	University of Melbourne
	John Wakerman	Centre for Remote Health
	Jane McQueen	Individual contribution
	Colin Mitchell	Individual contribution
	Linda Osman	Individual contribution
	Dick Sloman	Individual contribution
	Jo Smith	Individual contribution
	Reg Thorpe	Individual contribution
	Jim Thurley	Individual contribution

*The affiliations of the advisors shown are those for the time of their consultation and may no longer be current.

The views, methods and findings expressed in this report are not necessarily those of the members of the Steering Committees and the Technical Advisory Panels or the organisations to which the members belong.

Executive summary

0.1 Introduction

Governments are aware that *'informed purchasing'* is central to efforts to harness health expenditure growth and use available budgets more efficiently. Informed purchasing, however, requires reliable information on the costs and health outcomes of current practice and of options for change. Such information enables governments to:

- direct available resources towards best-practice cost-effective services;
- modify not cost-effective services to improve their cost-effectiveness;
- discontinue not cost-effective services that cannot be made more cost-effective or be justified on other compelling grounds; and
- target services to those in need, as opposed to people with low-risk profiles who are unlikely to benefit in a cost-effective manner.

Box 0.1 Overview of ACE–Prevention methods

In economic evaluation the costs and benefits of health interventions are compared to make a judgement about value for money; that is, to answer the question: 'relative to cost, does intervention A provide greater health benefits than intervention B?' ACE–Prevention makes an important contribution to the evidence base for priority setting in prevention by:

- its comprehensive evaluation of prevention for non-communicable disease in Australia;
- using comparable methods across all 150 interventions; and
- evaluating combinations of prevention approaches for major topic areas (such as alcohol, diet, cardiovascular risks) and for the most cost-effective interventions packages across topic areas.

To ensure valid comparisons between results:

- each intervention is modelled to apply to the relevant people in the 2003 Australian population and the costs and health outcomes are measured for as long as they occur, often over a lifetime;
- all results are expressed as a cost per disability-adjusted life year (DALY) averted, where:
  - the DALY is a measure of the difference in healthy time lived comparing an intervention scenario with 'current practice' or 'do nothing'; the disability adjustment reflects the severity of disease or disability. More DALYs 'saved' means a longer life, a life with less disability, or a combination of these;
  - costs take into account the expenditure required to implement each health intervention as well as the downstream consequences for disease treatment;
- best available evidence on effectiveness is derived from the international literature, preferably using estimates that are pooled across all available studies;
- costs and outcomes are modelled based on realistic expectations of how interventions would be implemented under routine health service conditions in Australia;
- uncertainty is explicitly quantified and presented around all results; and
- stakeholders from government, health non-government organisations, academia and service providers provided guidance to the researchers during the five-year course of the project and helped to formulate conclusions taking the technical results into consideration, together with other policy relevant considerations such acceptability, feasibility and equity.

In this report we present the results from a National Health and Medical Research Council Health Services Research Grant (ACE–Prevention). We evaluated 123 preventive interventions and 27 treatment interventions. We also adapted our general population models to estimate the cost-effectiveness of 21 interventions for the Indigenous population. ACE–Prevention is a significant achievement, more than doubling the published economic appraisal research on health promotion/illness prevention in Australia. While not purporting to be exhaustive, ACE–Prevention does provide an extensive and balanced coverage of the available evidence base for priority-setting in the prevention of non-communicable disease in Australia. Following are our main findings together with the strengths and limitations of our work and key messages. Box 0.1 provides an overview of ACE–Prevention methods.

0.2 Main findings for the general population

0.2.1 Results classified by size of health impact

A ***large impact*** on population health (i.e. >100,000 DALYs prevented per intervention) can be achieved by a limited number of cost-effective interventions (Table 0.1):

- taxation of tobacco, alcohol and unhealthy foods;
- a mandatory limit on salt in just three basic food items (bread, cereals and margarine);
- improving the efficiency of blood pressure- and cholesterol-lowering drugs using an absolute risk approach and choosing the most cost-effective generic drugs (or potentially introducing a low-cost polypill that combines three blood-pressure-lowering drugs and one cholesterol-lowering drug into one single pill);
- gastric banding for severe obesity; and
- an intensive SunSmart campaign.

Key second-stage filter considerations for these interventions are:

- the evidence base (Table 2.2) is 'likely' for the taxation and regulation interventions, 'sufficient' for the treatment interventions and 'limited' for SunSmart (based on a comparison of skin cancer rates between states);
- taxation and regulation changes have low implementation costs, but do involve 'political costs' that require political will to overcome;
- the proposed changes for blood pressure and cholesterol involve stakeholder acceptability issues for practitioners that would need to be carefully managed; and
- government subsidies for gastric banding would need to be accompanied by explicit guidelines, e.g. restricting access to people with severe obesity who have demonstrably failed to lose weight by diet and exercise.

There are more cost-effective interventions with a ***moderate impact*** on population health (between 10,000 and 100,000 DALYs prevented per intervention). The main missed opportunities at the national level among these are screening programs for pre-diabetes, chronic kidney disease and low bone mineral density in elderly women. There is good evidence for the effectiveness of the drug and lifestyle treatments that are recommended for the high-risk individuals identified by such screening programs. Smoking cessation aids, pedometers and mass media for physical activity are other approaches with moderate population health impact. We note that a considerable health impact of physical activity can be achieved without reducing body weight.

Of the cost-effective interventions with a ***small population health impact*** (<10,000 DALYs per intervention), the growing list of potential preventive measures for mental disorders deserves special mention. Hepatitis B and HPV vaccination are cost-effective measures for preventing cirrhosis and cancers.

Table 0.1 Lifetime health outcomes, intervention costs and cost offsets for the most cost-effective preventive interventions with the largest population health impact

Intervention	(Lifetime, discounted) DALYs prevented	Intervention costs (A$ billion)	Cost offsets (A$ billion)
Taxation			
Tobacco tax 30%	270,000	0.02	–0.7
Alcohol tax 30%	100,000	0.02	–0.5
Alcohol volumetric tax 10% above current excise on spirits	110,000	0.02	–0.7
Unhealthy foods tax 10%	170,000	0.02	–3.5
Regulation			
Mandatory salt limits on processed food	110,000	0.07	–1.5
Preventive treatments			
Three blood-pressure-lowering drugs to replace current practice of preventive drug treatments*	20,000	–1.9†	–0.3
Polypill to replace current practice*	60,000	–7.0†	–0.8
Laparoscopic gastric banding (body mass index >35)	140,000	3.7	–2.9
Health promotion			
Intensive SunSmart	120,000	2.0	–0.3

DALY, disability-adjusted life year

* We estimate a lifetime health benefit of 230,000 DALYs prevented from current practice. The polypill or a combination of blood-pressure-lowering drugs targeting by absolute cardiovascular disease risk and 'realistic' assumptions on uptake and adherence would lead to large cost savings and some greater health gain additional to the 230,000 DALYs of current practice (hence we classify these as interventions with a large impact greater than 100,000 lifetime DALYs).

† The current practice of blood pressure- and cholesterol-lowering treatments is inefficient and hence the negative costs (i.e. cost savings) if replaced by more efficient treatment.

0.2.2 Results classified by cost-effectiveness result

For clarity of presentation, we have 'triaged' our cost-effectiveness results into five categories and then within each category reported on broader issues that impact on policy decisions. The categories are:

- ***dominant***: interventions that both improve health and achieve net cost savings;
- ***very cost-effective***: interventions that improve health at a cost of less than $10,000 per DALY prevented;
- ***cost-effective***: interventions that improve health at a cost of between $10,000 and $50,000 per DALY prevented;
- ***not cost-effective***: interventions that improve health at a cost of more than $50,000 per DALY prevented; and
- ***dominated***: interventions for which more cost-effective alternatives are available.

In ACE–Prevention we assumed a decision threshold of '$50,000 per DALY prevented' to determine whether an intervention was 'cost-effective' or not. There is no consensus on the cut-off point for such a threshold, but there are rules of thumb related to available national income and empirical evidence on funding decisions. It is not uncommon to use GDP per capita as a reference point for national income. In the UK, for example, the National Institute for Health and Clinical Excellence has used a threshold (£20,000–30,000) that reflects the UK GDP per capita. Similarly, our threshold approximates the Australian GDP per capita. Our threshold also reflects available empirical evidence on what constitutes acceptable value for money in Australia, including recommendations of the Pharmaceutical Benefits Advisory Committee [1] and government decisions in public health [2, 3]. We add another threshold of $10,000 per DALY to distinguish very cost-effective interventions.

The results for the 123 preventive and 27 treatment interventions evaluated are classified by triage category in Table 0.2. All 150 interventions are included in Table 0.4 at the end of this Executive Summary (see Table 0.4), with full documentation (including multiple variations of some interventions) in Appendix 2 and discussion in Section 3. Our key observations are:

- Many interventions for prevention have very strong cost-effectiveness credentials (43 that are either dominant or cost less than $10,000 per DALY prevented). Such interventions should only be ignored if decision-makers have very serious reservations about the evidence base or are facing insurmountable problems in relation to stakeholder acceptability or feasibility of implementation.
- Another group of interventions (31) are good value for money compared to the decision threshold of less than $50,000 per DALY prevented.
- Many interventions for prevention have poor cost-effectiveness credentials (38); an insufficient evidence base (4); are associated with more harm than benefit ('dominated': 2); or are dominated by more cost-effective alternatives (2). It is vital to recognise that prevention is not always value for money and is not always 'better than cure'. These interventions should only be implemented if there are compelling social justice reasons to do so (e.g. the 'rule of rescue' or special equity needs) or, for dominated interventions, an important 'clinical place' rationale can be demonstrated.

Table 0.2 Cost-effectiveness results for preventive and treatment interventions by topic area: total population

Topic area	Total	Dominant	Very cost-effective ($0–10,000/DALY)	Cost-effective ($10,000–50,000/DALY)	Not cost-effective (>$50,000/DALY)	Dominated	Insufficient evidence
Preventive interventions							
Alcohol	9	4	3	2	–	–	–
Tobacco*	8	2	3	–	–	–	–
Physical activity	6	2	2	2	–	–	–
Nutrition	26	3	1	3	19		–
Body mass	9	1	1	2	4	–	1
Blood pressure/ cholesterol	13	2	2	7	–	2	
Osteoporosis	3	1	–	1	1	–	–
Illicit drugs	2	–	–	1	1	–	–
Cancer	9	–	–	5	3	1	–
Diabetes	7	–	–	5	1	1	–
Kidney disease	2	1	–	1	–	–	–
Mental disorders	11	2	5	2	1	–	1
Cardiovascular disease	1	–	–	–	–	–	1
Other prevention	11	4	1	–	5	–	1
Infectious disease	6	1	2	–	3	–	–
Total	**123**	**23**	**20**	**31**	**38**	**4**	**4**
Treatment interventions							
Alcohol	2	–	–	–	2	–	–
Illicit drugs	1	–	1	–	–	–	–
Cancer	1	–	–	1		–	–
Kidney disease	2	–	–	1	1	–	–
Mental disorders	10	1	4	5	–	–	–
Cardiovascular disease	5	–	1	2	2	–	–
Other treatment	6	1	2	1	–	–	2
Total	**27**	**2**	**8**	**10**	**5**	–	**2**

DALY, disability-adjusted life year

* Analyses for three tobacco control interventions have not yet been completed.

It follows that there are strong economic grounds to implement/expand interventions in the dominant and very cost-effective groups and contract/terminate interventions in the not cost-effective or dominated groups. The potential for such *informed purchasing* applies not only across different risk factor or disease areas, but also within priority problem areas. Nutrition, obesity, mental disorders and diabetes are vital areas for preventive action, for example, but all contain interventions that range from very cost-effective to not cost-effective.

Comparison of the preventive and benchmark interventions suggests that the benchmarks considered have a similar spread across the cost-effectiveness triage categories. The need for informed purchasing applies across the board – not just in prevention. It is worth mentioning that the benchmark interventions generally had stronger evidence credentials than the prevention group. The evidence platform for prevention must remain a focus in research and policy funding; particularly for policy initiatives and community-based interventions that have the potential to have large health impacts.

0.2.3 Optimal intervention mix for selected risk factors and health problems

For the main topic areas, we have analysed combinations of interventions to identify the optimal prevention mix. We can then contrast this against current practice; that is, the level at which these preventive interventions are currently implemented. This approach better reflects reality for many decision-makers, where interventions are normally combined into strategies to deal with policy issues. Also, the experience of decades of tobacco control suggests that a multi-pronged approach is required to successfully deal with a health problem [4, 5]. Our key findings are:

- Current practice in **blood pressure- and cholesterol-lowering** is inefficient. Large immediate cost savings are available if prevention is targeted by absolute risk rather than individual risk factor thresholds and if the most cost-effective, generic drugs are prescribed rather than expensive ones. If a polypill (a combination of three generic blood-pressure-lowering drugs – diuretic, calcium channel blocker and ACE (angiotensin-converting enzyme) inhibitor – at half strength and a statin in a single pill) were introduced at an annual cost of $200 per person treated, the immediate cost savings would be much greater still. The package would prevent more than 500,000 DALYs over the lifetime of the 2003 Australian population.
- A 10% tax on unhealthy foods and lap banding for very obese people could avert 270,000 DALYs caused by **obesity**. A diet and exercise program for overweight people identified in primary care, while considered cost-effective, would contribute just a tiny additional health gain to the package of obesity interventions.
- Taxation, advertising bans, an increase in minimum legal drinking age to age 21, brief intervention by a GP, licensing controls, drink driving mass media and random breath testing form the optimal mix of cost-effective **alcohol** control interventions. Of these, a 30% increase in tax, or a volumetric tax at 10% above the current excise on spirits, would achieve more than 90% of the 120,000 DALY health gain estimated for the package.
- Pedometers, mass media campaigns, GP interventions with or without referral to an exercise physiologist and TravelSmart (a program to encourage more active transport) can address 60,000 lifetime DALYs due to **physical inactivity**.
- Screening for **chronic kidney disease** and treatment with ACE inhibitors would lead to greater health gain than is currently achieved by the combined dialysis and kidney transplant program. This initiative would lead to large cost savings by preventing people from reaching end-stage kidney failure.
- We are yet to complete cost-effectiveness analyses of three tobacco control interventions. However, there is no doubt that past control measures have been effective, cost-effective and successful in reducing the prevalence of smoking in Australia. We have established that tobacco tax increases and cessation aids are very cost-effective interventions. The potential for health gain from smoking cessation or prevention of smoking uptake is so great that additional regulatory and mass media approaches are likely to be very cost-effective.

0.2.4 Cost-effectiveness of combined intervention packages

The different risk factor and disease interventions in the 'dominant' and 'very cost-effective' triage groups have been modelled independently, but many have common disease outcomes. To determine the combined effect of these interventions on the total costs and health outcomes of the intervention packages, the interventions have been re-evaluated in a model that integrates all relevant risk factors and disease parameters. For comparison, we also simulated current practice. The key results are:

- The package of 20 'dominant' interventions could avert one million DALYs over the lifetime of the 2003 Australian population. Eighty per cent of this health gain could be achieved with the taxation and regulation interventions on salt, alcohol and tobacco, and the polypill for cardiovascular disease prevention.
- The 'dominant' intervention package would cost $4.6 billion, but could avert $11 billion in health care costs. Fourteen per cent of the investment would be required in the first year, with lower annual costs thereafter for ongoing delivery of drugs for cardiovascular disease prevention. The healthcare costs saved would reach a peak around 12 years after intervention.
- Costs of implementing the 'dominant' package are substantially less than those for blood pressure- and cholesterol-lowering drugs for preventing cardiovascular disease. The taxation and regulation interventions also reduce the need for cardiovascular disease drugs that remain expensive even if prescribed most efficiently.
- Adding interventions with cost-effectiveness between zero and $10,000 per DALY prevented to the 'dominant' package leads to substantially greater upfront costs of intervention. Total cost of the 'dominant' and 'very cost-effective' package would be $13 billion, but this would be more than matched over time by $14 billion in reduced costs of health care. A total of 1.4 million DALYs would be averted, 400,000 DALYs more than for the 'dominant' package alone.

0.3 Main findings for the Indigenous population

Our decision to undertake separate analyses for the Indigenous population reflects our experience that key evaluation parameters are all significantly different. These include the target disease burden; the prevalence and distribution of harmful exposures; the effectiveness of intervention strategies; the type of effective health service models; the acceptability to stakeholders; and the cost of implementing interventions. To inform policy decisions, health services need to be evaluated separately for the Indigenous and non-Indigenous populations, but undertaken in a way that enables meaningful analysis across and within these two populations. What makes this task more challenging is that conventional cost-effectiveness information may not provide sufficient economic guidance in Indigenous health, where 'community health gain' and 'cultural security' have special significance. Here we report on the cost-effectiveness results in a select number of topic areas for the Indigenous population achieved under the ACE–Prevention project. Further work is planned to extend this research program and to include separate analyses using an Indigenous concept-of-benefit, as well as outcomes measured in DALYs.

Our results that involve adaptation of mainstream analyses were either assumed to operate from mainstream health services, with model parameters adjusted for target population, participation and adherence rates; or they were assumed to operate from Aboriginal community controlled health services (ACCHS), with model parameters adjusted using our Indigenous Health Service Delivery Template. The template adjusted cost parameters as well as participation and adherence assumptions.

0.3.1 Cost-effectiveness results

In Section 4 we report on 19 interventions (Table 4.4) that were adapted from analyses undertaken for the general population (17 prevention and 2 treatment interventions). In Table 0.3, these results are presented in the cost-effectiveness triage categories. Interventions that were modelled separately for delivery by mainstream health services and by ACCHS have been counted once. For the Indigenous population results, we included an additional cost-effectiveness category ($50,000–150,000 per DALY prevented) in recognition of the special equity considerations that apply to Indigenous health.

The key results are:

- The polypill (at $200 per person per year) is a cost-saving intervention if delivered via mainstream services to all Indigenous Australians over the age of 35. Delivery by ACCHS is very cost-effective, but no longer cost-saving. Delivery by ACCHS would, however, lead to greater health gain because of improved Indigenous access to health services (via greater utilisation of services and adherence to treatment).
- Of the individual drugs, diuretics and ACE inhibitors delivered by mainstream services are cost-effective, but the addition of statins or the delivery of ACE inhibitors by ACCHS have a cost-effectiveness ratio one to three times the decision threshold for the total population ($50,000 per DALY prevented). It is important to note, however, that equity concerns could be expressed as a greater willingness to pay more for the same health gain.
- Vaccination for hepatitis B and screening for chronic kidney disease are cost-saving or very cost-effective interventions because of the high rates of disease in the Indigenous population. Screening for pre-diabetes followed by drug (metformin or acarbose) and lifestyle interventions is cost-effective. As in the total population the cost-effectiveness ratio for dialysis and transplant is higher than $50,000 per DALY but the same argument applies: that it is established life-saving practice and unlikely to change.
- While the Looma lifestyle intervention (a community-based intervention encouraging physical activity and healthy eating practices) would rate highly on cultural security, it has very poor cost-effectiveness credentials measured as a 'traditional' cost per DALY prevented. This reflects the small change in risk factor levels measured during the study. Further evaluation would be warranted using an expanded concept-of-benefit measurement, which is under development.
- Application of an equity weight would improve the cost-effectiveness of all the Indigenous population results, but this adjustment is still work in progress.

Table 0.3 Cost-effectiveness results for preventive and treatment interventions by topic area: Indigenous population

Topic area	Total	Dominant	Very cost-effective ($0–10,000/DALY)	Cost-effective ($10,000–50,000/DALY)	Not cost-effective ($50,000–150,000/DALY)	Not cost-effective (>$150,000/DALY)	Dominated or insufficient evidence
Blood pressure/ cholesterol	5	–	1	1	2	1	–
Diabetes	7	–	–	5	1	1	–
Kidney disease	4	2	–	–	2		–
Hepatitis B	3	3	–	–	–		–
Total	**19**	**5**	**1**	**6**	**5**	**2**	**0**

DALY, disability-adjusted life year

0.4 Strengths and limitations

The greatest strength of ACE–Prevention is the number of interventions evaluated using consistent methods. We covered the most important strategies for main diseases and risk factors. While greater detail is possible within topic areas, we are confident that we provide a comprehensive overview of the current evidence base of prevention and how it applies to the context of Australian health services.

Another important strength is that ACE–Prevention couples a large volume of work with technical rigour. Key factors in achieving technical rigour are:

- Interventions were evaluated as an integral part of the work on priority-setting in prevention using consistent methods and assumptions.
- Best available evidence of efficacy was evaluated and adjusted to reflect effectiveness under routine health service conditions in Australia.
- Analyses are based on a comprehensive and consistent set of disease and risk factor parameters pertaining to the Australian population from the Australian Burden of Disease study [6].
- Costs of interventions and future disease treatment costs are based on Australian data and estimated in a consistent manner across all interventions following a detailed protocol.
- Cost-effectiveness results are presented with adjustment for uncertainty and variation in key assumptions.
- Cost-effectiveness results are also presented for the ideal package of interventions for major topic areas and can be contrasted with current practice to identify areas of inefficiency. This is important as decisions are not taken in isolation and the implementation of one intervention can influence the cost-effectiveness of another.
- While much of the research endeavour focused on ensuring the technical rigour of the cost-effectiveness analyses, we also put emphasis on 'due process' involving stakeholders from governments, health non-government organisations, academics and service providers. They provided invaluable advice on the selection of interventions, modelling methods, interpretation of results, formulation of policy-relevant recommendations and a dissemination strategy.

Weaknesses and/or methodological challenges in our research include:

- We could not include a number of prevention strategies for which there was no evidence of effectiveness. That is, there has been no long-term, independent, well-funded, sustained media campaign on alcohol and therefore no evidence on effectiveness. However, there is evidence that such media campaigns on tobacco have been effective. The least this suggests is that applying the same approach to other health problems has promise. We did include a cost-effectiveness analysis of a media campaign on physical activity, albeit based on limited evidence of effectiveness.
- Interventions were modelled targeting the Australian population of 2003 who would be eligible (depending on the focus of each intervention). This means that after the baseline year 2003, our models deal with a dwindling cohort rather than the dynamic Australian population over time.
- It was not possible to specify identical assumptions for the duration of all interventions. Some interventions are clearly implemented as a 'once-off' (taxation and regulation interventions); others are intended to extend for life; while a large number fall in between. We applied the principle that duration should be based on the inherent characteristics of the intervention in 'steady-state' operation.
- For many interventions there was little or no information in the literature on design characteristics that would sustain longer term impacts. We therefore incorporate a decay function as an important assumption in our models. This is one of the reasons we report less favourable cost-effectiveness ratios than other studies.
- A number of modelling approaches were used in ACE–Prevention. Importantly, our large combined model produced results of health gain that were systematically lower by up to 25% than those estimated in the individual risk factor models. The reasons for this 'model uncertainty' will be explored in greater detail in academic publications.

- While the inclusion of second-stage filter criteria has been welcomed and embraced by policy-makers, there are opportunities to add more empirical evidence to these considerations. An example is the work we started with the Indigenous Steering Committee on how to incorporate aspects of health benefits that are important to Indigenous Australians, such as community health gain and cultural security. Also remaining is a significant gap in the literature on how best to incorporate equity concerns into measures of efficiency for special needs groups.

0.5 Key messages and recommendations

ACE–Prevention has provided a solid platform for policy action on the prevention of non-communicable disease in Australia. In particular there is now sufficient evidence:

- to justify immediate funding of the most cost-effective opportunities for health gain through prevention and thereby reduce pressure on healthcare services. Recommended action includes:
  - a 30% increase in tax on tobacco (which is close to the 25% tax increase announced in the May 2010 budget);
  - a tax increase on alcohol, preferably changing to a volumetric taxation at a level 10% above the current excise on spirits;
  - a taxation of 10% on non-core unhealthy foods;
  - mandatory limits on salt in bread, margarine and cereals;
  - a shift to screening for absolute cardiovascular risk and targeted treatments with the most cost-effective generic drugs;
  - pursuit of the introduction of a low-cost generic polypill (not containing aspirin) for cardiovascular prevention;
  - expansion of access to lap band surgery for the severely obese; and
  - increased funding for SunSmart programs, accompanied by rigorous evaluation to strengthen the evidence base for its effectiveness.
- to make the tough but necessary reallocation of funding towards best-practice prevention activities with strong cost-effectiveness credentials and away from prevention activities with poor cost-effectiveness credentials, including:
  - inefficient current practice in cardiovascular preventive treatment;
  - prostate-specific antigen (PSA) testing for prostate cancer;
  - aspirin for primary prevention of cardiovascular disease;
  - most approaches promoting fruit and vegetable intake and weight loss programs; and
  - school-based illicit drug interventions.
- to argue for expanded funding of a larger package of health promotion and illness prevention interventions where funds can be spent wisely, particularly for those interventions either not implemented at all or under-funded. These include:
  - screening for pre-diabetes, chronic kidney disease, low bone mineral density in elderly women;
  - subsidising nicotine replacement therapies; and
  - a range of interventions promoting physical activity (pedometers, mass media, GP prescription or referrals).
- to introduce a number of cost-effective preventive interventions for mental disorders (screening for minor depression in adults, childhood depression and anxiety; problem-solving after a suicide attempt; and early psychosis intervention) accompanied by rigorous evaluation to expand the evidence base that is still thin and short-term; and
- to invest in evaluation research to contribute to the evidence base of prevention, particularly for policy initiatives and community-based interventions that have the potential to have large health impacts but that we had to model based on suggestive rather than solid evidence. This concerns most of the population-wide taxation, regulatory and mass media interventions.

Table 0.4 Interventions in ACE–Prevention

Intervention number*	Alcohol	Intervention type
1	Volumetric tax (revenue-neutral)	P
10	General tax 30%	P
14	Advertising bans	P
15	Minimum legal drinking age to 21	P
16	Brief intervention via GPs	P
17	Licensing controls	P
18	Drink drive mass media	P
19	Random breath testing	P
20	Brief intervention and telemarketing and support	P
195	Residential treatment and naltrexone	T
196	Residential treatment	T
	Tobacco	
21	Cessation aid: varenicline	P
22	Cessation aid: bupropion	P
23	Cessation aid: nicotine replacement therapy	P
28	Taxation +30% with indexation in line with inflation	P
29	Taxation +30%	P
34	Package of current population-wide strategies of tobacco control (not including taxation)	P
35	Brief intervention via GPs	P
36	QUIT line versus extended QUIT line	P
	Physical activity	
37	Pedometers	P
38	Mass media	P
39	TravelSmart	P
40	GP prescription	P
41	GP referral to exercise physiologist	P
42	Internet intervention	P
	Nutrition	
43–65	23 dietary counselling/health information interventions on fruit & vegetable intake [67–86]	P
66	Dietary advice on salt (>140 mmHg)	P
68	Tick program to reduce salt intake from processed food	P
69	Mandatory salt limits for processed food	P
	Body mass	
70	Lighten Up program: weight loss, fruit and vegetable intake, physical activity	P
71	Diet and exercise for BMI>25	P
72	Low-fat diet for BMI>25	P
73	Sibutramine for BMI>30	P
74	Orlistat for BMI>30	P
75	Front-of-pack 'traffic light' nutrition labelling	P
76	Taxation +10% on unhealthy food with indexation in line with inflation	P
77	Gastric banding for BMI>35	P
78	Weight Watchers	P
	Blood pressure and cholesterol	
79	Current practice	P
80	Community heart health program	P
81	Dietary counselling by a dietitian >5% CVD risk	P
84	Dietary counselling by a GP >5% CVD risk	P
87	Phytosterol supplementation >5% CVD risk	P
90	Statins >5% CVD risk	P
93	Statins and ezitimibe >5% CVD risk	P
96	Low-dose diuretics >5% CVD risk	P
99	Beta blockers >5% CVD risk	P
102	Calcium channel blockers >5% CVD risk	P
105	ACE inhibitors >5% CVD risk	P
111	Polypill $200 >5% CVD risk	P
132	Polypill $200, ages 55+	P

	Osteoporosis	
137	Screen and alendronate for women aged 70–89	P
138	Screen and raloxifene for women aged 70–90	P
139	Mass media campaign: physical activity	P
	Illicit drugs	
140	School-based drug prevention: Gatehouse project	P
141	Random roadside drug testing	P
196	CBT for individuals with cannabis dependence	P
	Cancer	
144	Pap screen 2-yearly for women from age 18 (current practice)	P
147	HPV DNA test screen 3-yearly from age 18	P
148	Pap and HPV DNA test screen 3-yearly for women from age 18	P
151	HPV vaccination and Pap screen 2-yearly for women from age 18	P
154	HPV vaccination and HPV DNA test screen 3-yearly from age 18	P
155	HPV vaccination and combined Pap and HPV DNA test screen 3-yearly for women from age 18	P
158	SunSmart program (with optimal investment)	P
159	Screen prostate cancer for men with PSA test	P
160	Anal cytology for men having sex with men	P
197	Trastuzumab for early breast cancer; 9-week course	T
	Diabetes	
167	Screen pre-diabetes and dietary advice	P
168	Screen pre-diabetes and exercise physiologist	P
169	Screen pre-diabetes and dietary advice and exercise physiologist	P
170	Screen pre-diabetes and drug: rosiglitazone	P
171	Screen pre-diabetes and drug: metformin	P
172	Screen pre-diabetes and drug: acarbose	P
173	Screen pre-diabetes and drug: orlistat	P
	Kidney disease	
174	Screen chronic kidney disease and ACE inhibitor (non-diabetics)	P
175	Screen chronic kidney disease and ACE inhibitor (diabetics)	P
200	Current renal replacement therapy versus dialysis only	T
201	Dialysis only	T
	Mental disorders	
176	Screen and bibliotherapy for prevention of depression	P
177	Screen and group psychological treatment for prevention of depression	P
178	Screen and psychological treatment for prevention of post-partum depression	P
179	Screen and psychological intervention for prevention of childhood/adolescent depression	P
180	Screen and bibliotherapy for the prevention of childhood/adolescent depression	P
181	Problem-solving therapy for reduction of deliberate self-harm (suicide)	P
182	Emergency contact cards for the reduction of deliberate self-harm (suicide)	P
183	Gun ownership legislation and gun buy-back scheme for reduction in suicide	P
184	Responsible media reporting for reduction of suicide	P
185	Treatment for individuals at ultra-high risk for psychosis	P
186	Parenting intervention for prevention of childhood anxiety disorders	P
202	TCAs for major depressive episodes plus 6 months continuation	T
203	SSRIs for major depressive episodes plus 6 months continuation	T
204	Individual CBT treatment of major depressive episodes by psychologist	T
205	Group CBT treatment of major depressive episodes by psychologist	T
206	Bibliotherapy for major depressive episodes	T
207	5-year maintenance therapy with TCAs following a major depressive episode	T
208	5-year maintenance therapy with SSRIs following a major depressive episode	T
209	Individual maintenance CBT by a psychologist	T
210	Group maintenance CBT by a psychologist	T
211	Early psychosis prevention and intervention centre	T
	Cardiovascular disease	
108	Aspirin	P
212	Early stenting for acute myocardial infarction	T
213	Angioplasty coated stents: general population	T
214	Bypass surgery and stents versus optimal medical treatment	T
215	Rehabilitation following acute myocardial infarction	T
216	Angioplasty with coated stents: diabetic population	T

	Other prevention	
161	Universal infant hepatitis B vaccination	P
163	Universal vaccine and additional immunoglobulin for infants born to hepatitis B carrier mothers	P
164	High-risk infant hepatitis B vaccination	P
166	Selective vaccine and immunoglobulin to infants born to hepatitis B carrier mothers	P
187	Screen by regular vision testing	P
188	Ranibizumab for age-related macular degeneration	P
189	Public water fluoridation for all towns >1000 people (89% coverage)	P
191	Annual dental check, ages 12–17: oral examination only	P
192	Annual dental check, ages 12–17: oral examination and X-ray and clean	P
193	Annual dental check, ages 12–17: oral examination, X-ray, clean, scale and sealant	P
225	*Varicella zoster* vaccination at age 50	P
	Infectious disease	
225	Universal influenza vaccination, ages 50–64	P
227	Needle exchange program for prevention of HIV and hepatitis	P
228	Intermittent pre-exposure prophylaxis for HIV	P
229	Circumcision for all men having sex with men for HIV	P
230	Early antiretrovirals for HIV	P
231	Post-exposure prophylaxis for HIV	P
	Other treatment	
218	Asthma clinic, including benefits from emergency department visits and days off from work	T
220	Hip replacement for osteoarthritis	T
221	Knee replacement for osteoarthritis	T
222	Eradication with triple therapy for *Helicobacter pylori* in patients with peptic ulcer	T
223	Eradication therapy for *Helicobacter pylori* infection in uninvestigated dyspepsia	T
224	*Helicobacter pylori* eradication for non-ulcer dyspepsia	T
	Kidney disease (Indigenous)	
275	Screen and drug: ACE inhibitor (remote, non-diabetics)	P
276	Screen and drug: ACE inhibitor (non-remote, non-diabetics)	P
277	Screen and drug: ACE inhibitor (remote, diabetics)	P
278	Screen and drug: ACE inhibitor (non-remote, diabetics)	P
280	Dialysis only	T
281	Current renal replacement therapy versus dialysis	T
	Diabetes (Indigenous)	
268	Screen and dietary advice	P
269	Screen and exercise physiologist	P
270	Screen and dietary advice and exercise physiologist	P
271	Screen and drug: rosiglitazone	P
272	Screen and drug: metformin	P
273	Screen and drug: acarbose	P
274	Screen and drug: orlistat	P
	Blood pressure and cholesterol (Indigenous)	
232	Looma healthy lifestyle: community-based intervention for remote Indigenous, ages 20+	P
236	Statins; ACCHSs, ages 35+	P
240	ACE inhibitors; ACCHSs, ages 35+	P
244	Diuretics; ACCHSs, ages 35+	P
260	Polypill $200; ACCHSs, ages 35+	P
	Other prevention (Indigenous)	
265	Universal infant hepatitis B vaccination	P
266	Selective hepatitis B vaccination and immunoglobulin for infants born to carrier mothers	P
267	Universal hepatitis B vaccination and additional immunoglobulin for infants born to carrier mothers	P

ACCHS, Aboriginal community controlled health service; ACE, angiotensin-converting enzyme; CBT, cognitive behavioural therapy; HIV, human immunodeficiency virus; HPV, human papillomavirus; P, prevention; PSA, prostate-specific antigen; T, treatment; TCA, tricyclic antidepressant; SSRI, selective serotonin re-uptake inhibitor

* See Appendix 2 for further details of intervention numbers.

1. Introduction

Making difficult decisions in health care is not a new task. Decisions about what services to provide and what opportunities to let go, about who receives health care and who misses out, are made continually in a multitude of healthcare settings. What is new, however, is the increasing attention that decision-makers are giving to *how* they make these difficult decisions. Governments, clinicians and academics are now paying increasing attention to explicit methods for setting priorities. Four key reasons are discussed in the international literature:

- growing evidence that the deployment of current resources is far from optimal [7–13] ;
- concerns about the continued growth in healthcare expenditure, fuelled by ageing populations and technology growth [14, 15];
- social justice concerns about leaving access to essential healthcare services to the 'free market' based on willingness and ability to pay rather than need [16]; and
- the desire to bring growing community aspirations and limited health budgets closer [17–21].

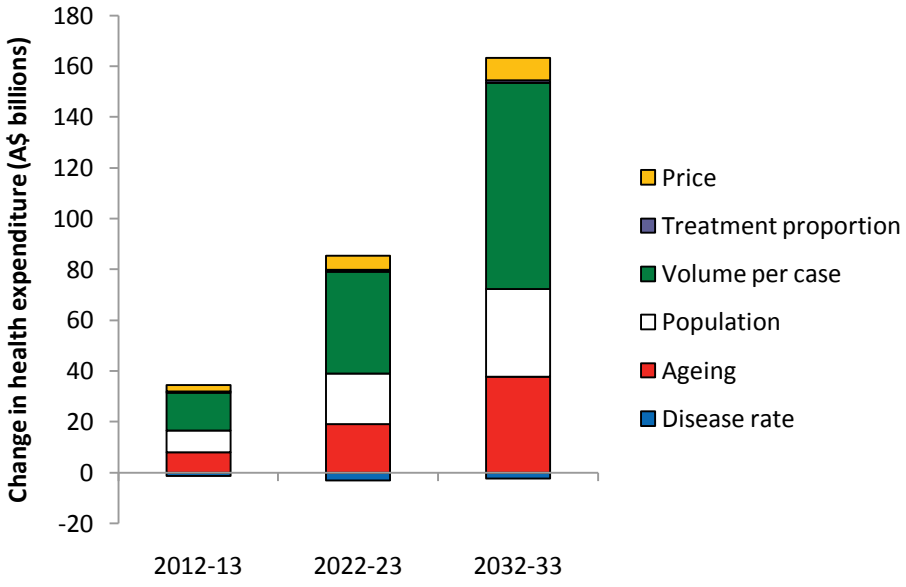


Figure 1.1 Breakdown by cost driver of projected change in total health and residential aged care expenditure, 2012–13 to 2032–33.

In Australia, for example, recent projections by the Australian Institute of Health and Welfare [14] have total health and residential aged care expenditure growing by 189% over the 2003 to 2033 period; increasing from $85 billion to $246 billion (an increase of $161 billion). This growth would increase health expenditure as a proportion of GDP from 9.3% to 12.4%. These estimates, whilst challenging in their own right, are lower than earlier estimates from the federal Treasury [22]. The projected increase of $161 billion (Table 1.1) in health expenditure is driven by an increase in the 'volume of services per case' ($81.3 billion; largely because of introduction of new technologies and changes in treatment practices and is expected to continue); an ageing population ($37.8 billion) and population growth ($34.4 billion) (Figure 1.1). These projections, however, and the underlying demographic, burden of disease and treatment practice assumptions, all reflect a 'business as usual' scenario. There is a growing appreciation amongst governments and their advisors that informed purchasing is central to efforts to harness this expenditure growth and use available budgets more efficiently. In short,

governments desperately need reliable information on the costs and health outcomes of current practice and of options for change that will enable them to:

- direct available resources towards best-practice cost-effective services;
- provide best-practice cost-effective services that address unmet need in the Australian community;
- modify not cost-effective services to improve their cost-effectiveness;
- discontinue not cost-effective services that cannot be made more cost-effective or cannot be justified on other compelling grounds;
- target services to those in need rather than to people with low-risk profiles who are unlikely to benefit in a cost-effective manner; and
- bundle services together into cost-effective strategies.

Table 1.1 Projected change in total health and residential aged care expenditure by disease category, 2002–03 to 2032–33

	Expenditure by year (A$ billion*)		Change (%)
Disease category	**2002–03**	**2032–33**	**2003–33**
Cardiovascular	9.3	22.6	143
Respiratory	7.2	22.0	206
Injuries	6.7	14.4	115
Dental	5.9	14.9	153
Mental	5.2	12.1	133
Digestive	4.9	16.5	237
Neurological	4.7	21.5	357
Musculoskeletal	4.4	14.2	223
Genitourinary	3.7	10.9	195
Cancer	3.5	10.1	189
Diabetes	1.6	8.6	438
Other†	28	78.3	180
Total	85.1	246.1	189

* 2006–07 dollars

† Includes other diseases and expenditure that cannot be assigned by disease

ACE–Prevention is a National Health and Medical Research Council-funded Health Services Research Grant designed to provide information for the prevention of non-communicable disease. We evaluate with rigorous epidemiological and health economic methods approximately 150 interventions for the general community, with adaptation to suit the Indigenous population of as many of these interventions as possible.

The goal of ACE–Prevention is thus to inform policy-makers about the most cost-effective bundle of preventive interventions given available resources and to illustrate the significance of an ongoing commitment to facilitating informed purchasing. But the provision of cost-effectiveness information is only part of the story. Governments need this information in a form that they can readily utilise in their decision-making. Policy relevance is greatly improved if this cost-effectiveness information is combined with information on broader issues that routinely impinge on healthcare decisions, such as affordability, equity of access, feasibility of implementation, reach and size of impact and quality of the evidence base. ACE methods have been designed to have regard to these broader policy issues through what we call our 'second-stage filter' analysis. Over a series of ACE studies, this element of our research has been highly regarded by stakeholders on our working groups [23–26].

Two aspects of the ACE approach to this task of priority-setting should be reassuring to decision-makers and the broader community:

- that it is underpinned by an explicit and detailed attempt to define what constitutes an 'ideal' approach to priority-setting, culminating in a published checklist and assessment of alternative approaches to priority-setting [26]; and
- that, as evidenced by the funding of a series of successful ACE studies [23–26], the resulting ACE approach has appealed to both academic peers (competitive grant funding) and to governments (commissioned work) in both Australia and overseas.

The Priority-Setting Checklist (Appendix 1), which identifies the ideal characteristics of priority-setting models, is based not only on guidance from economic theory, but also on ethics and social justice, lessons from empirical experience and the needs of decision-makers. The checklist is important because for the first time, to our knowledge, criteria from such a broad range of considerations have been brought together in a framework for priority-setting that endeavours to be both realistic and theoretically sound. Using resources wisely to optimise health outcomes is important, but respecting community values such as ethics, social justice and equity in the ways decisions are taken is also vital, particularly if decisions are to have legitimacy for patients, providers and the general public.

2. Methods

2.1 Background

The Priority-Setting Checklist (Appendix 1) underlying the ACE approach places importance on rigour in the economic appraisals, sound epidemiological modelling approaches and the use of best available evidence, but places this technical analysis within a broader setting that has regard for the concerns of decision-makers. The ACE approach, summarised here, reflects our wish to strike a balance between technical rigour (that matters to academics), relevance (that matters to policy-makers) and due process (that matters to stakeholders and the general community). In this section we cover:

- the ACE approach to priority-setting;
- key assumptions underlying the economic analysis;
- second-stage filter analysis; and
- presentation of results.

2.2 The ACE approach to priority-setting

The ACE approach to priority setting is summarised here, and more detail is available in an economic evaluation protocol document on our website (www.sph.uq.edu.au/bodce-ace-prevention). A comprehensive article has been published [26] that covers the origins, methods and application of the ACE approach. The decision context for ACE work is the possible Australia-wide adoption of options to improve the efficiency of current health services. Also, ACE results will inform policy-makers about the best bundle of interventions, given different levels of budget availability, to assist them to formulate strategies to address specific risk factors and/or diseases that are amenable to prevention and early intervention.

On the technical side, the ACE approach applies the key economic concepts of opportunity cost, marginal analysis and clear concept-of-benefit, using standardised evaluation methods clearly documented in the economic protocol. Undertaking the economic analysis as part of the priority-setting exercise addresses the reservations expressed by many economists about the simplistic use of league tables, where economic studies are assembled from the literature with little regard to differences in methods, context and setting. The key methodological characteristics of our ACE–Prevention study are:

- The rationale for the selection of interventions is discussed and clearly specified.
- The evaluation methods are standardised, documented and open to scrutiny, with special consideration given to methods appropriate for services utilised by Indigenous Australians.
- The setting, context and comparator (i.e. current practice) are common to all interventions for the general population, with careful thought given to modifications necessary for the Indigenous context.
- Australian data are used, wherever possible, for health system costs and demographic and epidemiological disease parameters.
- Cost–utility analysis is used to develop incremental cost-effectiveness ratios (ICERs) based on economic/epidemiological modelling techniques that utilise best available data on efficacy/effectiveness of interventions (usually based on systematic reviews).
- All costs and health outcome measures are reported as a range (around point estimates), reflecting explicitly the uncertainty of cost, process, outcome and value estimates.

- Data needs are made tractable by utilising the Australian Burden of Disease Study as the primary source of epidemiological parameters of diseases and risk factors [6], together with the Australian Disease Costs and Impacts Study [27] to assist with estimates of disease treatment costs that can be avoided by prevention.
- ICERs are placed within a broader decision-making framework that includes considerations about equity, strength of evidence, feasibility of implementation, acceptability to stakeholders and other study-specific considerations (such as cultural security for Indigenous Australians). We refer to these as the second-stage filter criteria.
- Information is assembled by a multidisciplinary research team, preparing briefing papers to a standardised format agreed by a steering committee of stakeholders who are involved throughout the study.

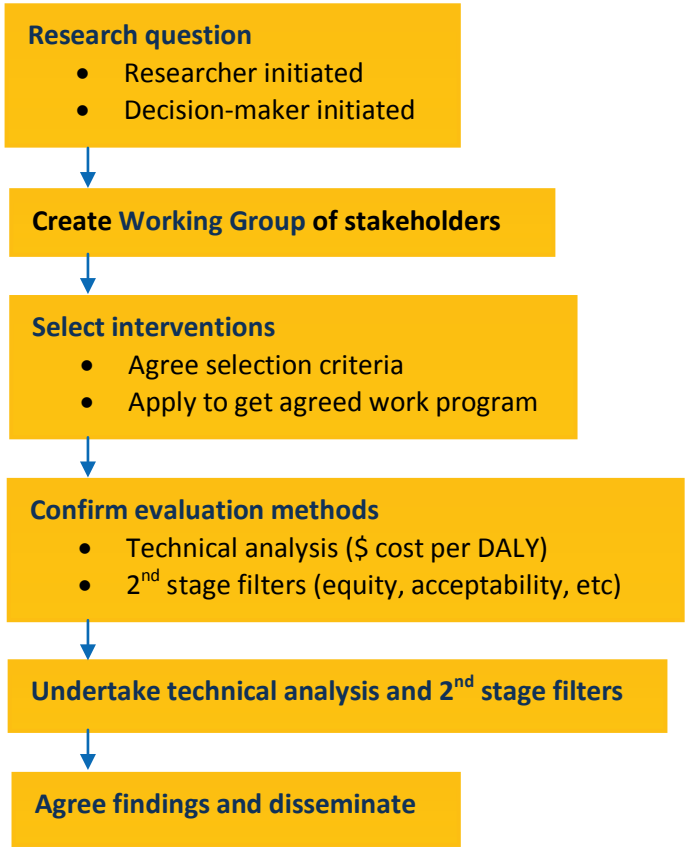


Figure 2.1 The ACE approach to priority-setting.

ACE Steering Committees generally consist of topic experts, clinicians and practitioners, representatives of relevant community organisations and policy-makers. The Steering Committee in ACE studies has an important role in selecting the interventions for evaluation, as well as achieving balance between the technical analyses and due process. Members contribute in areas of their expertise and discuss issues of method and evidence. Also, they ensure stakeholder interests and views are articulated; facilitate sensible interpretation of the technical analysis; assist with value judgement aspects of the second-stage filter analysis; help ensure transparency throughout the project; and assist in the promulgation of the results to policy-makers (Figure 2.1). In ACE–Prevention, because of the size and complexity of the task, there were two Steering Committees: one to guide overall project management and focus on interventions evaluated for the general population; and another to guide the Indigenous research and focus on interventions evaluated for Indigenous Australians. In addition, a series of Technical Advisory

Panels were constituted to guide researchers in specific topic areas. Membership of these Steering Committees and Technical Advisory Panels is set out in the acknowledgements of this report. We are indebted to the members of these committees and panels for their enthusiasm and contributions to the research effort. However, the authors of the report take full responsibility for the results and their interpretation.

2.3 Key assumptions underlying the economic analysis

The purpose of this section is to make explicit the key assumptions associated with the application of economic evaluation methods in ACE–Prevention, so that potential users of the results can judge the suitability of these assumptions for their decision context and use, or adjust the results accordingly.

In the economic literature these key assumptions are often divided into those concerning the study frame and others pertaining to the study design [28]. Taken together, study frame and study design define and describe the economic evaluation undertaken, including the approach to data collection and analysis.

Details are available in a protocol document on our website (www.sph.uq.edu.au/bodce-ace-prevention) [29].

2.3.1 Study frame

The decision context and objectives of ACE–Prevention are described in Section 1. Other key elements of the study frame are given here.

Study perspective: A 'health sector perspective' is adopted, with costs to government (both Commonwealth and State/Territory) and the private sector clearly identified. When non-health sector impacts are important to an intervention (either on the cost or outcome side), we flag the impact and undertake sensitivity analysis to assess the significance of adopting a broader perspective.

Reference year: We chose 2003 as the reference year because most of our disease and mortality rates are derived from the 2003 Australian Burden of Disease study [6].

Target group: The target group is the Australian population in 2003, who are potential recipients of the intervention. This can be either:

- the whole population, such as for population-wide health promotion campaigns; or
- a subpopulation, based on characteristics such as age, sex, risk factor profile or disease.

Study boundaries: Spill-over effects ripple out from every intervention and the question is how far to follow them. Key exclusions from the primary analysis are:

- production gains and losses in the wider economy and other non-health-sector impacts;
- health-related quality of life impacts other than those on intervention participants (e.g. family and carers); and
- all-of-life effects (i.e. unrelated ongoing healthcare costs of people who are alive because of the intervention).

Time horizon: The time horizon for modelling the implementation of interventions is based on how the interventions would be applied in real life. For instance, the duration of nicotine replacement for smoking cessation (recommended for up to three months of use) is very different from that of anti-retroviral drugs in the treatment of HIV/AIDS, which need to be taken over a lifetime to continue to

reap benefits. The time horizon for tracking the associated costs/cost savings and health consequences extends over the lifetime of the target population through to death or 100 years of age.

Defining the intervention: In modelling interventions we fully specify all activities (i.e. who does what, to whom, when and where?), and assume that all interventions are fully implemented (i.e. in 'steady-state' operation). Our focus question is: 'What is the cost-effectiveness of interventions when they achieve their full potential as per the evidence on effectiveness?'

Defining the comparator: We usually specify both 'current practice' and 'do nothing' as the comparator. With 'current practice' as the comparator, we address the research question: 'What is the cost-effectiveness of replacing existing practice for dealing with the health problem with the new intervention(s)?' This relates most closely to short-term policy decision-making: with 'do nothing' as the comparator, the research question relates more to long-term policy decision-making; that is, 'What is the most efficient approach to dealing with this health problem?' and 'How far removed from this ideal is current practice?' We use the 'do nothing' comparator when we develop intervention pathways (see Section 3.4) to address issues associated with putting interventions together into strategies. A 'do nothing' comparator also allows explicit quantification of the inefficiency of current practice.

2.3.2 Study design

Models: We use mathematical models to predict the costs and benefits that are relevant to an intervention by combining available information, often from disparate sources, on disease epidemiology, effectiveness and costs. In predicting population-level costs and consequences of health interventions, a variety of modelling techniques are available. Analyses in this project rely on the principles of Markov models, multi-state life tables and micro-simulation [30]. The first two types of models predict in discrete steps over time the difference in health risks, costs and outcomes for the average individual in the target population between the comparator scenario and an intervention scenario. When the data allow it, we use micro-simulation methods if there is considerable variation in the target populations in terms of response to the intervention and/or when the response to the intervention is strongly dependent on time.

Uncertainty and sensitivity analysis: We quantify uncertainty in our estimates in two ways. We use multivariate Monte Carlo simulation for the model variables that are based on sampled data, the effect size of the intervention being a prime example. This technique allows uncertainty to be expressed as a 95% interval around our point estimates. Sensitivity analysis is used for variables not based on sampled data, with the discount rate as an important example. We recalculate and present results for a number of possible values for this kind of variable.

Measurement of costs: To help identify relevant costs, interventions and their comparators are described in concrete and well-defined steps that generally include:

- an 'event pathway'; and
- a 'patient flowchart'.

The 'event pathway' will generally include the following elements:

- ongoing recruitment (+/– training of providers);
- key intervention elements (such as advice, consultations, care, change in legislation or regulations);

- monitoring, evaluation and support elements; and
- downstream effects such as the costs of treatment for long-term disabilities or side effects.

The 'patient flowchart' describes how we get from the target population to those who actually participate in the activities.

Costs included: Our choice of a 'health sector perspective' means we take into account costs to the health system, patients and families involved in the delivery of the intervention. This includes the costs associated with each step of the intervention pathway. We present results both with and without time and travel costs.

Costs excluded: As interventions are assessed in 'steady state' operation, we assume that trained personnel are available to deliver the intervention and that all necessary infrastructure is available. Given this, we exclude:

- costs associated with the research, development and maintenance of materials to be used in the intervention;
- costs associated with training the trainer;
- costs associated with the development and education of an adequate provider workforce;
- production gains and losses other than time cost of participation;
- time costs of children; and
- monitoring and evaluation above a routine level.

Valuation of costs: Unit cost data for all resources associated with an intervention are collated where possible based on the Pharmaceutical Benefits Advisory Committee Manual of Resource Items and Their Associated Costs and the Medicare Schedule, measured in real prices for the reference year (2003). In costing staff employed by an intervention, a factor of 1.6 is applied to the base salary to cover salary on-costs and a loading for administrative assistance, office space and utility services. We cost staff that are already employed by an organisation and have access to office space, equipment, etc. as part of that position with a factor of 1.3 to cover the salary oncost component only. If a unit cost for a particular resource is not available from the cited unit cost sources we endeavour to use national pricing as far as is practical (e.g. national pay scales).

Time costs: Time costs can be:

- an integral part of providing the health service itself (such as travelling time, waiting time, treatment time); or
- a consequence of providing the intervention (such as time of parents in taking children to an intervention activity).

There is no set method of valuing time. We adopt the simplest method using the hourly wage rate as a proxy for the value of time, combined with a common convention [31] of valuing leisure time at 25% of the wage rate. Our approach adopts a weighting for workforce participation and age/sex composition, which yields an average hourly time cost of $17.44, which we apply to all time costs in adults.

*Travel costs***:** Travel costs refer to the costs of travelling to and from the intervention and associated intervention activities (such as petrol and car costs). We use a weighted average of travel to and from primary care in rural and urban settings as an indicative cost of travel ($7.04 per trip).

*Cost of non-adherence***:** We assume that any non-adherers incur intervention costs but receive no benefit.

Cost offsets: If an intervention prevents future disease or treats current disease so that future complications are avoided, the projected healthcare costs in the eligible population are likely to be lower following the intervention. The difference in projected healthcare costs between the intervention and comparator situation are identified as cost offsets. We use disease-specific health expenditure estimates from the Australian Institute of Health and Welfare [27].

Discounting: We apply a 3% discount rate to both costs and benefits. In sensitivity analysis we test the impact of other discount rates.

Measurement of benefits: We measure the size of the health gain associated with each intervention in 'health-adjusted life years' where we value the loss of health due to non-fatal health states with the appropriate disability weight(s) used to estimate disability-adjusted life years (DALYs) in burden of disease studies. When we present our results we equate these health-adjusted life years gained to DALYs averted by the intervention. However, there are important differences between DALYs calculated in burden of disease studies and ACE–Prevention DALYs averted. First, in a burden of disease study, the health status of a population is estimated in a particular year. It is therefore, a cross-sectional measure. Economic evaluation methods always have a time dimension. Health gain is calculated as the difference in mortality and morbidity outcomes between a comparator and the intervention option over a defined period of time (the 'time horizon').

Second, in burden of disease studies the DALY is constructed as a health gap measure, i.e. an ideal is set (everyone ought to live into old age free of disease) and contrasted with the current health status of a population. Thus, years of life lost, the mortality component of the DALY, are calculated as the difference between age at death and a standard life expectancy at that age for each death. In economic analyses, we do not use the standard life table to give a value to loss of life. Instead, we keep track of a target population over time and count the health-adjusted years of life lived in intervention and comparator scenarios assuming realistic mortality risks as people age. This includes an adjustment for expected levels of disability by age and sex for conditions not immediately affected by the intervention of interest. In other words, extra years of life gained from a preventive intervention are counted as less than full years taking into account the probability that the person would suffer from osteoarthritis, dementia, hip fracture or any other condition as they age. We do this in order to measure realistic health gains, rather than hypothetical health gains assessed against perfect health.

Effectiveness and safety of interventions in ACE–Prevention: We seek data on the effectiveness and potential side effects of interventions by systematic review of relevant intervention trials and subsequent follow-up studies. We synthesise the outcome measure by meta-analysis. Trials of risk-factor-modifying interventions often only report an impact on exposure to the risk factor. That means we need to extrapolate to disease outcomes using available data on the relationship between risk factor and disease outcomes from observational studies. We identify potential effect modification of the intervention under routine health service conditions in Australia, often by assuming a lower adherence to an intervention than was observed under trial conditions.

Extrapolating treatment effects over time: In modelling health outcomes, ACE researchers have to confront the issue that trials measure outcomes over a limited time period while our interest is in the true impact on disease outcomes and costs. One option is to limit the modelling to the duration of the trial, but this does not adequately reflect reality. The alternative is to make assumptions about the impact beyond the duration of the available trials (i.e. to assume either a continued impact over time, a

lessening of the impact over a period beyond the known impact time from trials or the abrupt disappearance of the impact). The assumption we take depends on:

- the intervention in question;
- discussions with our technical experts; and
- the most plausible way of modelling.

Often, however, there is no clear choice and the solution we adopt is to present results as discrete scenarios using different choices as a sensitivity analysis. For instance, we assume an annual decay of the impact of GP-mediated physical activity interventions of 50% and vary this between 0% and 100% in sensitivity analyses.

2.4 Second-stage filter analysis

The ACE studies consciously adopt an explicit approach to priority-setting where visibility of the cost-effectiveness estimates, of judgements about broader issues that impact on decision-making, and of the evaluation processes employed, are all emphasised (Figure 2.2).

Consideration of broader issues in addition to cost-effectiveness results acts as a second stage by which each of the interventions is judged before recommendations are made concerning allocation of resources. In the first stage of the ACE analysis, options are ranked by those criteria directly related to determining the resources consumed or released by the option, together with the size of the anticipated health gain (based on the ICERs). The first stage is characterised by aspects that lend themselves to logical decision rules, drawn essentially from the health economics discipline. The second stage incorporates aspects for which it is very difficult to develop decision rules and decisions will rest heavily on judgement and due process.

A common set of filters have been used in all ACE studies, which reflect government generic policy objectives and facilitate comparability of ACE results. ACE methods provide for additional filters to be added where the study context warrants their selection. The core filters used in all ACE studies are:

- capacity of the intervention to reduce inequity;
- acceptability to stakeholders;
- feasibility of implementation; and
- strength of the evidence base.

The additional filters adopted by the Project Steering Committee in ACE–Prevention are:

- sustainability; and
- potential for other consequences (side effects).

The additional filters adopted by the Indigenous Steering Committee in ACE–Prevention are:

- cultural security; and
- community health gain.

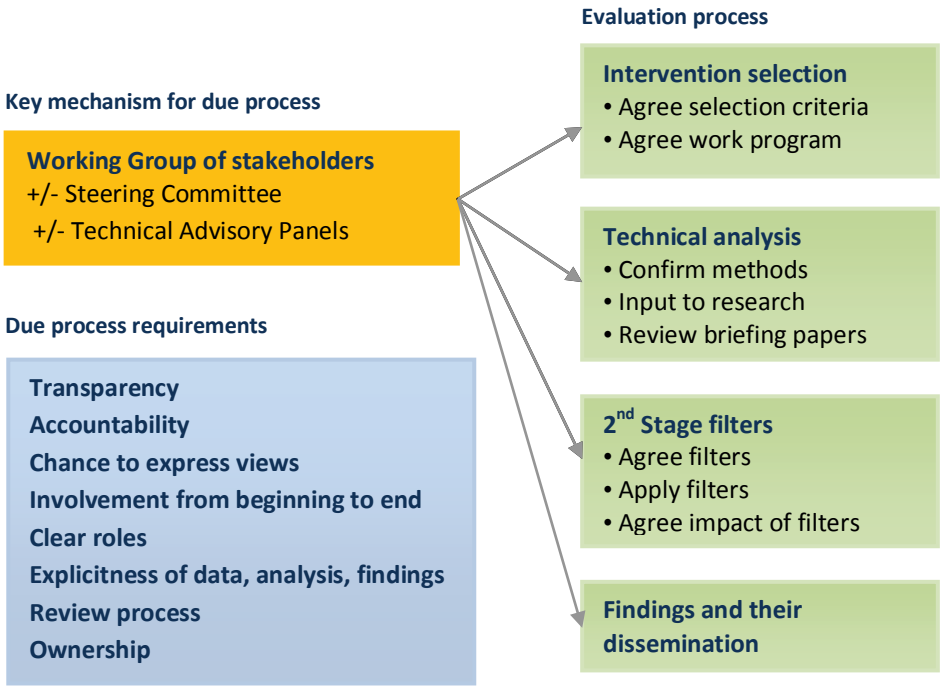


Figure 2.2 Overview of due process in ACE approach to priority-setting.

The filters applied to interventions for the general population are defined below. The main outcome of the second-stage filter analysis is a table for each intervention in which these broader issues are flagged and a qualitative judgement made explicit about each of the criteria and their impact (Table 2.1). Issues raised under the 'equity filter' or the 'acceptability to stakeholders' filter, for example, are briefly described and then a summary entry made (such as 'not a key issue'; 'possible concerns, needs attention') under a 'decision point' heading; these are then brought together under 'policy considerations', combining both the cost-effectiveness and second-stage filter information. The second-stage filter analysis can lead to recommendations about the need for pilots prior to widespread implementation; about the need for intervention re-design to address equity concerns; and/or the need for ongoing evaluation/research to improve the evidence base.

2.4.1. Capacity of the intervention to reduce inequity

This filter was defined as 'the impact of the intervention on inequity in the distribution of disease and health status and access to, or utilisation of, specific intervention(s)'. Particular attention is given to instances where an intervention or option for change may aggravate or worsen existing inequities. The equity filter may include an analytical component (e.g. numerical evidence of inequalities in current health status and/or access to or utilisation of services); but the judgement by the Project Steering Committee is still inherently qualitative. Various possible methods can be used to combine cost-effectiveness ratios and equity considerations in a numerical way. These include weighting the DALY measure in accordance with who gains the DALY reduction, using decision theory to create a new index score [31] and cost value analysis developed by Nord [32]. The Project Steering Committee preferred to keep equity considerations separate as an explicit filter and not attempt to internalise equity within the cost-effectiveness ratios. The Indigenous Steering Committee decided likewise, but, importantly, endorsed the development of an additional Indigenous concept-of-benefit instrument (see Section 4.3).

Table 2.1 Summary of incremental cost-effectiveness ratios and second-stage filter analysis

Intervention	Cost per DALY summary	Strength of evidence	Equity	Acceptability to stakeholders	Feasibility and sustainability	Potential for side effects
Brief description of intervention	Summary of central ICER information	Summary of key issues for each filter →				
Decision point: Assessment of impact of filter	Conclusion about ICER credentials	Evidence base strong enough to support implementation or more cautious approach required?	For each filter, whether there is or is not a problem. If so, nature of problem? If not, supportive or neutral to adoption?			
Policy considerations: Overall review of ICERs, plus the impact of filters for non-Indigenous Australians; for example, ICERs are favourable, but caution is required due to impact of second-stage filter issues or uncertainty requires a more cautious approach (e.g. pilot before widespread implementation)						

DALY, disability-adjusted life year; ICER, incremental cost-effectiveness ratio

2.4.2 Acceptability to stakeholders

This criterion refers to the anticipated acceptability of proposed interventions to the various stakeholders affected by the intervention (participants/patients, parents and carers, the general community, third-party funders, health service providers, government and the non-government sector). By its very nature, acceptability is a difficult criterion on which to find empirical data. Judgements must thus be made by the Project Steering Committee, the Indigenous Steering Committee and the various Technical Advisory Committees.

2.4.3 Feasibility of implementation

This criterion is concerned with the ease of implementing the intervention, considering factors such as the availability of appropriate expertise to implement the intervention on a national scale (particularly in rural and/or remote areas), the potential size of the financial commitment, and the time scale for implementation.

As with equity, feasibility is a criterion that may be informed by quantitative data, but essentially involves judgement rather than the application of technical decision rules. For this criterion, the Project Steering Committee largely restricted itself to flagging issues that required attention and to presenting descriptive information to assist policy-makers.

2.4.4 Strength of the evidence base

Evidence is a fundamental consideration in the ACE approach and impacts on the ACE–Prevention study through (i) the selection of the options for change for which evidence of effectiveness is available; (ii) the sensitivity and uncertainty analysis around the ICERs; and (iii) the confidence that policy-makers can have in the cost-effectiveness results.

A view is emerging of a single framework within which evidence on clinical, public health and behavioural interventions can be assessed. While the nature of the evidence for different kinds of health interventions inevitably varies, and the evidence for public health and social science interventions often is weaker than that for clinical interventions, the logic used to assess the evidence is the same for all of them. Following work on alternative classifications, the Project Steering

Committee resolved at its March 2005 meeting to accept a classification system that sought to combine the traditional classification of evidence based on epidemiologic study design with indirect and parallel forms of evidence that would not ordinarily be captured. This classification is based on the classifications used for the ACE-Obesity study [33] and draws on the work of Hawe and Shiell [34], Swinburn and Kumanyika [35] and also reflects aspects of other evidence frameworks [36–38]. The approach of the ACE–Prevention study is set out in Table 2.2.

To some extent, this strength of evidence criterion is presented quantitatively in the sensitivity and uncertainty analyses. In other words, if the evidence on effectiveness is weak, large uncertainty around the size of the impact measure was used during the simulation modelling of uncertainty. However, for some interventions evidence is so limited that the Project Steering Committee would not want to make a firm recommendation to increase funding for the intervention even if the uncertainty analysis showed a favourable cost-effectiveness ratio. In such cases, a recommendation is made to implement the intervention as a pilot project and to monitor the impact before recommending wider implementation.

2.4.5 Sustainability

This criterion refers to the durability of the intervention considering such factors as: (i) the level of ongoing funding support required; (ii) the community empowerment and capacity building likely to be achieved; (iii) the level of policy support likely to be achieved; and (iv) the likelihood of required changes in behaviours, practices and attitudes being achieved on an ongoing basis.

2.4.6 Potential for other consequences

This criterion refers to the potential for both positive and negative side effects arising from an intervention. These might be impacts such as: (i) other health consequences (such as anxiety/depression stemming from stigmatisation); (ii) environmental consequences (for example due to air quality); (iii) social capital (for example, from empowered communities or improved social networks); (iv) increased household costs; and (v) other economic consequences (such as impact on industry). We took care to ensure that any consequences noted under this filter are not already captured in the cost-effectiveness ratio, either on the cost side (cost impacts on families) or on the outcome side (in the DALY measure).

Table 2.2 Classification of the strength of the evidence approach adopted in ACE–Prevention

Conventional approach based on epidemiological study design *Evidence from level I–III study designs*	**Additional categories utilised in the ACE–Prevention study** *Evidence from level IV studies, indirect or parallel evidence and/or from epidemiological modelling using a mixture of study designs*
'Sufficient evidence of effectiveness' *Effectiveness is demonstrated by sufficient evidence from well-designed research that the effect:* • is unlikely to be due to chance (e.g. p<0.05); and • is unlikely to be due to bias, e.g. evidence* from: - a level I study design; - several good quality level II studies; or - several high quality level III-1 or III-2 studies from which effects of bias and confounding can be reasonably excluded on the basis of the design and analysis).	**'Likely to be effective'** *Effectiveness results are based on:* • sound theoretical rationale and program logic; and • level IV studies, indirect† or parallel‡ evidence for outcomes; or • epidemiological modelling to the desired outcome using a mix of evidence types or levels. The effect is unlikely to be due to chance (the final uncertainty interval does not include zero and there is no evidence of systematic bias in the supporting studies). Implementation of this intervention should be accompanied by an appropriate evaluation budget.
'Limited evidence of effectiveness' *Effectiveness is demonstrated by limited evidence from studies of varying quality that:* • the effect is probably not due to chance (e.g. p<0.10); but • bias, while not certainly an explanation for the effect, cannot be excluded as a possible explanation (e.g., evidence* from: - one level II study of uncertain or indifferent quality; - one level III or III study of high quality; - several level III or III studies of insufficiently high quality to rule out bias as a possible explanation; or - a sizeable number of level III studies of good quality and consistent in suggesting an effect).	**'May be effective'** *Effectiveness results are based on:* • sound theoretical rationale and program logic; or • level IV studies, indirect† or parallel‡ evidence for outcomes; or • epidemiological modelling to the desired outcome using a mix of evidence types or levels. The effect is probably not due to chance but bias, while not certainly an explanation for the effect, cannot be excluded as a possible explanation. Would benefit from further research and/or pilot studies before implementation.
'Inconclusive evidence of effectiveness' *Inadequate evidence due to insufficient or inadequate quality research.* No position could be reached on the presence or absence of an effect of the intervention (e.g. no evidence from level I or level II studies and level III studies are available, but they are few and of poor quality.)	**'No evidence of effectiveness'** No position could be reached on the likely credentials of this intervention. Further research may be warranted.

*Evidence classifications based on those of the National Health and Medical Research Council [39]:

I Evidence obtained from a systematic review of all relevant randomised controlled trials.

II Evidence obtained from at least one properly designed randomised controlled trial.

III-1 Evidence obtained from well-designed pseudo-randomised controlled trials (alternate allocation or some other method).

III-2 Evidence obtained from comparative studies with concurrent controls and allocation not randomised (cohort studies), case-control studies, or interrupted time series with a control group.

III-3 Evidence obtained from comparative studies with historical control, two or more single-arm studies, or interrupted time series without a parallel control group.

IV Evidence obtained from case series, either pre-test and post-test.

† Information that strongly suggests that the evidence exists (e.g. a high and continued investment in food advertising is indirect evidence that there is positive (but propriety) evidence that food advertisement increases sales of those products) [35].

‡Evidence of intervention effectiveness for another public health issue using similar strategies (e.g. the role of social marketing, regulation or behavioural change initiatives in tobacco control, sun exposure, speeding) [35]

Source: Haby MM, et al. [33].

2.5 Presentation of results

Concisely presenting a large number of results, each with many aspects, is challenging. Inevitably, it requires making choices. This section explains the choices we have made, and how to read the tables in the Results section below. Readers should realise that this report only gives a 'helicopter' view: details of the interventions are available in pamphlets, briefing papers and/or journal articles. These are available at our website (www.sph.uq.edu.au/bodce-ace-prevention).

Table 2.3 Categories used to classify interventions according to various aspects

Aspect	Categories		
Cost-effectiveness ratio	• *Dominant*: interventions that improve health and saves money; • *Very cost-effective*: interventions that improve health at a cost of less than $10,000 per DALY; • *Cost-effective*: interventions that improve health at a cost of between $10,000 and $50,000 per DALY; • *Not cost-effective*: interventions that improve health at a cost of more than $50,000 per DALY; and • *Dominated*: interventions with worse health outcomes at a cost; or more cost-effective alternatives are available that 'replace' the dominated intervention.		
Health impact (lifetime)	+	++	+++
	Small	Medium	Large
	0–10,000 DALYs	10,000–100,000 DALYs	>100,000 DALYs
Intervention cost (annual)	+	++	+++
	Small	Medium	Large
	<$10 million	$10–100 million	>$100 million
Strength of evidence (Table 2.2)	Comparative evidence: • sufficient; • limited; or • inconclusive;	No comparative evidence: • likely; • maybe; or • no evidence	
Other issues	No pre-defined categories		

One of the main characteristics of the ACE methodology is that economic evaluation is not just about calculating cost-effectiveness ratios. While the cost-effectiveness ratio is pivotal, other important aspects of the intervention concern its health impact, the cost when implemented, the strength of the evidence, and any other issues that are deemed important, such as acceptability, feasibility and equity.

In order to simplify the body of this report, we treat all these aspects as categorical variables. Table 2.3 lists the aspects and the categories we use. We then proceed to discuss them. Appendix 2 provides a complete list of all interventions and more details of each.

An example: Table 2.4 is part of a results table. The first thing to notice is which of the five cost-effectiveness classes this concerns: very cost-effective ($0–10,000 per DALY). Then there is an entry for topic area (physical activity) and one or more interventions (two in this case).

The GP prescription intervention has a medium-sized health impact (between 100 and 10,000 DALYs, denoted by yellow colour and two plus signs), high intervention costs (more than $100 million, denoted by red colour and three plus signs), the evidence is sufficient, but there are issues with feasibility and equity.

The internet intervention also has a medium-sized health impact, but low cost (less than $10 million, green colour and one plus sign), sufficient evidence and an equity issue.

Table 2.4 Example of presentation of interventions

Topic area	Intervention	Lifetime health impact	Annual intervention cost	Strength of evidence	Other issues
Very cost-effective ($0–10,000/DALY)					
Physical activity	GP prescription	+	+++	Sufficient	Feasibility/equity: limited capacity GPs, esp. in rural areas
	Internet intervention	+	+	Sufficient	Equity: requires computer literacy and internet access

3. Results, total population

3.1 Interventions

We set out to perform cost-effectiveness analyses of 100 preventive interventions addressing non-communicable disease and to benchmark these against a further 50 interventions of treatment or infectious disease control. We strived to be comprehensive in our evaluation of prevention of non-communicable disease and its main risk factors. Eventually, we selected and analysed 121 preventive interventions, of which six concerned prevention of infectious disease but with no impact on non-communicable disease. Interventions addressing an infectious cause of non-communicable disease (such as human papillomavirus and cervical cancer; hepatitis B and liver cirrhosis and cancer; and *Helicobacter pylori* and peptic ulcer disease) were classified as prevention of non-communicable disease. We also completed analyses for 24 treatment interventions. There was one Indigenous-specific intervention addressing lifestyle risk factors in a remote community. We adapted our total population models to estimate the cost-effectiveness of 16 prevention interventions and two treatment interventions for Indigenous Australians.

We have addressed a broad spread of interventions across risk factors and disease areas (Table 3.1). It should be noted that the risk factors affect multiple diseases. For instance, cardiovascular disease is affected by seven of the risk factors included in the table. For each intervention we chose the most appropriate category with a preference for listing interventions under risk factors rather than disease groups. Interventions that were modelled in several scenarios (such as 15% and 30% tax increase on excise duty of tobacco and alcohol) were counted only once. Full details of all interventions evaluated are presented in Appendix 2.

Table 3.1 Number of preventive and treatment interventions by topic area, ACE–Prevention

Topic area	Total population		Indigenous population	
	Prevention	Treatment	Prevention	Treatment
Alcohol	9	2		
Tobacco	8			
Physical activity	6			
Nutrition	26			
Body mass	9			
Blood pressure/cholesterol	12		5	
Bone mineral density	3			
Illicit drugs	2	1		
Cancer	9	1		
Diabetes	7		7	
Kidney disease	2	2	4	2
Mental disorders	11	10		
Cardiovascular disease	1	5		
Other prevention	11		3	
Infectious disease	7			
Other treatment		6		
Total	**123**	**27**	**19**	**2**

A few topics have been given no or little attention. We decided not to include prevention of air pollution due to the complexity of the modelling required (with a lot of benefits outside the health sector) and an inadequate evidence base for attributing non-fatal outcomes to air pollution. Similarly, we have not included analyses of prevention of age-related hearing loss, as the evidence base for prevention is thin.

In terms of the benchmarks (i.e. treatment or infectious disease control options), we have largely been opportunistic rather than systematic in choosing interventions, being guided by preferences of project researchers and students/researchers wishing to have a short-term association with the project. We deliberately included a number of common high-cost treatment interventions such as stenting of coronary arteries, kidney dialysis and transplant, and hip and knee joint replacement.

Eight interventions on our list have not made it past the scoping phase for lack of evidence on effectiveness (Table 3.2). These have, nonetheless, involved research effort and are therefore counted in Table 3.1, and more detailed documentation on these is available electronically.

Table 3.2 ACE–Prevention interventions not modelled through to cost-effectiveness due to lack of evidence on effectiveness

Topic area	Intervention	Comments
Obesity	'Traffic light' labelling of food	Scenario analysis based on what was deemed a plausible effect
Vision	Screen by regular vision testing	No evidence of effectiveness
Oral health	Subsidisation of annual dental check at ages 12–17: • check-up only • + radiography • + cleaning/scaling/sealants	No evidence of effectiveness
Mental health	Emergency contact cards for the reduction of deliberate self-harm/suicide	Not effective
Other	*Helicobacter pylori* eradication therapy for: • non-ulcer dyspepsia; and • uninvestigated dyspepsia	No evidence of effectiveness but likely to be cheaper than symptomatic treatment

3.2 Cost-effectiveness: introduction

We start by presenting the cost-effectiveness results for each of the individual interventions in what is often called a league table format. This is a first sifting of interventions into those that are and are not good value for money. We also indicate the relative size of the annual intervention costs and the amount of health gain projected over the lifetime of the 2003 Australian population receiving the interventions. If other important policy considerations might facilitate or hinder the implementation, these are raised.

This approach is not fully informative for two reasons. First, some interventions appear cost-effective when analysed in isolation but have more efficient alternatives. For instance, the cost-effectiveness ratio of beta blockers for prevention of cardiovascular disease appears favourable when analysed as a single intervention option. However, because three other classes of blood-pressure-lowering drugs are more cost-effective, beta blockers are not recommended. When treating individual patients a GP may, for important other reasons, have a preference for prescribing beta blockers over the alternatives. Second, the one-by-one analyses do not take into account that many interventions are not

implemented in isolation. When combinations of interventions are analysed, care must be taken not to double-count shared costs and benefits. The latter tends to be the more important consideration: other interventions in the chosen package reduce disease rates and any additional intervention cannot claim the same reduction. Therefore, in topic areas with many alternative intervention options (such as blood pressure and cholesterol-lowering, alcohol, physical inactivity, body mass and kidney disease) we have analysed the most cost-effective 'optimal' mix. These 'intervention pathways' are presented in a separate section following the league table. It demonstrates the inefficiency of current practice and marks as undesirable some interventions that had reasonable cost-effectiveness credentials when analysed in isolation, but are 'crowded out' or 'dominated' by more efficient options.

Lastly, we present the results of an intervention pathway that combines the impact of many interventions across different topic areas. This allows us to quantify the overall intervention costs, downstream disease treatment costs averted and health gain for packages of interventions. In particular, we show this for the group of interventions that in the league table section are labelled as 'dominant' (i.e. cost-saving) or very cost-effective (costing less than $10,000 per disability-adjusted life year (DALY)).

3.3 Cost-effectiveness: league table

Acknowledging the uncertainty around the cost-effectiveness results we present the league table of our results in five categories in an order from most to least favourable.

3.3.1 Dominant (cost-saving) interventions

Twelve of the 23 dominant prevention interventions have a population-wide focus aiming to reduce exposure to harmful risk factors and behaviours by taxation (of alcohol, tobacco and unhealthy food) or regulation (alcohol advertising bans, raising minimum age of drinking, limiting salt in processed food and fluoridation of drinking water). Four others are health promotion interventions that advocate physical activity and fruit and vegetable consumption or address cardiovascular health in general. The remaining seven are screening interventions targeting treatment to those at high risk (Table 3.3). These seven interventions address cardiovascular disease, chronic kidney disease, suicide, psychosis and liver cirrhosis or liver cancer as long-term consequences of hepatitis B.

The polypill combines three blood-pressure-lowering drugs in low dose and a statin in a single pill. The polypill is not yet available in Australia but early results from a trial in Australia and New Zealand indicate that it is as effective as was estimated from the effect sizes of the individual drugs. Using generic drugs it can be produced very cheaply and the expectation is that it would be possible to market the polypill at an annual cost of around $200 per person treated (personal communication, Anthony Rodgers). The polypill has been developed based on the principles of 'absolute risk', an assessment of an individual's cardiovascular risk profile determined by age, sex, diabetes, smoking, body mass index, blood pressure and cholesterol. We have classified the Australian population based on their risk of a cardiovascular event (stroke, heart attack or serious angina) over the next five years: >15%, 10–14%, 5–9% and a low-risk category of <5%. This absolute risk determines the need for treatment regardless of the values of the individual risk factors. Thus, if someone has a high risk of cardiovascular disease (CVD) (e.g. because of being a smoker and a diabetic with high cholesterol) treatment with a blood-pressure-lowering drug may be the first line treatment even if blood pressure is within a normal range. For people at greater than 5% absolute CVD risk the polypill is a cost-saving

intervention with a large impact on population health. The polypill (assuming a yearly cost of $200 per person treated), given to all people at greater than 5% absolute CVD risk, would cost $260 million per year and lead to 340,000 DALYs averted over the lifetime of the 2003 population.

Table 3.3 Dominant (cost-saving) preventive interventions for non-communicable disease, ACE–Prevention

Topic area	Intervention	Lifetime health impact*	Annual intervention cost*	Strength of evidence
Alcohol	Volumetric tax	++	+	Likely
	Tax increase 30%	+++	+	Likely
	Advertising bans	+	+	Limited
	Raise minimum legal drinking age to 21	+	+	Limited
Tobacco	Tax increase 30% (with or without indexation)	+++	+	Likely
Physical activity	Pedometers	++	++	Sufficient
	Mass media	++	++	Inconclusive
Nutrition	Community fruit and vegetable intake promotion	+	++	May be effective
	Voluntary salt limits	+	+	Likely
	Mandatory salt limits	+++	+	Likely
Body mass	10% tax on unhealthy food	+++	+	May be effective
Blood pressure and cholesterol	Community heart health program	++	+	May be effective
	Polypill $200 for >5% CVD risk	+++	+++	Likely
Osteoporosis	Screen women aged 70+ and alendronate	++	++	Sufficient
Hepatitis B	Vaccine and immunoglobulin to infants born to carrier or high-risk mothers	+	+	Sufficient
	High-risk infant vaccination	+	+	Sufficient
	Selective vaccination of infants with mothers from highly endemic countries	+	+	Sufficient
Kidney disease	Proteinuria screen and ACE inhibitors for diabetics	++	+	Sufficient
Mental disorders	Problem-solving post-suicide attempt	+	+	Sufficient
	Treatment for individuals at ultra-high risk for psychosis	+	+	Likely
Oral health	Fluoridation drinking water, non-remote	+	+	Limited

ACE, angiotensin-converting enzyme; CVD, cardiovascular disease

* See Section 2.5 for an explanation of table symbols and colour-coding.

The regulatory and taxation interventions are the least costly interventions from a health sector perspective. The taxation interventions and the mandatory limits in the salt content of processed food can lead to substantial health gain in the population. From a public health point of view there are no hesitations to advocate the implementation of these interventions. Their implementation requires political will. The recent debate around the introduction of a higher tax on 'alcopop' drinks has shown that such new measures require a substantial effort and the right political environment to be adopted. It is therefore unlikely that any government would be willing to adopt many of these interventions at the same time. We would argue that the expected health impact ought to be an important argument to select interventions that are worth the effort of guiding it through the long process of decision-making. The regulatory and taxation interventions for alcohol in Table 3.3 (with greater detail in Appendix 2) illustrate this point. The health impact of raising the legal drinking age to 21 is very modest compared to the large health gain expected from alcohol tax increases and taxation reform.

It is noteworthy that two physical activity interventions fall in this very favourable category but it includes none for obesity prevention, apart from the somewhat speculative analysis of taxing unhealthy food (non-core foods that are high in saturated fat, sugar and/or salt) that used 'parallel' rather than observed evidence on its effectiveness. The evidence for the effectiveness of a mass media campaign to promote physical activity is from a lack of decline in physical activity in NSW compared to other states. That is not considered a very robust level of evidence. We classified the evidence for pedometers as sufficient because it came from a meta-analysis of eight randomised trials, but we have reservations about the sustainability of their effect. Only five of these dominant interventions were judged to have strong evidence for effectiveness: screen and alendronate for osteoporosis; ACE inhibitors for chronic kidney disease, problem-solving for people who have attempted suicide and the two hepatitis B vaccination strategies. An important reason is that population-wide interventions are more difficult to evaluate than clinical interventions. Our analysis does indicate, however, that there is an important research agenda for more frequent and better evaluation of such population-wide interventions.

The benefits of a community heart health program were modelled against a 'do nothing' comparator. We assume that most of the benefits that could be achieved by such health promotional activities around a diet that protects against cardiovascular disease have already been made.

We made a conscious effort to include a range of preventive interventions for mental disorders. The two dominant mental health interventions address suicide and psychosis; two outcomes that only more recently have become a focus of prevention. The suicide intervention, which targets people who have attempted suicide with a problem-solving intervention, is very cost-effective as it is quite effective at preventing further attempts. The psychosis intervention addresses adolescents with early warning signs. The program mainly delays the onset of psychosis and is associated with lower costs than usual care in this high-risk group.

3.3.2 Very cost-effective interventions ($0–10,000 per DALY)

Fifteen of the 20 very cost-effective preventive interventions (with a cost-effectiveness ratio less than $10,000 per DALY) are interventions that involve screening people, either in primary care or in schools, for severe obesity, physical inactivity, hazardous or harmful alcohol use or increased risk of cardiovascular disease or symptoms of mental disorders. The screen is followed by a drug, psychological, health promotional or surgical intervention. Two more interventions in this category are of a regulatory nature (licensing controls of alcohol outlets and responsible media reporting of suicides). A further two interventions are in health education (for physical activity and fruit and vegetable intake), and a universal infant vaccination intervention is also in this category (Table 3.4).

Gastric banding for severe obesity and the four interventions that address blood pressure and cholesterol are estimated to have the largest health impact. We assumed that 25% of people who have a BMI greater than 35 (severely obese) would take up gastric banding. This would lead to considerable health gain (140,000 DALYs) at large cost to the health sector ($3.7 billion), though compensated by large cost offsets from averting future disease ($2.9 billion).

If the polypill were provided to every person over the age of 55, regardless of their absolute CVD risk profile, 640,000 DALYs could be averted over their lifetime at a cost of $520 million per year. This raises a question about the desirability of putting a large proportion of the population on daily medication for the rest of their lives. On the other hand, we have seen a very large decrease of 70% in cardiovascular

mortality over the last 40 years. Our modelling indicates that greater decreases are still possible and can be achieved by very cost-effective means, but that the overall cost is considerable.

Table 3.4 Very cost-effective preventive interventions ($0–10,000 per DALY) for non-communicable disease, ACE–Prevention

Topic area	Intervention	Lifetime health impact*	Annual intervention cost*	Strength of evidence
Alcohol	Brief alcohol intervention GP with or without telemarketing and support	+	+	Sufficient
	Licensing controls	+	+	Likely
Tobacco	Cessation aid: varenicline	++	+++	Sufficient
	Cessation aid: bupropion	++	+++	Sufficient
	Cessation aid: nicotine replacement therapy	++	++	Sufficient
Physical activity	GP Green Prescription	+	+++	Limited
	Internet intervention	+	++	Sufficient
Nutrition	Information mail-out, multiple re-tailored to promote fruit and vegetable intake	+	+	Limited
Body mass	Gastric banding for severe obesity	+++	+++	Sufficient
Blood pressure and cholesterol	Low-dose diuretics >5% CVD risk	+++	+++	Sufficient
	Polypill $200 to ages 55+	+++	+++	Likely
	CCBs >10% CVD risk	++	++	Sufficient
	ACE inhibitors >15% CVD risk	++	++	Sufficient
Mental disorders drugs/suicide	Screen and bibliotherapy to prevent adult depression	+	++	Likely
	Screen and psychologist to prevent childhood/adolescent depression	+	++	Sufficient
	Screen and bibliotherapy to prevent childhood/adolescent depression	+	+	Limited
	Responsible media reporting for the reduction of suicide	+	+	Likely
	Parenting intervention for the prevention of childhood anxiety disorders	+	+	Sufficient
Other	Universal infant hepatitis B vaccination	+	++	Sufficient

ACE, angiotensin-converting enzyme; CCB, calcium channel blocker; CVD, cardiovascular disease

* See Section 2.5 for an explanation of table symbols and colour-coding.

Individual blood-pressure-lowering drugs and dietary counselling also fall in this category of very cost-effective interventions. Diuretics are the cheapest option and are very cost-effective if given to people at a five-year CVD risk greater than 5%. The more expensive calcium channel blockers (CCBs) and ACE inhibitors and dietary counselling are indicated for higher risk categories only, at a cost below $10,000 per DALY prevented. In Section 3.4.1 we look at combinations of interventions addressing cholesterol and blood pressure as risk factors for CVD.

The four screening and psychological treatments for mental disorders in this category would cost around $90 million annually and avert 15,000 DALYs. The main limiting factor to implement these interventions is the availability of skilled staff (mainly psychologists) to provide the diagnosis and therapies. Moreover, unlike the case for treatment of adult depression and anxiety, there are no provisions yet in Medicare to subsidise the cost of psychologists for these indications.

Brief alcohol interventions by a GP have very modest costs and health outcomes because only a small proportion of GPs are recruited and choose to implement the intervention, even if additional telemarketing and support are provided. The GP Green Prescription of physical activity is rather costly ($230 million) but leads to a healthy 7000 DALYs, even if we assume a relatively rapid decay in the intervention effect (a yearly halving of the remaining effect).

Most of these very cost-effective interventions have sufficient or likely evidence for effectiveness. The fruit and vegetable intervention was deemed to have limited evidence as it is based on a single study and only five out of 23 fruit and vegetable interventions were cost-effective. We had to model each of these separately, as they used a wide range of methods with different costs and target population groups. The fruit and vegetable intervention with better cost-effectiveness credentials had some distinguishing features: focusing on the general population rather than targeting those at high risk or in the workplace and keeping costs low by relying on mail-outs and tailored information. Nevertheless, the impact of this type of intervention is very modest. Overall, with so few of the counselling and health information interventions to improve fruit and vegetable intake proving cost-effective in our analyses, we have little confidence that these few interventions can be replicated cost-effectively in practice.

Universal vaccination of all infants for hepatitis B plus screening of mothers for carrier status and providing hepatitis B immunoglobulin to their infants as is currently implemented is a cost-effective intervention, despite health gain being achieved after several decades only. However, a more selective approach – vaccinating and providing hepatitis B immunoglobulin to infants of carrier mothers only – has better cost-effectiveness credentials, as indicated by their inclusion in the group of dominant interventions. As universal vaccination has become accepted it is unlikely that a more targeted approach would be adopted.

3.3.3 Cost-effective interventions ($10,000–50,000 per DALY)

Among the 28 cost-effective interventions with a cost-effectiveness ratio between $10,000 and $50,000 per DALY, one is of a regulatory nature (enforcement of laws on driving under the influence of alcohol) and four concern health education (addressing drink driving, fruit and vegetable intake, physical activity and skin cancer). The remaining 23 are targeted interventions following a screen to identify those with high levels of lifestyle-related diseases, cervical cancer or symptoms of mental disorders (Table 3.5). The level of evidence for the health promotional interventions was judged to be limited while all the targeted interventions in this category had sufficient or likely evidence to support effectiveness.

Table 3.5 Cost-effective preventive interventions ($10,000–50,000 per DALY) for non-communicable disease, ACE–Prevention

Topic area	Intervention	Lifetime health impact*	Annual intervention cost*	Strength of evidence
Alcohol	Drink drive mass media	+	++	Limited
	Roadside breath testing	+	++	Likely
Physical activity	TravelSmart	+	+++	May be effective
	GP referral	+	+++	Limited
Nutrition	Multiple tailored mailed fruit and vegetable promotion	+	+	Limited
Obesity	Diet and exercise for overweight	+	+++	Sufficient
	Low-fat diet for overweight	+	++	Sufficient
Blood pressure and cholesterol	Dietary counselling >5% CVD risk by dietitian	++	++	Sufficient
	Dietary counselling >5% CVD risk by GP	++	++	Sufficient
	Phytosterol supplementation >5% CVD risk	++	+++	Sufficient
	Statins >5% CVD risk	+++	+++	Sufficient
	Statins and ezitimibe >5% CVD risk	+++	+++	Sufficient
	Beta blockers >5% CVD risk	++	+++	Sufficient
	CCBs >5% CVD risk	+++	+++	Sufficient
	ACE inhibitors >5% CVD risk	+++	+++	Sufficient
Cancer	Pap screen (current practice)	+	++	Sufficient
	HPV DNA test screen 3-yearly from age 18	+	+	Likely
	HPV vaccination and Pap screen	+	++	Likely
	HPV vaccination and HPV DNA test screen 3-yearly from age 18	+	++	Likely
	SunSmart	+++	+++	Limited
Pre-diabetes	Screen and dietary advice	+	++	Sufficient
	Screen and exercise physiologist	++	++	Sufficient
	Screen and dietary advice and exercise physiologist	++	++	Sufficient
	Screen and metformin	++	++	Sufficient
	Screen and acarbose	++	++	Sufficient
Kidney disease	Chronic kidney disease screen and ACE inhibitors for non-diabetics age >25	++	++	Sufficient
Mental disorders	Screen and group CBT to prevent adult depression	+	++	Likely
	Screen and CBT to prevent post-partum depression	+	+	Limited

ACE, angiotensin-converting enzyme; CBT, cognitive behaviour therapy; CCB, calcium channel blocker; CVD, cardiovascular disease; HPV, human papillomavirus

* See Section 2.5 for an explanation of table symbols and colour-coding.

The largest impact on population health outcomes can be expected from an increase in national investment for a SunSmart program at the average level achieved by Victoria in the 1990s, blood pressure and cholesterol control, drugs for smoking cessation and treating people identified with pre-diabetes or chronic kidney disease. These interventions tend to be more costly. A large proportion of the costs of the SunSmart intervention are borne by individuals purchasing sunscreen lotion. The evidence for effectiveness was imputed from a reduction in the increase in skin cancer cases seen in

Victoria as compared to other states and assuming the extra investment in SunSmart activities in Victoria was responsible. As there was no control population, this is a rather uncertain result.

3.3.4 Not cost-effective interventions (>$50,000 per DALY)

Not cost-effective preventive interventions include the majority of fruit and vegetable interventions, dietary advice on salt and a multiple-component intervention addressing diet, weight and exercise (Table 3.6). Each of these has poor effectiveness and some have high cost. The commercial Weight Watchers program is not cost-effective as there is poor maintenance of weight loss. The high cost of orlistat and sibutramine makes them not cost-effective.

Table 3.6 Not cost-effective preventive interventions (>$50,000 per DALY) for non-communicable disease, ACE–Prevention

Topic area	Intervention	Comments
Diet	Fruit and vegetable interventions targeting individuals (except tailored mailings)	Poor effectiveness
	Fruit and vegetable interventions at workplace	Poor effectiveness
	Dietary advice on salt	Poor effectiveness and high cost
	Weight Watchers	Poor maintenance of weight loss
	Multi-component diet/physical activity/weight intervention	Poor effectiveness
	Orlistat, sibutramine	Too expensive
Osteoporosis	Raloxifene	No effect on hip fractures and too expensive
Cancer	Combined Pap and HPV DNA test screen 3-yearly from age 18	No benefit from start at age 18 instead of 25
	HPV vaccination and combined Pap and HPV DNA test screen 3-yearly from age 18	No benefit from start at age 18 instead of 25
	Anal cytology for MSM	Expensive screen for rare cancer
Pre-diabetes	Screen and orlistat	Too expensive
	Screen and rosiglitazone	Too expensive
CVD	Aspirin	Risk of bleeding and ambiguous evidence for effect in primary prevention
Vision loss	Ranibizumab for age-related macular degeneration	Too expensive
Mental health/drugs	School-based drug intervention	Poor effectiveness
	Gun buy-back and legislation changes to reduce suicides	Only ecological evidence for reduction in suicide; high cost
Shingles	*Varicella zoster* vaccination at age 50	Low frequency of shingles; expensive

CVD, cardiovascular disease; HPV, human papillomavirus; MSM, males who have sex with males

Raloxifene has not been shown to prevent hip fractures and is too expensive a drug to be considered for prevention of osteoporosis. Aspirin has been considered for a long time to be an effective drug for preventing cardiovascular disease. As it is so cheap, it would become one of the most efficient options for CVD prevention. However, recently two studies showed no beneficial effect of aspirin [40, 41]. As aspirin also carries a risk of bleeding in the stomach and brain, particularly in the elderly [24], not using it in primary prevention may be wiser.

A school-based drug intervention had poor effectiveness. The gun buy-back scheme introduced after the 1996 Port Arthur massacre in Tasmania was very expensive. The drop in suicide that followed cannot be unequivocally attributed to the scheme.

3.3.5 Dominated interventions ('do more harm than good' or 'better options available')

Three interventions fall in the category of dominated interventions (Table 3.7). The first is prostate-specific antigen (PSA) testing to screen for prostate cancer. A large proportion of false positive test results means a greater number of expensive and unpleasant follow-up diagnostic procedures and, in some cases, unnecessarily aggressive treatments for a disease that may never have given symptoms during an individual's lifetime. These harmful effects are greater than the modest population health gain from detecting true cases of prostate cancer. While there is no official PSA screening program, there is an extensive level of de facto screening.

The second dominated intervention is rosiglitazone for people identified with pre-diabetes. It is associated with an increased risk of cardiovascular disease. Third, beta blockers, while effective in preventing cardiovascular disease, compete with three more cost-effective blood-pressure-lowering drugs. Combining more than three such drugs is contrary to clinical practice. Lastly, dietary advice by a GP is dominated by dietary advice provided by a dietitian.

Table 3.7 Dominated interventions, ACE–Prevention

Topic area	Intervention	Comments
Cancer	Prostate cancer screen by PSA	More harm than benefit
Diabetes	Screen and rosiglitazone	Adverse effect on cardiovascular disease
Blood pressure and cholesterol	Beta blockers	Three more efficient drugs in class
	Dietary advice by a GP	Less expensive option

PSA, prostate-specific antigen

3.3.6 Treatment interventions

Four benchmark interventions were dominant (Table 3.8). Australia's needle exchange program is very good value for money with a sizeable impact. The rates of HIV and hepatitis C infection in intravenous drug users would have been closer to the high levels observed in western countries, rather than the very low levels in Australia, if this successful program had not been in place [42]. The early psychosis intervention has modest impact on health outcomes but saves costs compared to usual treatment. Probiotics to prevent antibiotic-associated diarrhoea in hospitalised elderly patients and eradication therapy for *H. pylori* in people with peptic ulcer disease are associated with modest health gain at a population level and are not very costly to implement.

Kidney transplant is a cost-effective intervention compared to chronic dialysis but availability of donor organs is the limiting factor. A nine-week short course of trastuzumab for early breast cancer appears to be cost-effective although the trial demonstrating its effectiveness was underpowered. A full-year course of trastuzumab, the current practice in Australia, is not good value for money despite multiple previous cost-effectiveness studies indicating the opposite [43]. These studies used inappropriate modelling methods in assuming all women with breast cancer have the same experience as a woman of average age with breast cancer.

Table 3.8 'Benchmark' treatment or infectious disease control interventions, ACE–Prevention

Topic area	Intervention	Lifetime health impact*	Annual intervention cost*	Strength of evidence
Dominant (net cost savers)				
Psychosis	Early psychosis prevention and intervention centre	+	+	Likely
HIV	Needle exchange program	+++	++	Likely
Diarrhoea	Probiotic *Lactobacillus* to prevent antibiotic-related diarrhoea in hospitalised elderly	+	+	Limited
Peptic ulcer disease	Eradication with triple therapy in *Helicobacter pylori* and patients with peptic ulcer	+	+	Sufficient
Very cost-effective ($0–10,000/DALY)				
Illicit drugs	Individual CBT for cannabis dependence	+	+	Sufficient
Depression	Individual CBT treatment major depressive episodes by psychologist	++	+++	Sufficient
	Group CBT treatment major depressive episodes by psychologist	++	++	Sufficient
	Bibliotherapy for major depression	+	+	Sufficient
	Maintenance group CBT by psychologist	++	++	Sufficient
CVD	Rehabilitation after myocardial infarction	+	++	Sufficient
HIV	Intermittent pre-exposure drug prophylaxis	++	+++	Sufficient
	Circumcision all MSM	+	++	Sufficient
Osteoarthritis	Hip replacement for osteoarthritis	+++	+++	Sufficient
	Knee replacement for osteoarthritis	+++	+++	Sufficient
Cost-effective ($10,000–50,000/DALY)				
Breast cancer	Trastuzumab for early breast cancer, 9-week course	+	++	Limited
Depression	TCAs for major depressive episodes plus 6 months continuation	+	++	Sufficient
	SSRIs for major depressive episodes plus 6 months continuation	+	+++	Sufficient
	Maintenance TCAs following major depressive episode	++	+++	Sufficient
	Maintenance SSRIs following major depressive episode	++	+++	Sufficient
	Maintenance individual CBT by psychologist	++	+++	Sufficient
CVD	Early stenting for myocardial infarction	+	+++	Sufficient
	Angioplasty coated stents in diabetics	+	++	Sufficient
Asthma	Asthma clinic; generous interpretation of benefits	+	+++	Limited
Not cost-effective (>$50,000/DALY)				
Breast cancer	Trastuzumab for early breast cancer, 1-year course	+	+++	Limited
Alcohol	Residential treatment and naltrexone	+	++	Sufficient
	Residential treatment	+	++	Sufficient

Topic area	Intervention	Lifetime health impact*	Annual intervention cost*	Strength of evidence
Kidney disease	Current dialysis and transplant	++	+++	Sufficient
	Dialysis only	+	+++	Sufficient
CVD	Angioplasty coated stents non-diabetics	+	++	Sufficient
	Elective bypass surgery and stents versus optimal medical treatment	+	+++	Sufficient
Influenza	Universal influenza vaccination for adults age 50–64 assuming Australian influenza-like illness incidence rate 1.79%	+	++	Limited
Varicella	*Herpes zoster* vaccine	+	+++	Sufficient
HIV	Early antiretrovirals	++	++	Sufficient
	Post-exposure prophylaxis for HIV	+	+	Sufficient

ACE, angiotensin-converting enzyme; CBT, cognitive behaviour therapy; CVD, cardiovascular disease; HIV, human immunodeficiency virus; MSM, males who have sex with males; TCA, tricyclic antidepressant; SSRI, selective serotonin re-uptake inhibitor

* See Section 2.5 for an explanation of table symbols and colour-coding.

Coronary bypass surgery and stenting have no impact on survival compared to optimal medical treatment (Table 3.8). The impact on reducing the pain symptoms of angina do not weigh up against the high cost. Nevertheless, this intervention is used widely at considerable cost to government. Assuming 10% bypass surgery at $25,000 and 90% stenting at $6500, and 18,551 cases in Australia in 2003, the cost would be $150 million.

Early treatment with antiretroviral drugs for HIV is expensive. Giving the drugs as prophylaxis after males who have sex with males (MSM) have been exposed has uncertain efficacy and is cost-effective as too many people at low-risk exposures are currently receiving prophylaxis. Residential treatment, with or without naltrexone pharmacotherapy, for alcohol dependence has low effectiveness but imperatives other than health concerns may justify residential treatment.

The intervention with the highest total expenditure in this list is kidney dialysis ($0.6 billion in 2003). The cost per individual is estimated at $70,000 per year. As there is considerable disability associated with dialysis, at such a high annual cost it obviously cannot have a cost-effectiveness ratio below our threshold of $50,000 per DALY, even though a person would die quickly without intervention. Economists invoke the ‘rule of rescue’ to justify spending a large amount on a small number of individuals who stand to benefit greatly, e.g. averting imminent death in end-stage kidney failure.

Anal cytology in MSM to detect anal cancer is not cost-effective compared to the much cheaper digital rectal examination screening method. The evidence for the effectiveness of asthma clinics is ambivalent. A Cochrane review shows a reduction in emergency department visits but the indicators on hospitalisations and days out of role are ambiguous [44].

3.4 Optimal intervention mix for selected risk factors and health problems

We have completed 'intervention pathways' in the areas of physical activity, obesity, alcohol, blood pressure- and cholesterol-lowering and kidney disease. A pathway for tobacco is still outstanding as some cost-effectiveness analyses are yet to be completed. A pathway for the pre-diabetes screening interventions could not be made as the two cost-effective options (metformin and lifestyle intervention on diet and exercise) were not a cost-effective option when combined. In the pathways we combine intervention options that address the same health problem (disease or risk factor) and determine the most cost-effective package of interventions.

3.4.1 Intervention pathway of blood pressure- and cholesterol-lowering interventions

The intervention pathway for blood pressure- and cholesterol-lowering combines the largest number of interventions for a single topic area and is the only example of a pathway with a significant level of current practice interventions analysed within ACE–Prevention. The pathway includes all drug and non-drug interventions that primarily aim to reduce blood pressure and/or cholesterol. The range of other interventions that affect cardiovascular disease (e.g. interventions that address tobacco, physical activity, diet or body mass) has been included not in this pathway but in the larger pathway in the next section. We had to use current practice estimates from the Australian Diabetes, Obesity and Lifestyle Study [45] in the year 2000, in which respondents reported use of blood pressure- or cholesterol-lowering drugs in general, because we needed to have estimates for each absolute CVD risk category. We extrapolated that the mix of cholesterol- and blood-pressure-lowering drugs prescribed in Australia in 2003, based on Pharmaceutical Benefits Scheme (PBS) data, would be the same for their use in primary prevention. While we are unable to verify these assumptions, it is clear that current drug treatments are inefficient (Figure 3.1). Current practice averts 380,000 DALYs over the lifetime of the 2003 Australian population, at a lifetime cost of $12 billion.

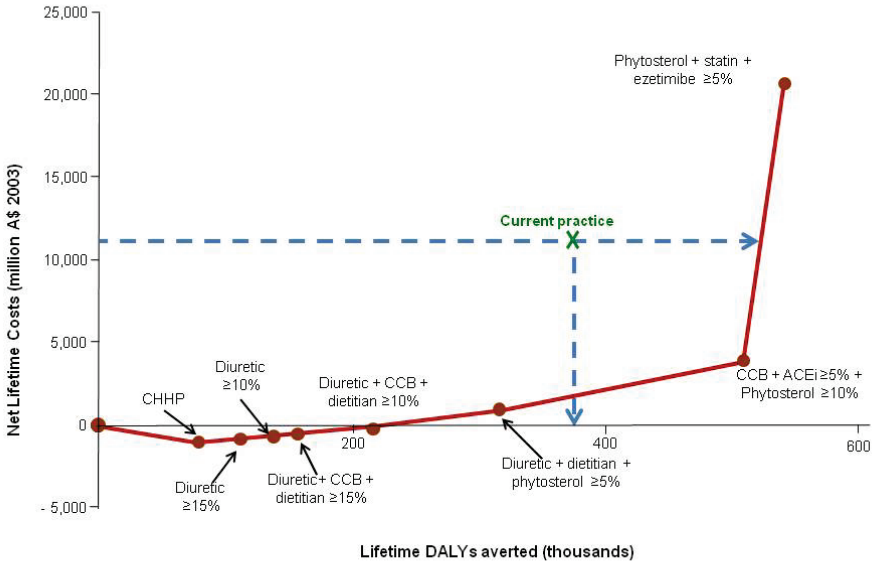


Figure 3.1 Intervention pathway of the most cost-effective interventions for blood pressure- and cholesterol-lowering interventions compared to current practice. ACEi, angiotensin-converting enzyme inhibitor; CCB, calcium channel blocker; CHHP, community heart health program; DALY, disability-adjusted life year

A more cost-effective mix of interventions consisting of a community heart health program, three blood-pressure-lowering agents, dietary advice and use of phytosterols in margarine would achieve a 30% increase in health gain at a third of the cost of continuing current practice. Figure 3.1 indicates that the greatest inefficiency is due to the cost of the current intervention mix. Current practice already has a significant impact on health outcomes and is one of the more important contributors to the decline in cardiovascular disease since the 1970s. The main reasons for the inefficiency of current practice are the choice of prescribing expensive rather than cheaper drugs even if they are as effective; and the prescription of expensive drugs to people who may have elevated levels on one risk factor while at low levels of absolute risk.

Introduction of the polypill at a feasible price of $200 is a more efficient option. With the non-drug interventions it can achieve as much health gain as current practice at a net cost saving (Figure 3.2). The combination of three separate blood-pressure-lowering drugs achieves greater health gain than can be achieved with the polypill, even if no cholesterol-lowering drug is added. The difference lies in the strength of the blood-pressure-lowering component agents in the polypill, which were assumed to be half the strength of the usual dose, to reduce side effects. The incremental cost-effectiveness ratio of adding cholesterol-lowering drugs to the pathway is greater than our threshold of $50,000 per DALY in both scenarios (Figures 3.1 and 3.2). Note that the combination of statins and ezetimibe is considered a more cost-effective option than use of statins only. The reason that cholesterol-lowering drugs become not cost-effective, if the most efficient mix of interventions is put in place first, is due to the high price of these drugs.

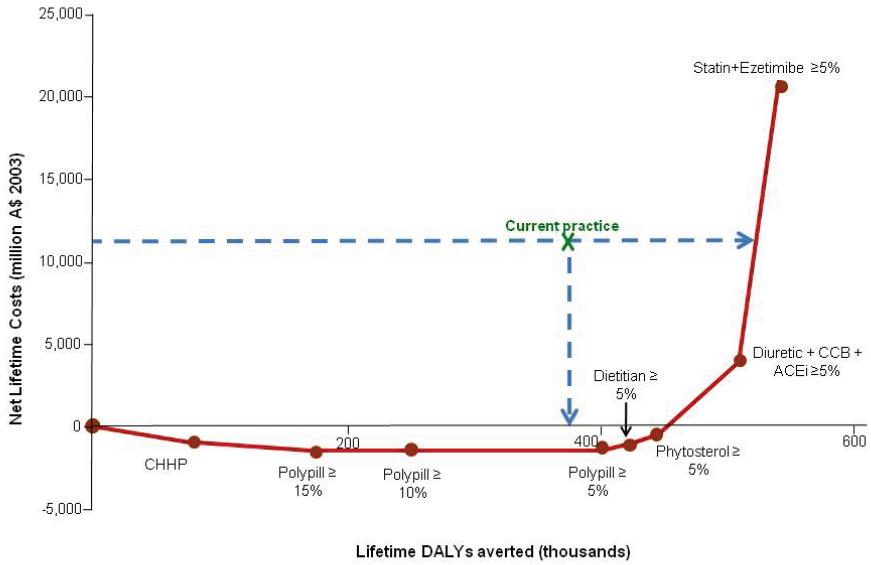


Figure 3.2 Intervention pathway of the most cost-effective interventions for blood pressure- and cholesterol-lowering interventions, including the polypill, compared to current practice. ACEi, angiotensin-converting enzyme inhibitor; CCB, calcium channel blocker; CHHP, community heart health program; DALY, disability-adjusted life year

3.4.2 Intervention pathway of alcohol interventions

The intervention pathway for alcohol combines seven interventions to prevent alcohol-related disease and injury and one intervention to treat alcohol dependence (Figure 3.3). Of the seven prevention interventions, random breath testing is considered the only intervention with more than negligible level of implementation in current practice. The vast majority of the health gain is achieved by the 30% tax on alcohol. The 30% tax alone could achieve 21% of the population health improvements that would be achieved if all drinkers reduced their daily alcohol consumption to fewer than four standard drinks for men and two standard drinks for women (the limits that the international literature and National Health and Medical Research Council until recently used to describe moderate alcohol intake). A volumetric tax that is revenue-neutral would have a far lower impact on health than the general tax increase. Further combinations of volumetric and increased taxation on alcohol are provided in Appendix 2 and in a separate report [46].

Taxation, advertising bans and an increase in minimum legal drinking age to 21 are cost-saving (dominant) interventions as indicated by the downward slope in the pathway in Figure 3.3. Brief intervention by a GP, licensing controls, drink driving mass media and the current practice of random breath testing are cost-effective additions to the pathway. The slope of the line towards residential treatment (with or without naltrexone pharmacotherapy) is very steep. Its inclusion in the pathway is not cost-effective.

The total package of alcohol interventions could avert 110,000 DALYs. However, there is only modest evidence around the preventive alcohol interventions and we have limited understanding of their effects on long-term drinking behaviour.

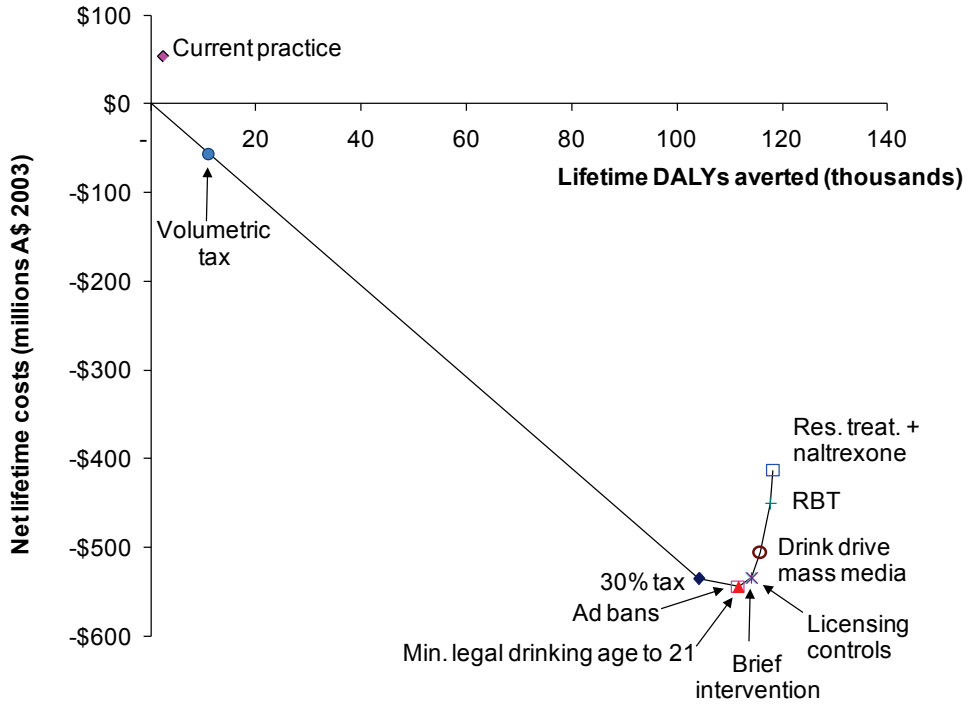


Figure 3.3 Intervention pathway for the alcohol interventions. DALY, disability-adjusted life year; RBT, random breath testing

3.4.3 Intervention pathway of physical activity interventions

The pathway combines six interventions that we evaluated for promoting physical activity (Figure 3.4). Overall, the evidence of effectiveness of physical activity interventions is quite weak. We excluded interventions that had not been evaluated for at least three months or studies that did not include measurement in a 'do nothing' comparator group. We chose interventions studies that were most generalisable to the Australian population.

Currently, in Australia, GPs are relied upon to deliver physical activity interventions (when time permits). In addition, governments provide some encouragement to change physical activity behaviour through local mass media and transport campaigns, but investment is minimal. In our review, we found that while some of the interventions were being implemented in the baseline year of 2003 all were operating at less than 5% of the estimated full capacity.

When evaluated incrementally in the pathway, the pedometer and mass media-based community campaigns and GP referral interventions are cost-saving to the health sector. These would be best followed up with the internet-based intervention program, the GP physical activity prescription program, and the TravelSmart program to encourage more active transport, which are all under the $50,000 per DALY threshold of cost-effectiveness.

The total package of physical activity interventions would cost $850 million to deliver, but would avert 61,000 DALYs, which is 34% of the population health improvements that could be achieved if everyone increased their physical activity to recommended levels.

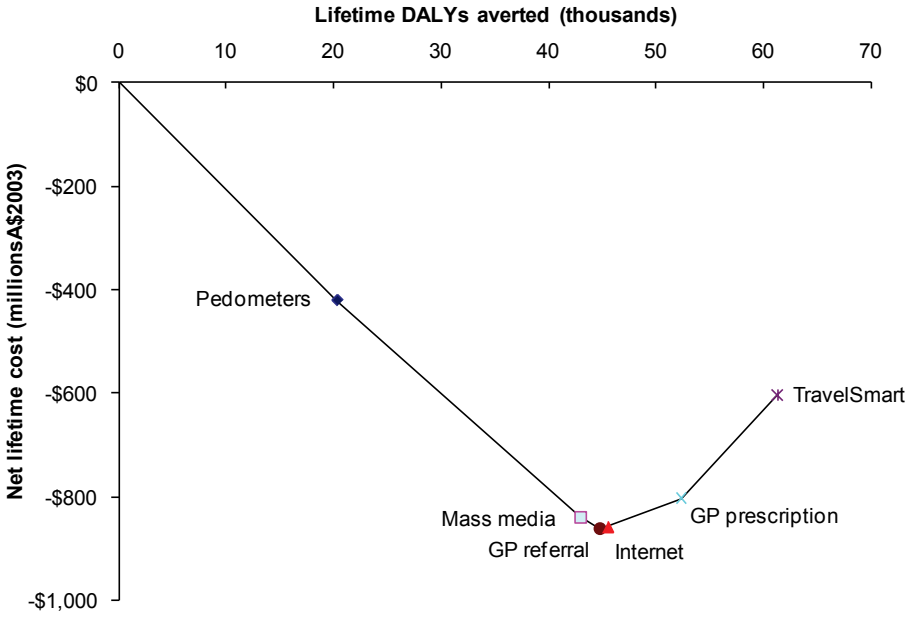


Figure 3.4 Intervention pathway for the physical activity interventions.

3.4.4 Intervention pathway of weight loss interventions

This pathway combines three interventions for weight loss that were found to be cost-effective in our league table: a 10% tax on unhealthy food (modelled for non-core foods that are high in saturated fat, sugar and/or salt content: biscuits, cakes, pastries, pies, snack foods, confectionery and soft drinks); laparoscopic gastric banding in people with body mass index greater than 35 (severely obese); and a

diet and exercise intervention targeted at overweight and obese people in primary care settings (Figure 3.5). The tax intervention has the greatest potential health impact but the evidence base is rather weak using data from the UK on elasticities, i.e. the reduction in consumption per unit increase in price. There is much stronger evidence that gastric banding for people with severe obesity can have a considerable impact on health outcomes. The large upfront costs are countered by considerable cost savings from not having to treat the diseases associated with obesity. The diet and exercise interventions in primary care offered to overweight and obese people, while cost-effective, have only a minor impact on population health outcomes as the weight lost is regained within a few years on average.

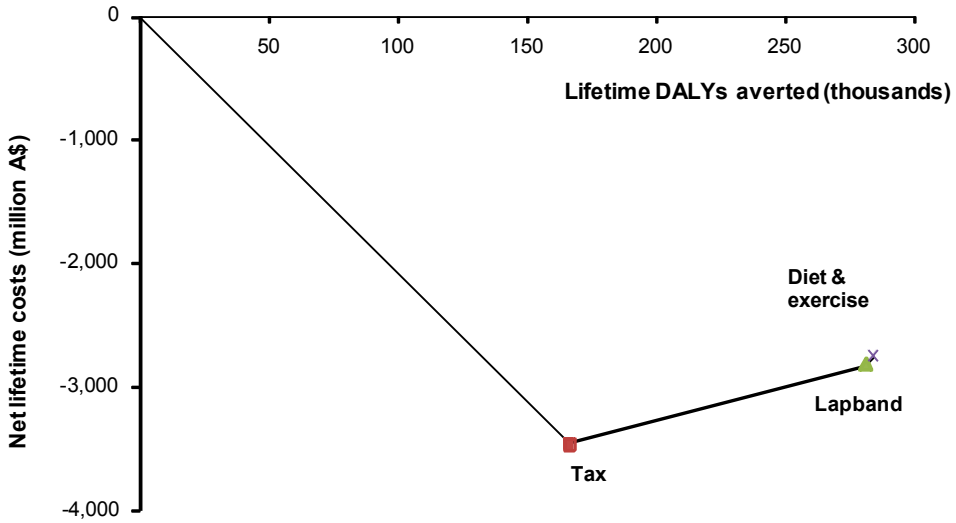


Figure 3.5 Intervention pathway for the weight loss interventions.

3.4.5 Intervention pathway of chronic kidney disease interventions

Guidelines are available for the screening of people with diabetes but not yet for the general population. The screening test is simple and cheap. The treatment with ACE-inhibitor drugs for those identified with chronic kidney disease is very effective and has the added benefit of preventing cardiovascular disease. Screening in diabetics leads to a net cost saving. Adding non-diabetics to the screening guidelines is very cost-effective for ages 50 to 79 and inclusion of younger people is also cost-effective but with some uncertainty. In contrast, the costs and health outcomes of not screening and having to provide dialysis and transplant services are not favourable. However, it has become accepted practice to invest in the high treatment costs of people with end-stage kidney failure as the alternative is imminent death. Due to ageing of the population and the increase in diabetes, demand for dialysis is increasing and kidney donor organs are in short supply. For these reasons, we consider screening for chronic kidney disease one of the missed opportunities in prevention (Figure 3.6).

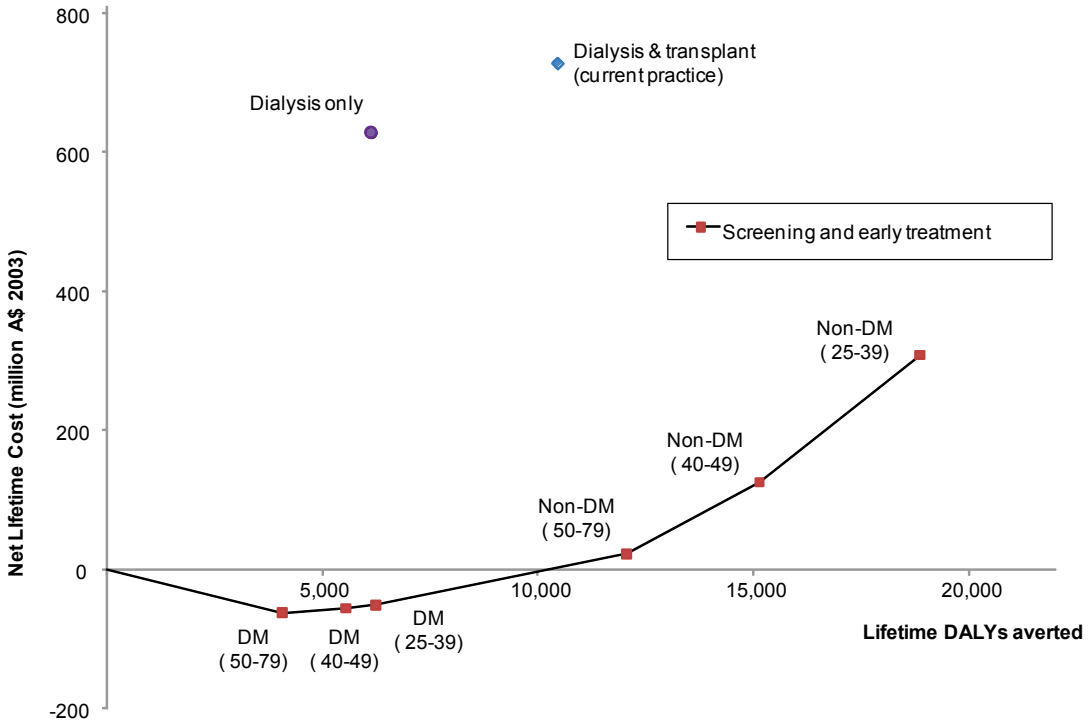


Figure 3.6 Intervention pathway for the chronic kidney disease interventions. DALY, disability-adjusted life year; DM, diabetes mellitus

3.5 Cost-effectiveness of combined intervention packages

We have evaluated the total intervention costs, cost offsets and health gain associated with implementing the package of interventions that are dominant (cost-saving) and the package of interventions that are dominant or very cost-effective (all interventions with cost-effectiveness less than $10,000 per DALY).

The different risk factor and disease interventions in Table 3.3 (dominant) and Table 3.4 (very cost-effective) have been modelled independently, but many have common disease outcomes (e.g. ischaemic heart disease or bowel cancer). In particular, these include the 'lifestyle' interventions that target blood pressure- and cholesterol-control, physical activity, nutrition (salt intake), alcohol intake and use of tobacco. Therefore, to determine the combined effect of these interventions on the total costs and health outcomes of the intervention packages, the interventions have been re-evaluated in a large combined model that integrates all relevant risk factors and disease parameters.

The packages of interventions are evaluated in the combined model in comparison to a partial null ('no intervention') scenario. For comparison, we also simulate current practice, which largely reflects the current use and prescribing practices for the primary preventive use of cardiovascular disease drugs.

Results are presented over time from the baseline year of 2003 to illustrate the timing of investment in intervention packages and return in the form of population health improvements and disease and injury cost offsets.

3.5.1 Dominant (cost-saving) interventions

The package of dominant interventions could avert one million DALYs over the lifetime of the 2003 Australian population. Eighty per cent of this health gain could be achieved with the taxation and regulation interventions on salt, alcohol and tobacco, and the polypill for cardiovascular disease prevention.

The package of dominant interventions would cost the health sector $4.6 billion, but could avert $11 billion in healthcare costs. Fourteen per cent of the investment would be required in the first year, with lower annual costs thereafter for the ongoing delivery of drugs for cardiovascular disease prevention (Figure3.7).

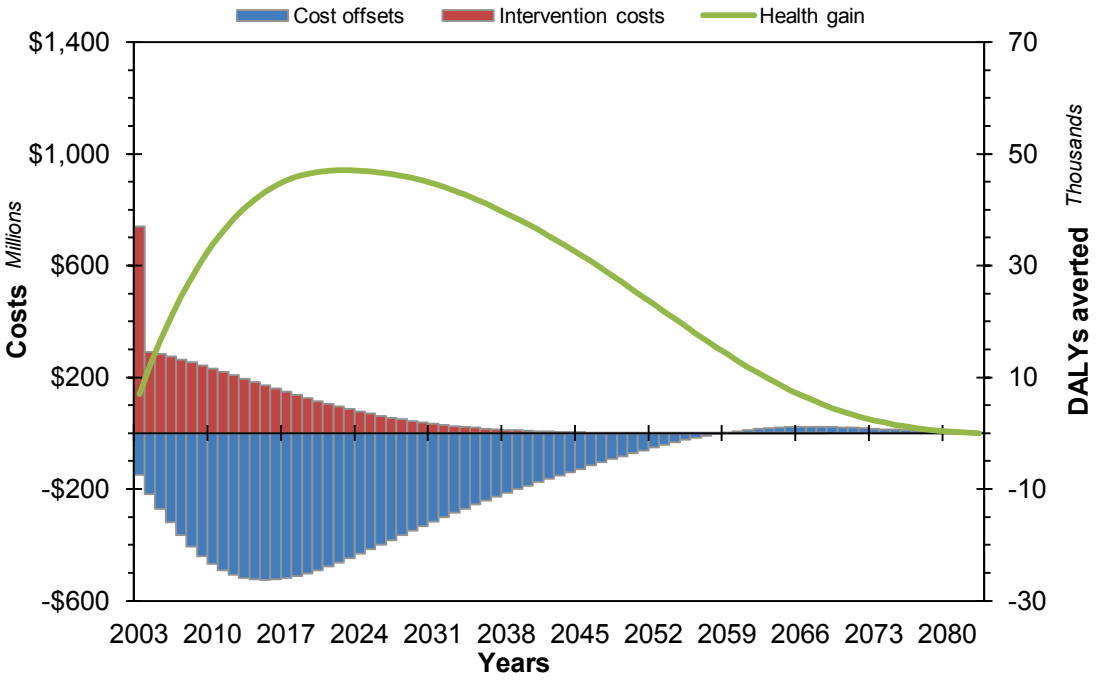


Figure 3.7 Intervention costs, cost offsets and health gain with the package of dominant (cost-saving) preventive interventions. DALY, disability-adjusted life year

The healthcare costs saved would reach a peak around 12 years after intervention. The extension of life due to implementation of this set of interventions would lead to a small net additional disease treatment cost from 2059 onwards.

In Figure 3.8 we overlay the costs, health impact and disease treatment costs saved by current practice in prevention on the previous graph. The costs of implementing the dominant package of interventions are substantially less than is currently spent on blood pressure- and cholesterol-lowering drugs and lifestyle management for preventing cardiovascular disease. Current assessment and management practices lead to far less health gain and less treatment costs averted than could be achieved with the dominant intervention package. In part, this is because of the inefficiency of current practice in blood pressure- and cholesterol-lowering due to a preference for expensive drugs and the inadequate targeting of people at risk based on individual risk factor levels rather than absolute cardiovascular risk.

Also, the taxation and regulation interventions in the dominant intervention package reduce the need for preventive cardiovascular disease drugs, which remain expensive even if prescribed most efficiently.

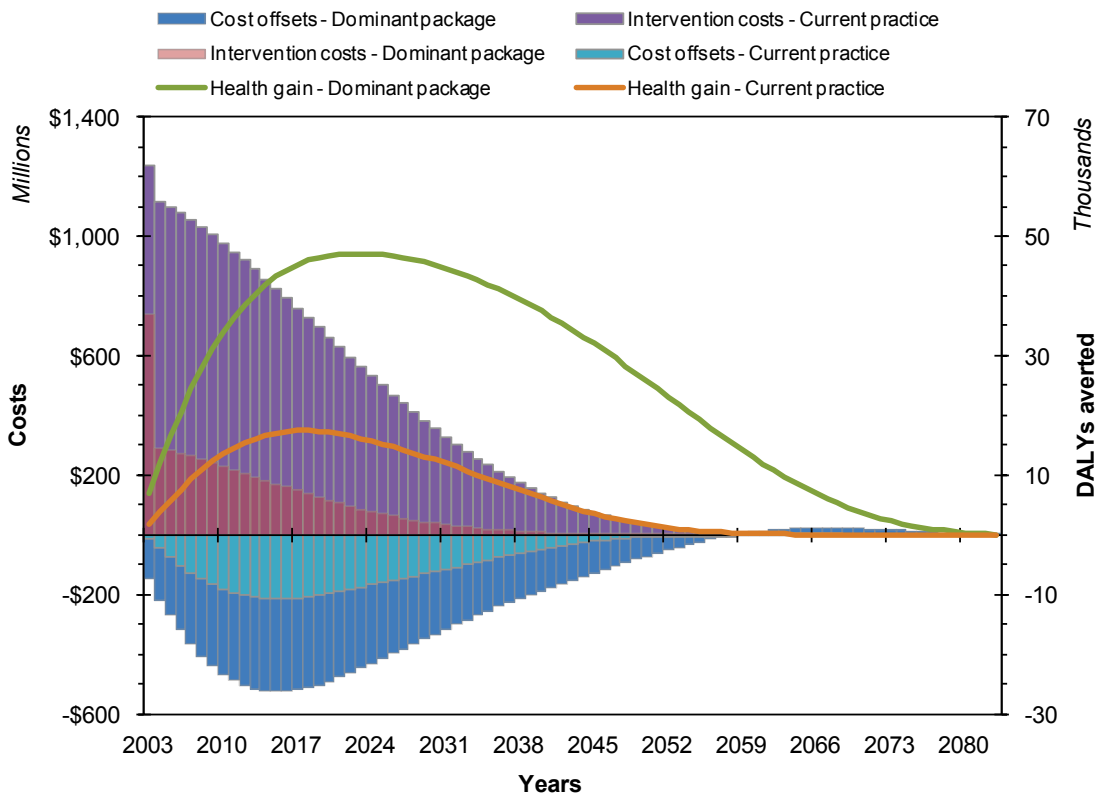
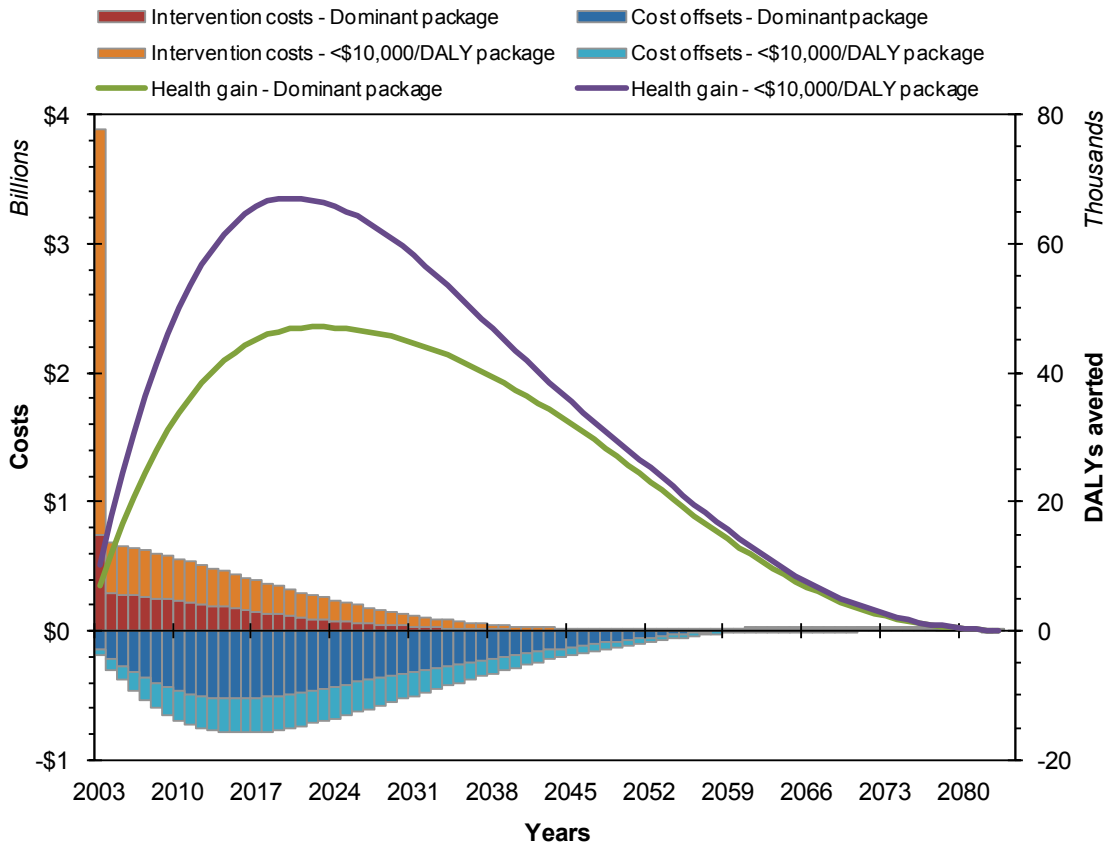


Figure 3.8 Intervention costs, cost offsets and health gain with the package of dominant (cost-saving) preventive interventions and current practice.

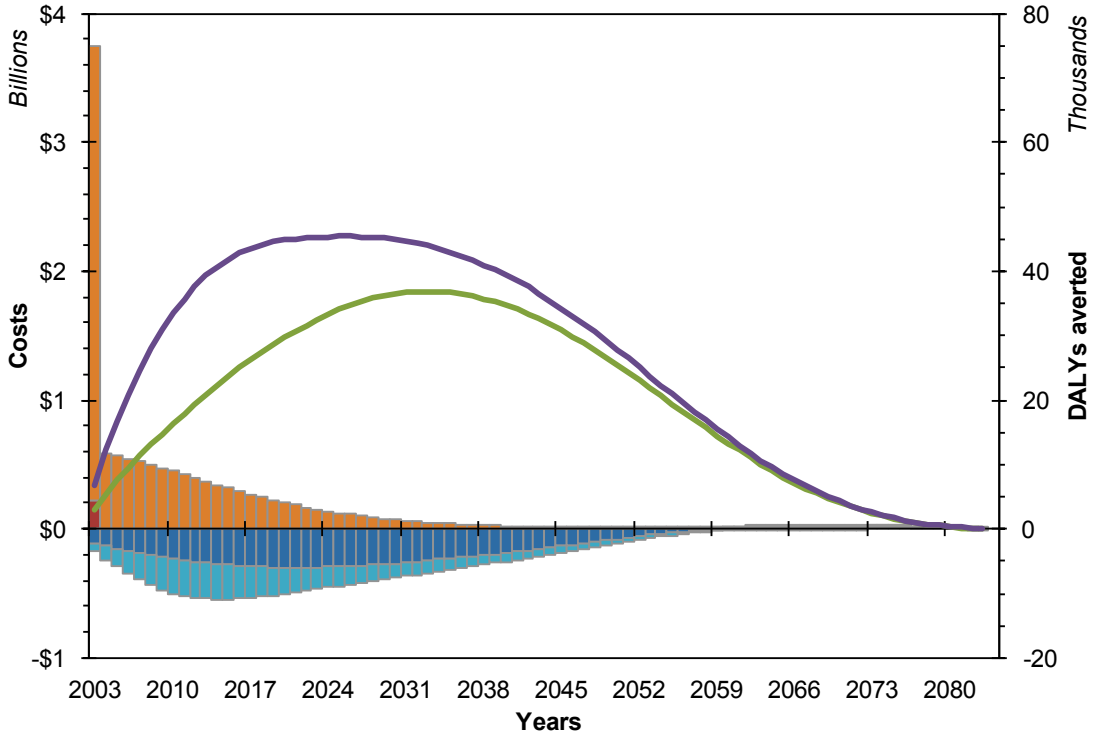
3.5.2 Very cost-effective interventions ($0–10,000 per DALY)

Adding interventions with cost-effectiveness less than $10,000 per DALY prevented to the package of dominant interventions leads to substantially greater upfront costs of intervention (Figure 3.9). Total cost of the package of dominant and very cost-effective interventions would be $13 billion, but this would be more than matched over time by $14 billion in reduced costs of health care.

A total of 1.4 million DALYs would be averted by the package of dominant and very cost-effective interventions, which is 400,000 DALYS more than the dominant package alone. A large proportion of the additional health gain is attributable to the polypill interventions, which include delivery to people at more than 5% absolute risk or at least 55 years in age, or the individual cardiovascular disease drugs if the polypill is not implemented (compare Graphs *a* and *b* in Figure 3.9).



(a)



(b)

Figure 3.9 Intervention costs, cost offsets and health gain with the package of very cost-effective ($0–10,000/DALY) preventive interventions: (a) including the polypill; (b) including individual blood pressure- and cholesterol-lowering drugs instead of the polypill.

4. Indigenous research in ACE–Prevention

4.1 Background and rationale for providing separate analyses

If Indigenous Australians experienced the same level of mortality and disability as the total Australian population, their total burden of disease in 2003 would have been 59% lower [47]. While considerable efforts are being made to reduce this health gap, there is a critical lack of information to guide policy-makers on what works and what represents good 'value for money'. It is our experience that the target disease burden, the prevalence and distribution of harmful exposures, the effectiveness of intervention strategies, the type of health service models, the acceptability to stakeholders and the cost of implementing effective interventions are all substantially different for Indigenous and non-Indigenous Australians. It is vital for effective policy, therefore, that health services are evaluated separately for the Indigenous and non-Indigenous populations, but undertaken in a way that enables meaningful analysis across and within these two populations. What makes this task more challenging is that conventional cost-effectiveness information may not provide sufficient economic guidance in Indigenous health. This is because: (i) the lip service given to equity within applied economic evaluation gives insufficient weight to increasing concerns about the health gap; and (ii) Indigenous Australians define 'good health' quite differently to non-Indigenous Australians. Indigenous Australians incorporate broader concepts of benefit, such as 'community health gain' and 'cultural security' not picked up in current quality-of-life metrics used by economists.

To meet this challenge, we need:

- sensible application and adaptation of existing knowledge on cost-effective interventions in the general population to the Indigenous population. The large size of the Indigenous health gap strongly suggests that this research effort has the potential to make a substantial difference;
- evaluation of interventions for health promotion and illness prevention that have been designed for and/or by Indigenous Australians and that reflect Indigenous knowledge systems; and
- development of innovative decision tools that are sensitive to Indigenous concepts of 'value', both in terms of health outcomes and in the way in which health services are delivered.

In ACE–Prevention we made important progress in meeting these needs, but are very conscious that much more remains to be done. In Section 4.4 we report the technical and second-stage filter analysis for 21 interventions that were adapted from analyses undertaken for the general population. These results cover interventions targeting blood pressure and cholesterol, pre-diabetes, kidney disease and hepatitis B. We also present results for the Looma Healthy Lifestyle Community-based intervention, an Indigenous-designed initiative for Indigenous Australians living in remote areas.

We adapted our analyses for the general population with one of two approaches. Either interventions were assumed to operate from mainstream health services, with model parameters adjusted for target population, participation and adherence rates or from ACCHSs, with model parameters adjusted using our Indigenous Health Service Delivery (IHSD) template. The template adjusted cost parameters as well as participation and adherence assumptions. More detail is given in Section 4.2.

4.2 Indigenous Health Service Delivery template

This section draws on the PhD work of Katherine Ong, who developed the IHSD template, and is reproduced from a pamphlet that describes this work (available from our website; see Appendix 3).

4.2.1 Background

Qualitative evidence suggests that a 'best-practice' model of primary healthcare delivery for Indigenous populations is based on self-determination and community control, epitomised by the ACCHS model of comprehensive primary health care [48, 49]. Therefore, the ACE–Prevention project has set out to evaluate the impact of delivering interventions to the Indigenous population using this health service type. However, there is a lack of quantitative evidence of the costs and effectiveness for interventions delivered from ACCHSs on which to base economic evaluations. To overcome this issue, the IHSD template was developed.

4.2.2 Overview

The IHSD template includes components that describe the additional activities provided by ACCHSs compared to mainstream GP practices, together with their impacts on the cost of delivering interventions and their health benefits for the Indigenous population. These can be described in terms of the differences between the two service types and are detailed in Box 4.1. The template transforms mainstream effectiveness data so that economic evaluations can be performed on interventions as if they were delivered from an ACCHS. Information used to construct the template has been obtained from the public literature and from interviews with people working within the ACCHS sector.

Table 4.1 The additional costs of IHSD Template components

IHSD template component category	Additional cost per ACCHS patient encounter
Basic health intervention delivery components	$16.67–31.57 (depending on consultation length)
Population health, social and community activities	$9.28
Management and governance	$3.87
Patient transport services	$47.01
Services to remote regions	$5.50

ACCHS, Aboriginal community controlled health service; IHDS, Indigenous Health Service Delivery

For the relevant IHSD template components in Box 4.1, values have been determined for both the additional costs involved each time a patient visits an ACCHS compared to a mainstream GP practice, and also for the differences in rates of Indigenous utilisation and adherence for the health service types (see Tables 4.1 and 4.2). A ratio of the differences in future cost offsets for the Indigenous compared to the non-Indigenous population has also been established, and these are also shown in the table. Additional costs have been attributed to a single encounter with a health service practitioner, as this then allows the intervention costs to be adjusted according to the number of health practitioner visits that are involved in the event pathway for an intervention. Calculated costs exclude services not directly related to healthcare delivery that may be provided by ACCHSs such as legal services.

Box 4.1 The Indigenous Health Service Delivery (IHSD) template components

Differences in health intervention delivery between ACCHSs and mainstream GP services, classified by key service characteristics, are shown.

- **Basic health intervention delivery components:**
  - role substitution: a patient may be seen by an Aboriginal health worker or a nurse in addition to, or instead of, a doctor;
  - compliance management, e.g. medication dosing and appointment recalls;
  - staff training activities, e.g. cultural in addition to professional training for non-Indigenous staff;
  - emphasis on home visits;
  - time spent on paperwork, case conferencing and the management of complex medical conditions; and
  - seeing of other family members as part of routine consultations.
- **Population health, social and community activities:**
  - provision of other services, e.g. social work and counselling;
  - provision of services usually provided by outside agencies, e.g. financial and housing assistance;
  - health promotion and community development activities; and
  - provision of a community space.
- **Management and governance structures:**
  - presence of a community management board and the associated need for community capacity-building in management; and
  - additional management resources required for overseeing larger staff numbers and multiple projects.
- **Patient transport services:**
  - provision of transport for patients to and from appointments.
- **Provision of services to a large remote population:**
  - out-of-hours emergency care;
  - outreach services;
  - housing and relocation costs for staff; and
  - additional costs associated with pharmaceutical and pathology services.
- **Rates of Indigenous utilisation of services and adherence to treatments**
- **Future cost offsets** (cost savings)

The IHSD Template values shown in Table 4.1 reveal that the costs of providing consultations via ACCHSs are higher than in mainstream GP practices, primarily due to the comprehensive nature of these services. In particular, the provision of patient transport contributes approximately 50% of the additional cost. In addition, improved access to health services for the Indigenous population is illustrated by higher rates of Indigenous utilisation of ACCHSs and adherence to treatments compared to mainstream GP services, thereby increasing the intervention's effectiveness when delivered from ACCHSs (see Table 4.2). Cost offsets are greater for the Indigenous population, irrespective of health service type, as disease treatment costs for Indigenous patients are higher due to greater co-morbidities and severity of disease, which leads to higher potential cost savings as a result of preventive interventions.

Table 4.2 IHSD template values (average across all services)

	Mainstream GP services	ACCHS
Short consultation cost	$30.85	$113.18
Indigenous utilisation rate (cf. non-Indigenous)	60.0%	73.2%
Indigenous adherence rate (cf. non-Indigenous)	77.8%	95.7%
Cost offsets ratio (Indigenous : non-Indigenous)	1.19	1.19

ACCHS, Aboriginal community controlled health service

4.2.3 Using the Indigenous Health Service Delivery template

It should be noted that the IHSD template remains a prototype at the completion of the ACE–Prevention project and requires further refinement and validation. It has been trialled in a number of ACE–Prevention evaluations involving the prevention of cardiovascular disease, diabetes and kidney disease; and these results are reported in Section 4.4. The data for these interventions taken from mainstream GP services modelling is adapted to the ACCHS setting using the IHSD template values prior to economic evaluation. For example, if an intervention entails one short GP consultation, the cost of $30.85 for mainstream GP services is substituted by $113.18 in the event pathway when delivered from ACCHSs. Similarly, the utilisation of health services by the Indigenous population is taken to be 60.0% for mainstream GP services, increasing to 73.2% for ACCHSs.

The IHSD template thus allows the resulting cost-effectiveness ratios to take these differences in treatment costs, utilisation and adherence rates into account when economic evaluations are performed. This is in addition to differences in Indigenous population demographics and disease risk, which are adjusted for separately in the modelling of health outcomes. As a result, the ACE–Prevention economic evaluations are made more relevant to the Indigenous population for use in priority-setting within the Indigenous context.

4.3 Work on Indigenous concept-of-benefit instrument

An important element of research design for Indigenous health services is capturing the Indigenous concept of health and wellbeing [50]. Over the course of three workshops with the ACE–Prevention Indigenous Steering Committee, agreement was reached on benefit dimensions/sub-dimensions and on how to define them. The dimensions of health benefit from an Indigenous perspective were identified as:

- individual health gain, with both DALY and non-DALY sub-dimensions (with the non-DALY dimension defined to cover empowerment, emotional wellbeing and spiritual wellbeing);
- community health gain, defined to cover internal relationships (development of bonding, social capital and Indigenous governance/control of interventions and involvement in decision-making), external links to social policies and institutions affecting health and wellbeing and sustainability of interventions;
- equity, with both disease status differentials (between Indigenous and non-Indigenous populations and also within Indigenous populations) and access attributes (covering physical availability and user charges); and
- cultural security, judging whether interventions had a design informed by Indigenous knowledge, were an appropriate response to cultural differences and values; whether they facilitated strong partnerships between providers and the Indigenous community; and the extent of employment of Indigenous workers.

One of the challenges in developing the Indigenous concept-of-benefit instrument is balancing the need for clear measurement properties that health economics demands (such as orthogonal dimensions, clear simple language, interval properties) with the richness of language and nuances of meaning the more sociological/behavioural science approaches favour. While this task is feasible, it is time consuming and cannot be rushed. The next steps in developing the instrument involve: (i) calibration of each dimension on a measurement scale; (ii) agreement on weights to combine the dimensions into an index score; (iii) piloting of the new benefit metric; and (iv) application to all the

interventions evaluated using the cost per DALY approach. In the meantime, the second-stage filter analysis will be utilised to capture the key dimensions of cultural security and community health gain.

4.4 Cost-effectiveness results for Indigenous population

Our analyses for the Indigenous population focus on interventions that address cardiovascular disease, diabetes and kidney disease. Indigenous Australians suffer much higher rates of these three diseases and the three diseases are closely linked by common risk factors. The vaccination strategies for hepatitis B are part of a PhD student's project and available in time for inclusion in this report.

4.4.1 League table for Indigenous population

The evidence base for the only Indigenous-specific intervention (the community-based health lifestyle intervention in Looma) was limited as it was based on a before-and-after comparison of risk factor levels without a control group. All other interventions included have sufficient evidence for efficacy, although not specific for Indigenous Australians. However, for the drug and medical interventions chosen we assumed the same effect size applies while allowing for differences in outcomes by adherence levels.

As we did for the total population, we classify the lifetime health impact and annual intervention costs into three categories. To reflect the great disparities in disease burden between Indigenous and total population we set the thresholds at twice the level for the total population proportionate to population size (Tables 4.3 and 4.4). Greater numerical detail for each intervention is available in Appendix 2.

The polypill (at an assumed annual cost of $200 per person) is a cost-saving intervention if delivered by mainstream services to all Indigenous Australians over the age of 35. Delivery of the polypill by ACCHSs is no longer cost-saving due to the higher costs of health service visits but would lead to greater health gain because of an improved Indigenous access to health services (increased utilisation of services and adherence to treatment). Note that the blood pressure- and cholesterol-lowering interventions in the Indigenous population are modelled by age and not by absolute risk as was done in the total population. This is partly because there are no representative health measurement data for Indigenous Australians but is also based on the argument that the high cardiovascular disease rates might warrant treatment of the whole population rather than those at high risk only. Of the individual drugs, diuretics and ACE inhibitors delivered by mainstream services are cost-effective but the addition of statins or the delivery of ACE inhibitors by ACCHs have a cost between one and three times the threshold for the total population of $50,000 per DALY. We deliberately created this extra category as equity concerns could be expressed as a greater willingness to pay for the same amount of health gain. The lifetime health impact of any of these interventions delivered to the Indigenous population by ACCHSs is 50% greater than if these same interventions were delivered by mainstream health services, due to improved Indigenous access. This is important to consider in addition to cost-effectiveness ratios if an objective is to close the Indigenous health gap.

Table 4.3 Key to Indigenous results

Key to results			
Lifetime health impact (DALYs)	>$5000	$500–5000	<$500
Annual intervention costs	<$0.5 million	$0.5–5 million	>$5 million

DALY, disability-adjusted life year

Table 4.4 League table of 19 interventions for the Indigenous population

Topic area	Intervention	Lifetime health impact	Annual intervention cost	Strength of evidence
Dominant	**(net cost savers)**			
Blood pressure and cholesterol	Polypill $200; mainstream, ages 35+	++	+++	Sufficient
Hepatitis B	Universal infant hepatitis B vaccination	++	++	Sufficient
	Hepatitis B vaccination and immunoglobulin for infants born to carrier mothers	++	+	Sufficient
	Universal hepatitis B vaccination and immunoglobulin for infants born to carrier mothers	++	++	Sufficient
Kidney disease	Screening and ACE inhibitors for chronic kidney disease, ages 25+	++	++	Sufficient
Very cost-effective ($0–10,000/DALY)				
Blood pressure and cholesterol	Polypill $200; ACCHS, ages 35+	+++	+++	Sufficient
Cost-effective ($10,000–50,000/DALY)				
Blood pressure and cholesterol	ACE inhibitors; mainstream, ages 35+	++	+++	Sufficient
	Diuretics; mainstream, ages 35+	++	+++	Sufficient
	Diuretics; ACCHS, ages 35+	++	+++	Sufficient
Pre-diabetes	Screen and dietary advice	+++	+++	Sufficient
	Screen and exercise physiologist	+++	+++	Sufficient
	Screen and dietary advice and exercise physiologist	+++	+++	Sufficient
	Screen and metformin	+++	+++	Sufficient
	Screen and acarbose	+++	+++	Sufficient
$50,000 –150,000/DALY				
Blood pressure and cholesterol	Statins; Mainstream, ages 35+	++	+++	Sufficient
	Statins; ACCHS, ages 35+	++	+++	Sufficient
	ACE inhibitors; ACCHS, ages 35+	++	+++	Sufficient
Pre-diabetes	Screening and orlistat	+++	+++	Sufficient
Kidney disease	Dialysis and transplant	++	++	Sufficient
	Dialysis only	+	++	Sufficient
Not cost-effective (>$150,000/DALY)				
Blood pressure and cholesterol	Looma healthy lifestyle: community-based intervention for remote Indigenous, ages 20+	++	+++	Limited
Pre-diabetes	Screen and rosiglitazone	+	+++	Sufficient

ACCHS, Aboriginal community controlled health service; ACE, angiotensin-converting enzyme; HPV, human papillomavirus

Vaccination for hepatitis B and screening for chronic kidney disease are cost-saving interventions because of the high rates of disease in the Indigenous population. Screening for pre-diabetes followed by drug (metformin or acarbose) and lifestyle interventions is cost-effective. As in the total population the cost for dialysis and transplant is higher than $50,000 per DALY but the same rule of rescue argument holds, it is established practice and unlikely to change.

While the Looma lifestyle intervention would rate highly on the proposed dimension of cultural security for an extended Indigenous concept-of-benefit, the effectiveness measured during the study as a change in risk factor levels was so small that it has a very unfavourable cost-effectiveness measured as a 'traditional' cost per DALY. Further evaluation of this intervention would be warranted once the Indigenous concept-of-benefit instrument has been developed (see Section 4.3).

4.4.2 Intervention pathways for the Indigenous population

Screening for chronic kidney disease in Indigenous Australians from as early an age as 25 with or without diabetes, in remote and non-remote areas, is a very attractive preventive option. It is cost-saving due to the very high costs of treatment once end-stage kidney failure has been reached (Figure 4.1).

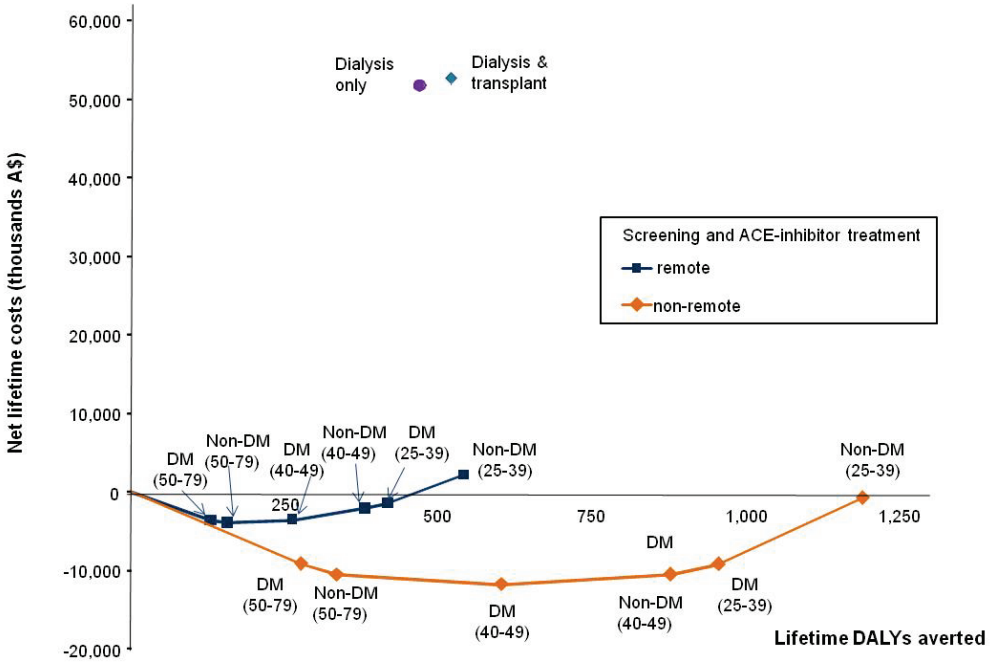


Figure 4.1 Intervention pathway for kidney disease interventions in the Indigenous population. DM, diabetes mellitus

5. Discussion and recommendations for policy-makers

5.1 Summary of results

Large impact on population health through prevention can be achieved by a limited number of interventions: taxation of tobacco, alcohol and unhealthy foods; a mandatory limit on salt in just three basic food items (bread, cereals and margarine); improving the efficiency of blood pressure- and cholesterol-lowering drugs using an absolute risk approach and choosing the most cost-effective generic drugs (or potentially introducing a low-cost polypill); gastric banding for severe obesity; and an intensive SunSmart campaign (Table 5.1). The evidence is strong for the treatment interventions, and 'likely' for the tax and regulation interventions. The SunSmart analysis is based on a rather weak comparison of skin cancer rates between states with low and high investment in SunSmart programs.

The taxation and regulation interventions have low implementation costs but the 'political cost' of implementing these may be much higher. In 2009, the National Preventative Health Task Force had recommended tax increases for tobacco and alcohol [51]. In May 2010, the federal government announced a 25% increase in excise on tobacco, indicating that the 30% tax increase we modelled as our main tobacco tax scenario is feasible. No increase in the tax on alcohol was announced. The protracted political decision-making around the introduction of a tax increase on alcopop drinks may have made government reluctant to contemplate another alcohol tax change. We have modelled a wide range of alcohol taxation options. As with tobacco we present a 30% tax increase as our main scenario. However, it would be advisable for Australia to move to a volumetric tax on alcohol. This would differentially increase taxation on cheap wines as these currently have a low tax relative to their alcohol content. Setting a volumetric tax at a level 10% above that currently imposed on spirits would achieve the same amount of health gain as the 30% tax increase of the current taxation levels for each type of drink. The impact of a tax on unhealthy foods is more speculative as we had to use UK data on the reduction in consumption of these foods in the absence of Australian data. We estimate that just a 10% tax on unhealthy non-core foods would lead to substantial health gain and considerable future cost savings by averting treatment of obesity-related diseases.

A mandatory limit on the salt content in processed foods is another cheap intervention with considerable health gains and cost savings from avoided cardiovascular disease events. It would also meant that less people would need to take preventive drug treatment.

The preventive treatments for cardiovascular disease by blood pressure- and cholesterol-lowering drugs are very effective and have contributed in part to the more than 70% decline in cardiovascular mortality over the last four decades. However, they are an expensive and recurrent cost. A shift towards cheaper generic drugs and guided by absolute risk rather than individual risk factor threshold levels could increase health gain by a third over what currently is being achieved, at very large immediate and ongoing cost savings. The cost savings would become even greater if Australia were to adopt a generic polypill containing three blood-pressure-lowering drugs and one cholesterol-lowering drug. Issuing new guidelines based on absolute risk and with strong recommendations for using the most efficient drugs is an important first step to persuade practitioners to prescribe more efficiently. A further set of incentives to promote desired practitioner behaviour and disincentives for continuing old habits may need to be put in place.

We estimate large health gain for laparoscopic gastric banding as a preventive surgical treatment. This estimate assumes a quarter of severely obese people would opt for surgery. The upfront costs would be enormous but would in large part be compensated by large cost savings from averting diseases like diabetes and cardiovascular disease. This may seem like a radical approach to prevention for a large number of people. However, apart from the suggestion that a tax on unhealthy food may deal with the growing obesity problem, our analyses show that there is no evidence for other viable alternatives currently available that can make significant inroads into the very large increase in obesity-related disease. Weight loss interventions through diet and exercise have little impact as, on average, weight is regained within a few years.

A national SunSmart program at the level of intensity in Victoria is a rather costly intervention when we include the cost of sunscreen purchase by individuals. The cost to government is a rather modest 5% of the total cost listed in Table 5.1. Introduction of greater investment in other states should be accompanied by a well-designed evaluation study to improve the evidence base of its effectiveness.

Table 5.1 Lifetime health outcomes, intervention costs and cost offsets for the most cost-effective preventive interventions with largest population health impact

		(Lifetime, discounted)	
Intervention	**DALYs**	**Intervention costs (A$ billion)**	**Cost offsets (A$ billion)**
Taxation			
Tobacco tax 30%	270,000	0.02	0.7
Alcohol tax 30%	100,000	0.02	0.5
Alcohol volumetric tax 10% above current excise on spirits	110,000	0.02	0.7
Unhealthy foods tax 10%	170,000	0.02	3.5
Regulation			
Mandatory salt limits processed food	110,000	0.07	1.5
Preventive treatments			
Three blood-pressure-lowering drugs to replace current practice of preventive drug treatments*	20,000	–1.9	0.3
Polypill to replace current practice	60,000	–7.0	0.8
Laparoscopic gastric banding BMI>35	140,000	3.7	2.9
Health Promotion			
Intensive SunSmart	120,000	2.0	0.3

BMI, body mass index; DALY, disability-adjusted life year

*We estimate a lifetime health benefit of 230,000 DALYs from current practice. The polypill or a combination of blood-pressure-lowering drugs targeting by absolute cardiovascular risk and 'realistic' assumptions on uptake and adherence would lead to some additional health gain but large cost savings.

Apart from these few high-impact preventive measures we have identified a large range of preventive interventions with more modest impact at a population level. In our results tables (Tables 3.2–3.8; Table 4.4; Appendix 2 for details), we have marked interventions with a lifetime impact of between 10,000 and 100,000 DALYs as having a moderate impact. The main missed opportunities among these are screening programs for pre-diabetes, chronic kidney disease and low bone mineral density in elderly women. Evidence is good for the effectiveness of the drug and lifestyle treatments that are recommended for the high-risk individuals identified by screening.

Smoking cessation aids, pedometers and mass media for physical activity are other approaches with moderate population health impact. We note that a considerable health impact of physical activity can be achieved without necessarily reducing body weight.

Of the cost-effective interventions with smaller population health impact, the growing list of potential preventive measures for mental disorders deserves mentioning. Until recently, the focus was solely on treatment of mental disorders. While it is encouraging to see an emerging literature on effective means of prevention, our analyses indicate that treatment will continue to be the mainstay of mental health services as the health gain from prevention is still modest. Hepatitis B and human papillomavirus vaccination are cost-effective measures of preventing largely what tend to be called non-communicable disease outcomes: cancers and cirrhosis.

We have also identified a range of not cost-effective forms of prevention (Table 3.6). A considerable investment in prevention is currently made for some of these, e.g. weight loss interventions and most of the approaches in the literature to promote the intake of fruit and vegetables. We would argue for a redirection of those resources towards more favourable interventions. The worst example of a not cost-effective intervention is screening by prostate-specific antigen test to detect prostate cancer. The properties of the test are so poor that it leads to many unnecessary invasive follow-up examinations and treatments that have serious long-term consequences. These harms are greater than the benefits of early detection of new cases that could lead to death. The strong recommendation is to stop using the test in asymptomatic men altogether.

For comparison, we also analysed the cost-effectiveness of a smaller number of treatment and infectious disease control interventions. These were intended as 'benchmarks' for our preventive interventions. A number of results are worth noting. Australia's needle exchange program is cost-saving and has contributed to the low HIV-seroprevalence in injecting drug users in Australia. Well established, high-cost treatments that are not considered cost-effective include kidney dialysis, stenting or bypass surgery for coronary heart disease and a one-year course of trastuzumab for early breast cancer. Providing a kidney transplant instead of ongoing dialysis is cost-effective but limited by the number of available donor organs. The alternative of imminent death in people with end-stage kidney disease justifies continued investment in current practice of dialysis and transplant services despite the not-so-favourable cost of $70,000 per DALY. Recent evidence shows that elective stenting or bypass surgery has no benefit on survival in people with coronary heart disease. Therefore, the cost is high in comparison to the limited benefits of symptom relief of angina only. The high drug cost makes trastuzumab in a full one-year course not cost-effective. Weak evidence from an underpowered study indicated that a similar effect can be achieved with just nine weeks of treatment.

5.2 Comparison with other cost-effectiveness studies of prevention

ACE–Prevention is an important achievement, more than doubling the published economic appraisal research on health promotion/illness prevention in Australia. During a search in 2005, Dalziel and Segal [52] found published cost-effectiveness results for 245 interventions in Australia. They classified 78 of these as prevention. At a recount excluding infectious disease control interventions and variations on the same intervention (e.g. different age cut-offs for a screening program) the review included 56 preventive interventions for non-communicable disease. Half of these were from Segal's group concerning prevention of diabetes, obesity and nutrition-related interventions [53, 54]. Where the

same interventions were modelled our results tend to be less favourable. Important differences in approach are that Segal and colleagues (i) assume no decay of intervention effect over time unless explicitly measured in a trial; (ii) base analyses on single trial information rather than meta-analysis of all available trial data; (iii) present results without uncertainty analysis; and (iv) do not estimate the effects and costs at a population level.

Internationally comparable economic evaluation studies that have addressed prevention include the WHO CHOICE (CHOosing Interventions based on Cost-Effectiveness) project [55, 56], modelling by the Dutch Centre for Public Health and the Environment (RIVM) and the National Institute for Clinical Excellence (NICE) in the UK. The focus of WHO CHOICE is on developing countries. An important difference in approach is their choice to model interventions based on efficacy rather than effectiveness while we have endeavoured to use realistic estimates of coverage, effectiveness and adherence under routine health service conditions. WHO CHOICE findings on cardiovascular disease prevention [57] and alcohol [58] lead to similar conclusions as our results although results are not so easy to compare as they are presented for large world regions.

RIVM has built up a complex chronic disease model. They run analyses mainly to inform Dutch national policies. The model has its epidemiologic input data from a continuous burden of disease-like exercise performed by another department at the same RIVM, which systematically collects, analyses and interprets all available national study data. Recent publications by this group are on alcohol taxes [59], brief GP interventions for alcohol abuse [60], lifestyle modification in diabetic patients [61], weight reduction with low-calorie diet alone or diet and orlistat [62], smoking cessation [63], tobacco taxes [63] and smoking prevention and cessation among students [64]. While the work of the RIVM has similarities to the ACE–Prevention project, it seems to be functioning at a smaller scale and does not cover anywhere near the number of interventions, although it could accumulate more over the years, it being a continuing program. In recent work the RIVM expressly includes the total healthcare costs in life years gained by interventions, which ACE–Prevention does not.

In the UK, NICE produces health technology assessments and cost-effectiveness studies across a wide range of topics. To 2010, NICE produced guidance on 24 prevention topics, including alcohol, tobacco and physical activity. It is not so clear how comparable their results are across different topic areas as segments of work were commissioned separately but we have not found a set of economic evaluation guidelines that is nearly as detailed as ours.

5.3 Strengths and limitations

The greatest strength of this body of work is the sheer number of comparisons of cost-effectiveness results. Economic evaluation is all about comparisons and the value of the information increases with the number of alternatives examined. We aimed to be comprehensive in our analysis of prevention options for non-communicable disease in Australia. We have managed to cover the most important strategies for the main diseases and risk factors. While greater detail is possible within topic areas, we are confident that we provide a comprehensive overview of the evidence base of prevention and how it applies to the context of Australian health services.

Another important strength is that ACE–Prevention couples volume of work with technical rigour. There are six key factors that we addressed in achieving technical rigour.

First, we carefully evaluated all evidence of efficacy for each intervention. Where we could, we applied effect sizes from meta-analyses. For each intervention we endeavoured to find data to determine the effectiveness under routine health service conditions in Australia. If no data were available, we made assumptions on coverage and adherence that were similar to those made for interventions with data available.

Second, we build our analyses on a comprehensive and consistent set of disease and risk factor parameters pertaining to the Australian population from the Australian Burden of Disease study. That allowed us to address idiosyncrasies of ill-defined deaths and disease codes in routine databases, which tend to be ignored in most disease-specific epidemiological and economic studies. It also enabled us to estimate the probability of health loss by age and, thus, to adjust the health gain from averted deaths in our economic models to reflect that a year gained at older ages is a less healthy year than that gained by a younger person.

Third, we estimated costs of interventions and future disease treatment costs based on Australian data and in a consistent manner across all interventions following a detailed protocol.

Fourth, we used a consistent approach to economic evaluation across all our analyses. Such a consistent approach allows valid comparisons of cost-effectiveness results in a league table. This is in contrast to league tables that haphazardly combine estimates from different studies in different contexts and using different methods and that are rightly criticised in the literature [65].

Fifth, we present our results with uncertainty and examine variations in important assumptions in sensitivity analyses. Apart from capturing uncertainty numerically in our results, separately, we also provide a more qualitative assessment of the strength of the evidence underlying each of the individual analyses.

Sixth, we present results for the ideal package of interventions for major topic areas and can contrast this with current practice to identify its degree of inefficiency. We also present results for a large combination of recommended prevention strategies across many different topic areas. This is important as decisions are not taken in isolation and the implementation of one intervention can influence the cost-effectiveness credentials of another. For instance, implementation of a 30% increase in tobacco tax will have a major impact on cardiovascular disease rates and we have been able to evaluate by how much this would reduce the amount of health gain from other cardiovascular preventive interventions. We have also been able to address synergies between costs, for example when a second intervention can be provided during the same health service contact. The combined analysis also gives a good indication of the magnitude of the aggregate health gains that are possible with optimal policy.

While most of the research endeavour focused on ensuring the technical rigour of the cost-effectiveness analyses in ACE–Prevention, we also put emphasis on ‘due process’ involving stakeholders from governments, health non-government organisations, academics and service providers. Represented in a project steering committee and technical advisory groups they have provided advice on the selection of interventions, the modelling methods, interpretation of the results, formulation of policy-relevant recommendations and a dissemination strategy. It has not always been easy to maintain stakeholders’ interest over the five-year period and there has been a rather rapid turnover of representatives from some of the organisations. Nevertheless, particularly the

representatives of government have expressed their satisfaction with the emphasis on collaboration and consultation in this project. This means that as researchers we are more likely to reach our aim of influencing decision-making on resource allocation to prevention.

Despite our efforts to provide valid comparisons by using consistent methods or the highest technical rigour, we recognise a number of weaknesses in our study design.

First, we could not include a number of prevention strategies for which there was no evidence of effectiveness. For instance, there has been no long-term, independent, well-funded, sustained media campaign on alcohol and therefore also no evidence on effectiveness. However, there is evidence that such media campaigns on tobacco have been effective. The least this suggests is that there is promise in applying the same approach for other health problems. We did include a cost-effectiveness analysis of a media campaign on physical activity, albeit based on limited evidence of effectiveness.

Second, we chose to model all interventions targeting the Australian population of 2003 who would be eligible depending on the focus of each intervention. We then modelled everyone to 100 years of age or death. That means that after the baseline year of 2003, our models deal with a dwindling cohort rather than the Australian population over time. We made that decision because the alternative is to make rather difficult assumptions about the time horizon over which interventions are implemented and consequences are being measured. WHO CHOICE, for instance, makes an assumption that interventions are implemented for 10 years and then stopped altogether while continuing to count the costs and benefits that would occur afterwards. That is a decision that is rather removed from reality. A decision on what time horizons to use for implementation and for health impacts is necessary to be able to capture all costs and benefits associated with an intervention. An alternative solution may be to extend the period of intervention for a period that is long enough that discounting no longer changes the results. At 3% discounting, that would be a period of at least 50 years.

Third, it was not easy to set rules about the duration of interventions. Some interventions are clearly implemented as ‘one-off’ (taxation and regulation interventions), others clearly intended to extend for life, but a large number of interventions fall in between. For many of these interventions there is little or no information in the literature on the design of interventions that would sustain longer term impacts. This is particularly the case for health promotional interventions (such as mass media campaigns) and behaviour change interventions targeted at individuals (such as dietary counselling or physical activity interventions by exercise physiologists). We decided to model these interventions with a one-year horizon and we applied a decay function of the effect after that. For some behaviour change interventions we found evidence for a dwindling effect in longer term follow-up studies but for most of these interventions we had to postulate the degree of decaying effect. It is a vital assumption in our models and is one of the reasons why we tend to measure higher cost-effectiveness ratios than other studies.

Fourth, we used a number of modelling approaches. The standard approach was to use a multi-state life table modelling approach applying average costs and effect sizes to the eligible cohort and modelling these in five-year age groups to death or 100 years of age. For some diseases we resorted to a micro-simulation approach when we had enough data and there were important variations between individuals. Examples of these are the model for cervical cancer screening that needed to take into account variation in the growth of tumours and the model for screening for pre-diabetes that needed to take into account a history of having been screened in the past. However, when we took the data

inputs from each of the risk factor life table models and constructed our large combined model using a micro-simulation approach we found a systematic difference with the combined estimates showing lower health gain by up to 25%. Part of the reason is that a micro-simulation approach allows a more accurate estimation of the intervention impact across the whole distribution of risk factor exposure. Another reason is that the 'null' (the hypothetical back calculation to a 'no intervention' scenario) is different in the combined model as it takes currently implemented interventions across multiple topic areas into account. We will explore this further in future and contribute to the literature on 'model uncertainty' an aspect of uncertainty in economic modelling that is not often quantified [66].

Fifth, while the inclusion of our second-stage filter criteria has been welcomed and embraced by policy-makers, there are opportunities to add more empirical evidence to these considerations. An example is the work we have started developing with the Indigenous Steering Committee on how to incorporate aspects of health benefits that are important to Indigenous Australians such as community health gain and cultural security. Also, there remains a gap in the literature regarding how to incorporate equity concerns into measures of efficiency (i.e. cost-effectiveness).

Glossary of terms

ACCHS	Aboriginal community-controlled health service
AIDS	acquired immunodeficiency syndrome
BMI	body mass index
CBT	cognitive behaviour therapy
CCB	calcium channel blocker
CHHP	community heart health program
CVD	cardiovascular disease
DALY	disability-adjusted life year
DWL	deadweight loss
GP	general practitioner
HIV	human immunodeficiency virus
HPV	human papillomavirus
ICER	incremental cost-effectiveness ratio
IHDS Template	Indigenous Health Delivery Service Template
MSM	males who have sex with males
PSA	prostate-specific antigen
SSRI	selective serotonin re-uptake inhibitor
TCA	tricyclic antidepressant

References

1. George B, Harris A, Mitchell A. Cost-effectiveness analysis and the consistency of decision making. Evidence from pharmaceutical reimbursement in Australia (1991–1996). *Pharmacoeconomics*, 2001; **19:** 1103–1109.

2. Australian Health Ministers' Advisory Council. Cervical cancer screening in Australia: options for change. *Australian Institute of Health: Prevention Program Evaluation Series No. 2 AGPS.* Canberra: Australian Institute of Health, 1991.

3. Australian Health Ministers' Advisory Council. Breast cancer screening in Australia: future directions. *Australian Institute of Health: Prevention Program Evaluation Series No. 1 AGPS* Canberra: Australian Institute of Health, 1990.

4. Farrelly MC, Pechacek TP, Chaloupka FJ. The impact of tobacco control program expenditures on aggregate cigarette sales: 1981–2000. *Health Economics*, 2003; **22:** 843–859

5. National Cancer Institute. Greater than the sum: systems thinking in tobacco control. Tobacco control monograph no. 18. Bethesda, MD: National Cancer Institute, 2007.

6. Begg S, Vos T, Barker B, Stevenson C, Stanley L, Lopez A. The burden of disease and injury in Australia, 2003. Research report. Canberra: Australian Institute of Health and Welfare, 2007.

7. Renwick M, Sadowsky K. Variations in surgery rates. *Health Services Series No. 2*. Canberra: Australian Institute of Health, 1991.

8. Hurley E, McRae I, Bigg I, Stackhouse L, Boxall AM. The Australian health care system: the potential for efficiency gains. A review of the literature. Background paper prepared for the National Health and Hospitals Reform Commission. Canberra: Australian Government, 2009.

9. Ham C. *Clinical Practice Variations: Assessing the Evidence in Health Care*. London: King's Fund, 1988.

10. Richardson J, Robertson I, Hobbs M. The impact of new technology on the treatment and cost of acute myocardial infarction in Australia. Technical report. Melbourne: Centre for Health Program Evaluation, 1998.

11. Richardson J, Robertson I. Variation in procedure rates across statistical local areas in Victoria. Research report. Melbourne: Centre for Health Program Evaluation, 1998.

12. McPherson K. International differences in medical care practice. In: OECD, ed. *Health Care Systems in Transition: The Search for Efficiency.* Paris: OECD, 1990; 17–28.

13. Leape L, Park RE, Solomon D, Chassin MR, Kosecoff J, Brook RH. Does inappropriate use explain small-area variations in the use of health care services? *The Journal of the American Medical Association*, 1990; **265:** 669–672.

14. Goss J. Projection of Australian health care expenditure by disease, 2003 to 2033. *Health and Welfare Expenditure Series No. 36.* Canberra: Australian Institute of Health and Welfare, 2008.

15. Richardson J. How much should we spend on health services? In: Baume, P, ed. *The Tasks of Medicine: An Ideology of Care*. Sydney: Maclennan & Petty, 1998; 250–276.

16. Rice T. *The Economics of Health Reconsidered*. Chicago: Health Administration Press, 1998.

17. Hauck K, Smith PC, Goddard M. The economics of priority setting for health care: a literature review. HNP discussion paper. Washington DC: World Bank, 2003.

18. Shiell A, Mooney GA. A framework for determining the extent of public financing of programs and services. Discussion paper no. 6. Ottawa: Commission on the Future of Health Care in Canada, 2002.

19. Ham C, Coulter A. International experience of rationing (or priority setting). In: Coulter A, Ham C, eds. *The Global Challenge of Health Care Rationing*. Philadelphia, PA: Open University Press, 2000.

20. Klein R, Day P, Redmayne S. *Managing Scarcity: Priority Setting and Rationing in the National Health Service*. Buckingham: Open University Press, 1996.

21. Maynard A. Rationing health care. *British Medical Journal*, 1996; **313**: 1499.

22. The Treasury. Intergenerational report 2007. Canberra: Commonwealth of Australia, 2007.

23. Carter R, Stone C, Vos T. Trial of program budgeting and marginal analysis (PBMA) to assist cancer control planning in Australia. Research report. Canberra: Department of Health and Aged Care, 2000.

24. Nelson MR, Liew, D, Bertram M, Vos T. Epidemiological modelling of routine use of low-dose aspirin for the primary prevention of coronary heart disease and stroke in those aged ≥70 years. *British Medical Journal*, 2005; **330:** 1306–1311.

25. Carter R, Moodie M, Markwick A *et al*. Assessing cost-effectiveness in obesity (ACE-obesity): an overview of the ace approach, economic methods and cost results*. BMC Public Health*, 2009; **9:** 419.

26. Carter R, Vos, T Moodie M, Haby M, Magnus A, Mihalopoulos C. Priority setting in health: origins, description and application of the assessing cost effectiveness (ACE) initiative. *Expert Review of Pharmacoeconomics and Outcomes*, 2008; **8:** 593–617.

27. Australian Institute of Health and Welfare. Health system expenditure on disease and injury in Australia, 2000–01. *Health and Expenditure Series No. 19*. Canberra: Austalian Institute of Healtha and Welfare, 2004.

28. Gold M. *Cost-effectiveness in Health and Medicine*. New York: Oxford University Press, 1996.

29. Carter R, Vos T, Barendregt J, Mihalopolous C. *ACE Prevention Economic Protocol*. Cited 17 Aug 2010. Available from URL: http://www.uq.edu.au/bodce/index.html?page=43983&pid=37712

30. Habbema JDF, Boer R, Barendregt JJ. Chronic disease models. In: Heggenhougen HK, ed. *International Encyclopedia of Public Health*. San Diego, CA: Academic Press, 2008; 704–709.

31. Mitton C, Donaldson C. *Priority Setting Toolkit—A Guide to the Use of Health Economics in Health Care Decision Making*. London: BMJ Books, 2004.

32. Nord E. *Cost Value Analysis in Health Care: Making Sense Out of QALYs*. Cambridge: Cambridge University Press, 1999.

33. Haby MM, Vos T, Carter R *et al*. A new approach to assessing the health benefit from obesity interventions in children and adolescents: the assessing cost-effectiveness in obesity project. *International Journal of Obesity*, 2006; **30:** 1463–1475.

34. Hawe P, Shiell A. Preserving innovation under increasing accountability pressures: the health promotion investment portfolio approach. *Health Promotion Journal of Australia*, 1995; **5:** 4–9.

35. Swinburn B, Gill T, Kumanyika S. Obesity prevention: a proposed framework for translating evidence into action. *Obesity Reviews*, 2005; **6:** 23–33.

36. Rychetnik L, Frommer M, Hawe P, Shiell A. Criteria for evaluating evidence on public health interventions. *Journal of Epidemiology and Community Health*, 2002; **56:** 119–127.

37. Loxley W, Toumbourou JW, Stockwell T *et al*. *The Prevention of Substance Use, Risk and Harm in Australia: A Review of the Evidence*. Canberra: National Drug Research Centre and The Centre for Adolescent Health, 2004.

38. NHMRC National Breast Cancer Centre Psychosocial Working Group. *Guidelines for the Treatment, Support and Counselling of Women With Breast Cancer*. Canberra: NHMRC National Breast Cancer Centre Psychosocial Working Group, 2000.

39. NHMRC. *How to Use the Evidence: Assessment and Application of Scientific Evidence. Handbook Series on Preparing Clinical Practice Guidelines*. Canberra: NHMRC, 2000.

40. Baigent C, Blackwell L, Collins R. Antithrombotic Trialists' (ATT) Collaboration. Aspirin in the primary and secondary prevention of vascular disease: collaborative meta-analysis of individual participant data from randomised trials. *Lancet*, 2009; **373:** 1849–1860.

41. Fowkes FGR, Price JF, Stewart MCW *et al*. Aspirin for prevention of cardiovascular events in a general population screened for a low ankle brachial index. A randomized controlled trial. *Journal of American Medical Association*, 2009; **303:** 841–848.

42. Mathers BM, Degenhardt L, Phillips B *et al*. Global epidemiology of injecting drug use and HIV among people who inject drugs: a systematic review. *Lancet*, 2008; **372:** 1709–1710.

43. McKeage K, Lyseng-Williamson KA. Trastuzumab: a pharmacoeconomic review of its use in early breast cancer. *Pharmacoeconomics*, 2008; **26:** 699–719.

44. Gibson PG, Powell H, Wilson A *et al*. Self-management education and regular practitioner review for adults with asthma. C*ochrane Database of Systematic Reviews*, 2002 (3). Art. No.: CD001117. DOI: 10.1002/14651858.cd001117.

45. Dunstan DW, Zimmet PZ, Welborn TA *et al*. The rising prevalence of diabetes mellitus and impaired glucose tolerance: the Australian Diabetes, Obesity and Lifestyle Study. *Diabetes Care*, 2002; **25:** 829–834.

46. Doran C, Vos T, Cobiac L *et al*. *Alcohol taxation and distribution of gains*. Melbourne: Victorian Health Promotion Foundation (VicHealth), 2010.

47. Vos T, Barker B, Begg S, Stanley L, Lopez AD. Burden of disease and injury in Aboriginal and Torres Strait Islander peoples. *International Journal of Epidemiology*, 2009; **38:** 477–479.

48. Hunter P, Myers N, Couzos S *et al*. Aboriginal community controlled health services. In: Department of Health and Ageing, ed. *General Practice in Australia 2004*. Canberra: Australian Government, 2005.

49. Rosewarne C, Vaarzon-Morel P, Bell S, Carter E, Liddle M, Liddle J. The historical context of developing an Aboriginal community controlled health service: a social history of the first ten years of the Central Australian Aboriginal Congress. *Health and History*, 2007; **9:** 114–143.

50. Henry B. *A Conceptualisation of 'the Good' in Economic Evaluation of Aboriginal Health Policy*. Perth: Curtin University, 2004.

51. National Preventative Health Taskforce. *Australia: The Healthiest Country by 2020. National Preventative Health Strategy—The Roadmap for Action*. Canberra: National Preventative Health Taskforce, 2009.

52. Dalziel K, Segal L, Mortimer D. Review of Australian Health Economic Evaluation—245 interventions: what can we say about cost effectiveness? *Cost-Effectiveness and Resource Allocation* (serial online), 2008; **6**. Cited17 Aug 2010. Available from URL: http://www.resource-allocation.com/content/6/1/9

53. Dalziel K, Segal L. Time to give nutrition interventions a higher profile: cost-effectiveness of 10 nutrition interventions. *Health Promotion International*, 2007; **22:** 271–283.

54. Segal L, Mortimer D, Dalziel K. How to reduce the burden of harm from poor nutrition, tobacco smoking, physical inactivity and alcohol misuse: cost-utility analysis of 29 interventions. Executive report. Melbourne: Centre for Health Economics, 2005.

55. Murray CJL, Evans DB, Acharya A, Baltussen RPM. Development of WHO guidelines on generalized cost-effectiveness analysis. *Health Economics*, 2000; **9:** 235–251.

56. Hutubessy R, Chisholm D, Edejer TTT. Generalized cost-effectiveness analysis for national-level priority-setting in the health sector. WHO-CHOICE. *Cost-Effectiveness and Resource Allocation* (serial online), 2003; **1**. Cited 17 Aug 2010. Available from URL: http://www.resource-allocation.com/content/1/1/8

57. Lim SS, Gaziano TA, Gakidou E *et al*. Prevention of cardiovascular disease in high-risk individuals in low-income and middle-income countries: health effects and costs. *Lancet*, 2007; **370:** 1954–1962.

58. Anderson P, Chisholm D, Fuhr DC. Effectiveness and cost-effectiveness of policies and programmes to reduce the harm caused by alcohol. *Lancet*, 2009; **373:** 2234–2346.

59. van den Berg M, van Baal P, Tariq L, Schuit A, de Wit G, Hoogenveen RT. The cost-effectiveness of increasing alcohol taxes: a modelling study. *BMC Medical* (serial online), 2008; **6**. Cited 17 Aug 2010. Available from URL: http://www.biomedcentral.com/1741-7015/6/36

60. Tariq L, van den Berg M, Hoogenveen RT, van Baal PHM. Cost-effectiveness of an opportunistic screening programme and brief intervention for excessive alcoholuse in primary care. *PLoS One* (serial online), 2009; **4**. Cited 17 Aug 2010. Available from URL: http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0005696

61. Jacobs-van der Bruggen MAM, van Baal PH, Hoogenveen RT *et al*. Cost-effectiveness of lifestyle modification in diabetic patients. *Diabetes Care*, 2009; **32:** 1453–1458.

62. van Baal PHM, van den Berg M, Hoogenveen RT, Vijgen SMC, Engelfriet PM. Cost-effectiveness of a low-calorie diet and orlistat for obese persons: modeling long-term health gains through prevention of obesity-related chronic diseases. *Value in Health*, 2008; **11:** 1033–1040.

63. van Baal PHM, Brouwer WBF, Hoogenveen RT, Feenstra TL. Increasing tobacco taxes: a cheap tool to increase public health. *Health Policy*, 2007; **82:** 142–152.

64. Vijgen SMC, van Baal PHM, Hoogenveen RT, de Wit GA, Feenstra TL. Cost-effectiveness analyses of health promotion programs: a case study of smoking prevention and cessation among Dutch students. *Health Education Research*, 2008; **23:** 310–318.

65. Mauskopf J, Rutten F, Schonfeld W. Cost-effectiveness league tables: valuable guidance for decision makers? *Pharmacoeconomics*, 2003; **21:** 991–1000.

66. Groot Koerkamp B, Weinstein MC, Stijnen T, Heijenbrok-Kal MH, Myriam Hunink MG. Uncertainty and patient heterogeneity in medical decision models. *Medical Decision Making*, 2010; **30:** 194–205.

67. Stevens VJ, Glasgow RE, Toobert DJ, Karanja N, Smith KS. One-year results from a brief, computer-assisted intervention to decrease consumption of fat and increase consumption of fruits and vegetables. *Preventive Medicine*, 2003; **36:** 594–600.

68. Sacerdote C, Fiorini L, Rosato R, Audenino M, Valpreda M, Vineis P. Randomized controlled trial: effect of nutritional counselling in general practice. *International Journal of Epidemiology*, 2006; **35:** 409–415.

69. Nitzke S, Kritsch K, Boeckner L *et al*. A stage-tailored multi-modal intervention increases fruit and vegetable intakes of low-income young adults. *American Journal of Health Promotion*, 2007; **22:** 6–14.

70. Havas S, Anliker J, Greenberg D *et al*. Final results of the Maryland WIC Food for Life program. *Preventive Medicine*, 2003; **37:** 406–416.

71. Marcus AC, Heimendinger J, Wolfe P *et al*. Increasing fruit and vegetable consumption among callers to the CIS: results from a randomized trial. *Preventive Medicine*, 1998; **27:** S16–S28.

72. Greene GW, Fey-Yensan N, Padula C, Rossi SR, Rossi JS, Clark PG. Change in fruit and vegetable intake over 24 months in older adults: results of the SENIOR project intervention. *The Gerontologist*, 2008; **48:** 378–387.

73. Kristal AR, Curry SJ, Shattuck AL, Feng Z, Li S. A randomized trial of a tailored, self-help dietary intervention: the Puget Sound Eating Patterns Study. *Preventive Medicine*, 2000; **31:** 380–389.

74. Radakovich K, Heilbrun LK, Venkatranamamoorthy R, Klurfeld DM, Djuric Z. Women participating in a dietary intervention trial maintain dietary changes without much effect on household members. *Nutrition and Cancer*, 2006; **55:** 44–52.

75. Howard BV, van Horn L, Hsia J *et al*. Low-fat dietary pattern and risk of cardiovascular disease: the Women's Health Initiative Randomized Controlled Dietary Modification Trial. *The Journal of the American Medical Association*, 2006; **295:** 655–666.

76. Heimendinger J, O'Neill, Marcus AC *et al*. Multiple tailored messages are effective in increasing fruit and vegetable consumption among callers to the Cancer Information Service. *Journal of Health Communication*, 2005; **10** (Suppl. 1): 65–82.

77. Ashfield-Watt PAL, Welch AA, Godward S, Bingham SA. Effect of a pilot community intervention on fruit and vegetable intakes: use of FACET (five-a-day community evaluation tool). *Public Health Nutrition*, 2007; **10:** 671–680.

78. Kristal AR, Godenhar L, Muldoon J, Morton RF. Evaluation of a supermarket intervention to increase consumption of fruits and vegetables. *American Journal of Health Promotion*, 1997; **11:** 422–425.

79. Tilley BC, Glanz K, Kristal AR *et al*. Nutrition intervention for high-risk auto workers: results of the Next Step Trial. *Preventive Medicine*, 1999; **28:** 284–292.

80. Hebert JR, Stoddard AM, Harris DR *et al*. Measuring the effect of a worksite-based nutrition intervention on food consumption. *Annals of Epidemiology*, 1993; **3:** 629–635.

81. Sorensen G, Thompson B, Glanz K *et al*. Work site-based cancer prevention: primary results from the Working Well Trial. *American Journal of Public Health*, 1996; **86:** 939.

82. Emmons K, Linnan LA, Shadel WG, Marcus B, Abrams DB. The Working Healthy Project: a worksite health-promotion trial targeting physical activity, diet, and smoking. *Journal of Occupational and Environmental Medicine*, 1999; **41:** 545–555.

83. Sorensen G, Stoddard A, Hunt MK *et al*. The effects of a health promotion–health protection intervention on behavior change: The WellWorks Study. *American Journal of Public Health*, 1998; **88:** 1685.

84. Beresford SAA, Thompson B, Feng Z, Christianson A, McLerran D, Patrick DL. Seattle 5 a Day worksite program to increase fruit and vegetable consumption. *Preventive Medicine*, 2001; **32:** 230–238.

85. Engbers L, van Poppel MNM, Paw MCA, van Mechelen W. The effects of a controlled worksite environmental intervention on determinants of dietary behavior and self-reported fruit, vegetable and fat intake. *BMC Public Health*, 2006; **6:** 253.

86. Herman DR, Harrison GG, Afifi AA, Jenks E. Effect of a targeted subsidy on intake of fruits and vegetables among low-income women in the Special Supplemental Nutrition Program for Women, Infants, and Children. *American Journal of Public Health*, 2008; **98:** 98–105.

Appendices

Appendix 1 Priority-setting checklist

For each criterion the letters in square brackets indicate the relevant rationale, viz. economic theory (T); ethical rationale (E); pragmatic rationale (P); and user considerations (U).

1. Is there a well-defined research question? (T; P; U)

Does the model specify a well-defined research question in answerable form? Is the model adaptable to variations in decision context and setting? If not, are the general settings and purposes for which the model is appropriate specified? Is the model appropriate to the specific research question of the decision-maker(s) and the context in which it occurs?

2. Is there a clear concept of benefit? (T; E; U)

Does the model have a mechanism or process to define benefit in a way that captures the perspective and objectives of the decision-maker? Does the model establish a clear logical connection between the concept of benefit, the research question and the priority-setting objectives? Are the ethical values underlying the concept of benefit made explicit?

3. Is there an acceptable process for generating the options for change? (T; U; P)

Does the model have an explicit mechanism for generating options for change? Do the options generated pay specific regard to the choice problem of the decision-maker(s) and the legitimate interests of stakeholders? Do the options for change meet the following criteria: comprehensiveness (important alternatives are not omitted; inclusion of both increments and decrements); relevance (to choice problem and decision-maker needs); evidence-based (including a process for establishing and dealing with the evidence base of options for change); defined in concrete terms so that the pathway of activities can be clearly determined; and manageable (the evaluation task is tractable in the time available))?

4. Is marginal analysis an integral component? (T)

Does the model utilise incremental analysis in comparing the options for change? Does it operationalise the measurement and analysis of costs and benefits associated with the options for change through marginal analysis? Does the marginal analysis cover the scale and scope of the interventions, the target/user groups or mode of service delivery?

5. Are the decision rules clearly specified? (T, E)

Does the model clearly articulate the decision rules by which the options for change are ranked (maximisation through equating marginal cost and marginal benefit; maximisation with equity weights; maximisation subject to constraints; two-stage decision process, etc.)? Does the model specify how any multiple dimensions of benefit are weighted and aggregated? If outcomes are weighted for equity, are the equity principles, data sources and methods clearly specified?

For each criterion the letters in square brackets indicate the relevant rationale, viz. economic theory (T); ethical rationale (E); pragmatic rationale (P); and user considerations (U).

6. Is the role of judgement recognised? (E; P; U)

Does the model check the need for judgement in the specification, application and interpretation of the technical analysis, particularly in relation to underlying assumptions and values? Does the model make explicit the basis on which judgement impacts on the technical results?

7. Are the data needs tractable? (P; U)

Does the model have a mechanism for making the data needs of the evaluation process tractable?

8. Is the need for due process recognised? (E; P; U; T)

Does the model check the need to place the technical analysis within a process for decision-making that contributes to the legitimacy of the decisions and their acceptability to stakeholders? Is this process characterised by transparency and openness; accountability; fairness and reasonableness (unbiased; consideration given to all relevant factors; disregarding of irrelevant factors; accessing of relevant information); involvement of key stakeholders; consistency in decision-making; with an appeal or review mechanism?

9. Do the measurement methods demonstrate appropriate rigour? (T; P; U, E)

Does the model involve a clearly specified evaluation protocol and standardised evaluation methods appropriate to the research question? Does the measurement of costs and benefits strike a reasonable balance between expense, difficulty and timeliness? Is there sensitivity analysis of key design parameters and evaluation assumptions? Is there rigour in the implementation of both efficiency and equity objectives; recognition that the choice of outcome measures has important ethical implications?

10. Reporting/implementation? (U; P; E)

Does the reporting address issues of likely concern to decision-makers, including ethical implications, feasibility of implementation, acceptability to stakeholders, importance of the problem addressed, financial implications? Is the reporting format designed to assist with judgements on what weight might be placed on the results, including generalisability to other settings and contexts; consultation processes adopted; strengths and weaknesses of the technical analysis, including comparison with similar evaluation studies in the literature?

Appendix 2 Interventions, cost-effectiveness ratios, health outcomes, intervention costs, cost offsets, strength of evidence and second-stage filter considerations, ACE–Prevention[*,†]

The table presents incremental cost-effectiveness ratio, number of disability-adjusted life years averted, intervention costs and healthcare cost savings over the lifetime of Australians alive in 2003, estimated annual intervention costs, strength of evidence and major issues identified in the second-stage filter analysis.

	Topic area	Intervention	ICER (95% uncertainty interval)			Lifetime DALYs	Lifetime intervention costs (A$ million)	Annual intervention costs (A$ million)	Cost offsets (A$ million)	Strength of evidence	Second filter
			Median	*Lower limit*	*Upper limit*						
Prevention: risk factors											
1	Alcohol	Volumetric tax (revenue-neutral)	Dominant	Dominant	Dominant	11,000	0.58	0.03	–57	Likely	Political will
2	Alcohol	Volumetric tax (DWL-neutral)	Dominant	Dominant	Dominant	13,000	0.58	0.03	–69	Likely	Political will
3	Alcohol	Volumetric tax (level: current excise high-strength beer; duty-free threshold: 1.15% all beverages except spirits)	Dominant	Dominant	3600	4700	18	0.9	–19	Likely	Political will
4	Alcohol	Volumetric tax (level: current excise spirits; duty-free threshold 1.15% all beverages except spirits)	Dominant	Dominant	Dominant	75,000	18	0.9	–460	Likely	Political will
5	Alcohol	Two volumetric alcohol tax tiers: • high-strength beer and wine at rate of current excise high-strength beer • alcopops and spirits at rate current excise spirits. Duty-free threshold 1.15% all beverages except spirits	Dominant	Dominant	Dominant	23,000	18	0.9	–140	Likely	Political will
6	Alcohol	Volumetric tax (level: 10% increase in current excise spirits; duty-free threshold 1.15% all beverages except spirits)	Dominant	Dominant	Dominant	110,000	18	0.9	–650	Likely	Political will

	Topic area	Intervention	ICER (95% uncertainty interval)			Lifetime DALYs	Lifetime intervention costs (A$ million)	Annual intervention costs (A$ million)	Cost offsets (A$ million)	Strength of evidence	Second filter
			Median	*Lower limit*	*Upper limit*						
7	Alcohol	Volumetric tiered tax (level: increasing exponentially by 1% for every per cent of alcohol content; duty-free threshold 1.15% all beverages except spirits; discount 70.4% and 42.6% on high and low strength beer sold onsite)	Dominant	Dominant	Dominant	13,000	18	0.9	–72	Likely	Political will
8	Alcohol	Volumetric tiered tax (level: increasing exponentially by 2% for every per cent of alcohol content; duty-free threshold of 1.15% all beverages except spirits; discount 70.4% and 42.6% on high and low strength beer sold onsite)	Dominant	Dominant	Dominant	28,000	18	0.9	–170	Likely	Political will
9	Alcohol	Volumetric tiered tax (level: increasing exponentially by 3% for every per cent of alcohol content; duty-free threshold of 1.15% all beverages except spirits; discount 70.4% and 42.6% on high and low strength beer sold onsite)	Dominant	Dominant	Dominant	46,000	18	0.9	–290	Likely	Political will
10	Alcohol	General tax 30%	Dominant	Dominant	Dominant	100,000	0.58	0.030	–530	Likely	Political will
11	Alcohol	General tax 15%	Dominant	Dominant	Dominant	64,000	0.58	0.030	–530	Likely	Political will
12	Alcohol	General tax 15% (DWL-neutral)	Dominant	Dominant	Dominant	64,000	100	5	–330	Likely	Political will
13	Alcohol	General tax 30% (DWL-neutral)	Dominant	Dominant	3000	100,000	400	19	–330	Likely	Political will
14	Alcohol	Advertising bans	Dominant	Dominant	1000	7800	20	1.0	–31	Limited	Political will
15	Alcohol	Minimum legal drinking age to 21	Dominant	Dominant	3700	150	1	0.2	–0.8	Limited	Political will
16	Alcohol	Brief intervention via GPs	3800	Dominant	14,000	160	2	1.9	–1.2	Sufficient	Feasibility/equity: limited GP capacity, esp. in rural areas
17	Alcohol	Licensing controls	3200	Dominant	8300	2700	20	1.0	–11	Likely	Political will

	Topic area	Intervention	ICER (95% uncertainty interval)			Lifetime DALYs	Lifetime intervention costs (A$ million)	Annual intervention costs (A$ million)	Cost offsets (A$ million)	Strength of evidence	Second filter
			Median	*Lower limit*	*Upper limit*						
18	Alcohol	Drink drive mass media	14,000	7100	450,000	1500	39	39	–11	Limited	–
19	Alcohol	Random breath testing	23,000	10,000	75,000	2300	71	71	–17	Likely	–
20	Alcohol	Brief intervention and telemarketing and support	7500	290	19,000	340	5	5	–3	Sufficient	Feasibility/equity: limited GP capacity, esp. in rural areas
21	Tobacco	Cessation aid: varenicline	5800	3500	9400	33,000	260	130	–76	Sufficient	–
22	Tobacco	Cessation aid: bupropion	7700	5300	11,000	23,000	230	120	–54	Sufficient	–
23	Tobacco	Cessation aid: nicotine replacement therapy	8900	6700	11,000	14,000	160	80	–34	Sufficient	–
24	Tobacco	Taxation +10% with indexation in line with inflation	Dominant	Dominant	Dominant	48,000	18	0.87	–130	Likely	Political will
25	Tobacco	Taxation +10%	Dominant	Dominant	Dominant	17,000	18	0.86	–140	Likely	Political will
26	Tobacco	Taxation +15% with indexation in line with inflation	Dominant	Dominant	Dominant	120,000	18	0.86	–320	Likely	Political will
27	Tobacco	Taxation +15%	Dominant	Dominant	Dominant	48,000	18	0.86	–320	Likely	Political will
28	Tobacco	Taxation +30% with indexation in line with inflation	Dominant	Dominant	Dominant	270,000	18	0.86	–690	Likely	Political will
29	Tobacco	Taxation +30%	Dominant	Dominant	Dominant	110,000	18	0.86	–690	Likely	Political will
30	Tobacco	Taxation +50% with indexation in line with inflation	Dominant	Dominant	Dominant	340,000	18	0.86	–860	Likely	Political will
31	Tobacco	Taxation +50%	Dominant	Dominant	Dominant	140,000	18	0.86	–870	Likely	Political will
32	Tobacco	Taxation +60% with indexation in line with inflation	Dominant	Dominant	Dominant	640,000	18	0.87	–1600	Likely	Political will
33	Tobacco	Taxation +60%	Dominant	Dominant	Dominant	270,000	18	0.87	–1600	Likely	Political will

	Topic area	Intervention	ICER (95% uncertainty interval)			Lifetime DALYs	Lifetime intervention costs (A$ million)	Annual intervention costs (A$ million)	Cost offsets (A$ million)	Strength of evidence	Second filter
			Median	*Lower limit*	*Upper limit*						
34	Tobacco	Package of current population-wide strategies of tobacco control (restrict advertising; legislation to restrict smoking in public places; minimum age for sale of tobacco; mass media; pack warnings)‡	In preparation	–	–	–	–	–	–	–	–
35	Tobacco	Brief interventions via GPs‡	In preparation	–	–	–	–	–	–	–	–
36	Tobacco	QUIT line versus extended QUIT line‡	In preparation	–	–	–	–	–	–	–	–
37	Physical activity	Pedometers	Dominant	Dominant	Dominant	20,000	54	54	–480	Sufficient	Sustainability of effect?
38	Physical activity	Mass media	Dominant	Dominant	Dominant	23,000	13	13	–440	Inconclusive	–
39	Physical activity	TravelSmart	21,000	Dominant	Dominated	9300	410	410	–220	May be effective	–
40	Physical activity	GP prescription	9500	Dominant	210,000	7100	240	240	–170	Limited	–
41	Physical activity	GP referral to exercise physiologist	21,000	Dominant	140,000	1900	110	110	–54	Limited	–
42	Physical activity	Internet intervention	2400	Dominant	210,000	740	21	21	–17	Sufficient	–
43	Nutrition	Fruit and vegetable intake: dietary counselling, telephone follow-up) [67]	140,000	62,000	350,000	17	2.7	2.7	–0.2	Limited	–
44	Nutrition	Fruit and vegetable intake: dietary counselling, information mail-out [68]	390,000	95,000	Dominated	96	37	37	–0.9	Sufficient	–
45	Nutrition	Fruit and vegetable intake: telephone counselling, information mail-out [69]	10,000,000	1,900,000	Dominated	0.2	2.1	2.1	–	Limited	–
46	Nutrition	Fruit and vegetable intake: peer counselling, telephone counselling, promotional materials [70]	3,700,000	1,400,000	68,000,000	35	130	130	–0	Limited	–
47	Nutrition	Fruit and vegetable intake: telephone counselling, information mail-out [71]	74,000	30,000	290,000	0	0	0	–	Limited	–

	Topic area	Intervention	ICER (95% uncertainty interval)			Lifetime DALYs	Lifetime intervention costs (A$ million)	Annual intervention costs (A$ million)	Cost offsets (A$ million)	Strength of evidence	Second filter
			Median	*Lower limit*	*Upper limit*						
48	Nutrition	Fruit and vegetable intake: telephone counselling, information mail-out [72]	410,000	140,000	2,300,000	760	330	330	–8	Limited	–
49	Nutrition	Fruit and vegetable intake: telephone counselling, information mail-out [73]	880,000	290,000	7,200,000	21	14	14	–0	Limited	–
50	Nutrition	Fruit and vegetable intake: individual dietary counselling [74]	520,000	250,000	1,300,000	33	18	18	–0	Limited	–
51	Nutrition	Fruit and vegetable intake: individual and group dietary counselling [75]	75,000	30,000	180,000	85	7	7	–1	Limited	–
52	Nutrition	Fruit and vegetable intake: information mail-out, tailored [76]	27,000	2900	Dominated	0	–	–	–	Limited	–
53	Nutrition	Fruit and vegetable intake: information mail-out, multiple tailored [76]	12,000	130	85,000	0	0	0	–	Limited	–
54	Nutrition	Fruit and vegetable intake: information mail-out, multiple re-tailored [76]	8600	Dominant	45,000	0	0	0	–	Limited	–
55	Nutrition	Fruit and vegetable intake: community-based events, sponsorship, promotion [77]	Dominant	Dominant	Dominant	5200	47	47	–54	May be effective	–
56	Nutrition	Fruit and vegetable intake: Supermarket displays, flyers, discount coupons [78]	2,500,000	86,000	Dominated	100	150	150	–1	Limited	–
57	Nutrition	Fruit and vegetable intake: information seminars, promotional materials [79]	77,000	35,000	230,000	100	9	9	–1	Limited	–
58	Nutrition	Fruit and vegetable intake: information seminars, promotional materials, cafeteria changes [80]	3,400,000	930,000	35,000,000	230	630	630	–2	Limited	–
59	Nutrition	Fruit and vegetable intake: information seminars and promotional materials and cafeteria changes [81]	650,000	230,000	2,800,000	180	100	100	–2	Inconclusive	–

	Topic area	Intervention	ICER (95% uncertainty interval)			Lifetime DALYs	Lifetime intervention costs (A$ million)	Annual intervention costs (A$ million)	Cost offsets (A$ million)	Strength of evidence	Second filter
			Median	*Lower limit*	*Upper limit*						
60	Nutrition	Fruit and vegetable intake: information seminars and promotional materials and cafeteria changes [82]	270,000	97,000	1,200,000	540	140	140	–5	Inconclusive	–
61	Nutrition	Fruit and vegetable intake: information seminars, promotional materials, cafeteria changes [83]	1,000,000	260,000	10,000,000	130	100	100	–1	Inconclusive	–
62	Nutrition	Fruit and vegetable intake: information seminars, promotional materials, cafeteria changes [84]	380,000	99,000	Dominated	280	89	89	–3	Limited	–
63	Nutrition	Fruit and vegetable intake: promotional materials, cafeteria changes [85]	47,000	Dominant	Dominated	1200	60	60	–12	Inconclusive	–
64	Nutrition	Fruit and vegetable intake: farmers' market vouchers [86]	270,000	130,000	860,000	32	9	9	–0	Inconclusive	–
65	Nutrition	Fruit and vegetable intake: supermarket vouchers [86]	660,000	220,000	Dominated	13	9	9	–0	Inconclusive	–
66	Salt	Dietary advice on salt (>140 mmHg)	160,000	99,000	270,000	1700	290	290	–22	Sufficient	Access to dietitians limited outside major cities
67	Salt	Dietary advice on salt (>115 mmHg)	260,000	160,000	440,000	2600	720	720	–34	Sufficient	Access to dietitians limited outside major cities
68	Salt	'Tick' program to reduce salt intake from processed food	Dominant	Dominant	Dominant	5300	5	0	–77	Likely	–
69	Salt	Mandatory salt limits for processed food	Dominant	Dominant	Dominant	110,000	69	3	1500	Likely	–
70	Multi-component	'Lighten Up': Weight loss, fruit and vegetable intake, physical activity	94,000	6500	Dominated	38	4	4	–0	May be effective	–
71	Body mass	Diet and exercise for BMI>25	28,000	1800	62,000	3000	140	140	–63	Sufficient	–

	Topic area	Intervention	ICER (95% uncertainty interval)			Lifetime DALYs	Lifetime intervention costs (A$ million)	Annual intervention costs (A$ million)	Cost offsets (A$ million)	Strength of evidence	Second filter
			Median	*Lower limit*	*Upper limit*						
72	Body mass	Low-fat diet for BMI>25	37,000	Dominant	290,000	1900	94	94	–40	Sufficient	–
73	Body mass	Sibutramine for BMI>30	230,000	170,000	330,000	5900	1500	1500	–88	Sufficient	–
74	Body mass	Orlistat for BMI>30	700,000	500,000	1,000,000	2100	1500	1500	–45	Sufficient	–
75	Body mass	Front-of-pack traffic light nutrition labelling	Dominant	Dominant	Dominant	32,000	77	4	–710	No evidence	
76	Body mass	Unhealthy food tax 10% with indexation in line with inflation	Dominant	Dominant	Dominant	170,000	18	1	–3500	May be effective	Political will and public; regressive tax
77	Body mass	Laparoscopic adjustable gastric banding for BMI>35	5800	Dominant	14,000	140,000	3700	120	–12,000	Sufficient	Only acceptable when all else failed. Side effects not modelled
78	Body mass	Weight Watchers	84,000	1000	Dominated	54	5	5	–0.8	Sufficient	–
79	Blood pressure and cholesterol[§]	Current practice	29,000	22,000	40,000	380,000	15,000	1300	–4100	–	–
80	Blood pressure and cholesterol[§]	Community heart health program	Dominant	Dominant	Dominant	80,000	47	3	–1100	May be effective	Mostly realised already in current practice
81	Blood pressure and cholesterol[§]	Dietary counselling by a dietitian >5% CVD risk	16,000	3100	55,000	41,000	1100	81	–490	Sufficient	–
82	Blood pressure and cholesterol[§]	Dietary counselling by a dietitian >10% CVD risk	11,000	710	41,000	21,000	470	39	–240	Sufficient	–
83	Blood pressure and cholesterol[§]	Dietary counselling by a dietitian >15% CVD risk	8600	Dominant	35,000	12,000	230	23	–130	Sufficient	–
84	Blood pressure and cholesterol[§]	Dietary counselling by a GP >5% CVD risk	35,000	15,000	130,000	17,000	770	55	–200	Sufficient	–

	Topic area	Intervention	ICER (95% uncertainty interval)			Lifetime DALYs	Lifetime intervention costs (A$ million)	Annual intervention costs (A$ million)	Cost offsets (A$ million)	Strength of evidence	Second filter
			Median	*Lower limit*	*Upper limit*						
85	Blood pressure and cholesterol[§]	Dietary counselling by a GP >10% CVD risk	25,000	9900	98,000	8700	320	26	–97	Sufficient	–
86	Blood pressure and cholesterol[§]	Dietary counselling by a GP >15% CVD risk	21,000	7500	84,000	4800	150	15	–52	Sufficient	–
87	Blood pressure and cholesterol[§]	Phytosterol supplementation >5% CVD risk	24,000	9900	65,000	43,000	1500	110	–510	Sufficient	–
88	Blood pressure and cholesterol[§]	Phytosterol supplementation >10% CVD risk	18,000	6000	50,000	22,000	630	53	–250	Sufficient	–
89	Blood pressure and cholesterol[§]	Phytosterol supplementation >15% CVD risk	14,000	4100	42,000	12,000	310	31	–130	Sufficient	–
90	Blood pressure and cholesterol[§]	Statins >5% CVD risk	34,000	26,000	44,000	100,000	4700	340	–1200	Sufficient	–
91	Blood pressure and cholesterol[§]	Statins >10% CVD risk	25,000	19,000	34,000	54,000	2000	160	–610	Sufficient	–
92	Blood pressure and cholesterol[§]	Statins >15% CVD risk	21,000	15,000	28,000	30,000	950	95	–330	Sufficient	–
93	Blood pressure and cholesterol[§]	Statins and ezitimibe >5% CVD risk	34,000	30,000	39,000	230,000	11,000	770	–2800	Sufficient	–
94	Blood pressure and cholesterol[§]	Statins and ezitimibe >10% CVD risk	25,000	21,000	29,000	120,000	4500	370	–1400	Sufficient	–
95	Blood pressure and cholesterol[§]	Statins and ezitimibe >15% CVD risk	21,000	17,000	25,000	69,000	2200	220	–750	Sufficient	–
96	Blood pressure and cholesterol[§]	Low-dose diuretics >5% CVD risk	4200	Dominant	13,000	120,000	1800	130	–1300	Sufficient	–
97	Blood pressure and cholesterol[§]	Low-dose diuretics >10% CVD risk	1,800	Dominant	8600	66,000	760	64	–660	Sufficient	–
98	Blood pressure and cholesterol[§]	Low-dose diuretics >15% CVD risk	600	Dominant	6600	37,000	370	37	–360	Sufficient	–

	Topic area	Intervention	ICER (95% uncertainty interval)			Lifetime DALYs	Lifetime intervention costs (A$ million)	Annual intervention costs (A$ million)	Cost offsets (A$ million)	Strength of evidence	Second filter
			Median	*Lower limit*	*Upper limit*						
99	Blood pressure and cholesterol[§]	Beta blockers >5% CVD risk	24,000	10,000	78,000	86,000	2700	190	–690	Sufficient	–
100	Blood pressure and cholesterol[§]	Beta blockers >10% CVD risk	17,000	6300	58,000	46,000	1100	94	–360	Sufficient	–
101	Blood pressure and cholesterol[§]	Beta blockers >15% CVD risk	14,000	4,300	50,000	26,000	550	55	–200	Sufficient	–
102	Blood pressure and cholesterol[§]	CCBs >5% CVD risk	12,000	3200	44,000	150,000	3300	230	–1400	Sufficient	–
103	Blood pressure and cholesterol[§]	CCBs >10% CVD risk	8200	770	33,000	78,000	1400	110	–730	Sufficient	–
104	Blood pressure and cholesterol[§]	CCBs >15% CVD risk	6200	Dominant	28,000	44,000	670	67	–400	Sufficient	–
105	Blood pressure and cholesterol[§]	ACE inhibitors >5% CVD risk	17,000	9100	32,000	130,000	3400	250	–1300	Sufficient	–
106	Blood pressure and cholesterol[§]	ACE inhibitors >10% CVD risk	11,000	5400	23,000	68,000	1400	120	–650	Sufficient	–
107	Blood pressure and cholesterol[§]	ACE inhibitors >15% CVD risk	9100	3600	19,000	38,000	700	70	–360	Sufficient	–
108	Blood pressure and cholesterol[§]	Aspirin >5% CVD risk	Dominant	Dominant	Dominant	80,000	710	51	–1200	Inconclusive	Increased bleeding; not proven effective for primary prevention
109	Blood pressure and cholesterol[§]	Aspirin >10% CVD risk	Dominant	Dominant	Dominant	43,000	300	25	–570	Inconclusive	
110	Blood pressure and cholesterol[§]	Aspirin >15% CVD risk	Dominant	Dominant	Dominant	24,000	140	14	–310	Inconclusive	
111	Blood pressure and cholesterol[§]	Polypill $200 >5% CVD risk	730	Dominant	4600	270,000	3000	250	–3700	Likely	–
112	Blood pressure and cholesterol[§]	Polypill $50 >15% CVD risk	Dominant	Dominant	Dominant	82,000	360	36	–1000	Likely	–

	Topic area	Intervention	ICER (95% uncertainty interval)			Lifetime DALYs	Lifetime intervention costs (A$ million)	Annual intervention costs (A$ million)	Cost offsets (A$ million)	Strength of evidence	Second filter
			Median	*Lower limit*	*Upper limit*						
113	Blood pressure and cholesterol[§]	Polypill $50 >10% CVD risk	Dominant	Dominant	Dominant	150,000	730	61	–1800	Likely	–
114	Blood pressure and cholesterol[§]	Polypill $50 >5% CVD risk	Dominant	Dominant	Dominant	270,000	1700	120	–3700	Likely	–
115	Blood pressure and cholesterol[§]	Polypill $100 >15% CVD risk	Dominant	Dominant	Dominant	82,000	450	45	–1000	Likely	–
116	Blood pressure and cholesterol[§]	Polypill $100 >10% CVD risk	Dominant	Dominant	Dominant	150,000	910	76	–1800	Likely	–
117	Blood pressure and cholesterol[§]	Polypill $100 >5% CVD risk	Dominant	Dominant	830	270,000	2200	150	–3700	Likely	–
118	Blood pressure and cholesterol[§]	Polypill $150 >15% CVD risk	Dominant	Dominant	Dominant	82,000	540	54	–1000	Likely	–
119	Blood pressure and cholesterol[§]	Polypill $150 >10% CVD risk	Dominant	Dominant	780	150,000	1100	92	–1800	Likely	–
120	Blood pressure and cholesterol[§]	Polypill $150 >5% CVD risk	Dominant	Dominant	2700	270,000	2600	190	–3700	Likely	–
121	Blood pressure and cholesterol[§]	Polypill $200 >15% CVD risk	Dominant	Dominant	1200	82,000	630	63	–1000	Likely	–
122	Blood pressure and cholesterol[§]	Polypill $200 >10% CVD risk	Dominant	Dominant	2300	150,000	1300	92	–1800	Likely	–
123	Blood pressure and cholesterol[§]	Polypill $500 >15% CVD risk	4900	1400	9000	82,000	1200	120	–1000	Likely	–
124	Blood pressure and cholesterol[§]	Polypill $500 >10% CVD risk	6700	3000	11,000	150,000	2400	200	–1800	Likely	–
125	Blood pressure and cholesterol[§]	Polypill $500 >5% CVD risk	11,000	6200	16,000	270,000	5800	410	–3700	Likely	–
126	Blood pressure and cholesterol[§]	Polypill $2500 >15% CVD risk	50,000	41,000	64,000	82,000	4900	490	–1000	Likely	–

	Topic area	Intervention	ICER (95% uncertainty interval)			Lifetime DALYs	Lifetime intervention costs (A$ million)	Annual intervention costs (A$ million)	Cost offsets (A$ million)	Strength of evidence	Second filter
			Median	*Lower limit*	*Upper limit*						
127	Blood pressure and cholesterol[§]	Polypill $2500 >10% CVD risk	58,000	48,000	74,000	150,000	9900	830	–1800	Likely	–
128	Blood pressure and cholesterol[§]	Polypill $2500 >5% CVD risk	77,000	63,000	96,000	270,000	24,000	1700	–3700	Likely	–
129	Blood pressure and cholesterol[§]	Polypill $5000 >15% CVD risk	110,000	89,000	130,000	82,000	9500	950	–1000	Likely	–
130	Blood pressure and cholesterol[§]	Polypill $5000 >10% CVD risk	120,000	100,000	150,000	150,000	19,000	1600	–1800	Likely	–
131	Blood pressure and cholesterol[§]	Polypill $5000 >5% CVD risk	160,000	130,000	200,000	270,000	46,000	3,300	–3700	Likely	–
132	Blood pressure and cholesterol[§]	Polypill $200 to ages 55+	2500	Dominant	6500	530,000	6800	510	–6900	Likely	–
133	Blood pressure and cholesterol[§]	Polypill $50 to ages 55+	Dominant	Dominant	Dominant	530,000	3400	260	–6900	Likely	–
134	Blood pressure and cholesterol[§]	Polypill $100 to ages 55+	Dominant	Dominant	1600	530,000	4500	340	–6900	Likely	–
135	Blood pressure and cholesterol[§]	Polypill $150 to ages 55+	310	Dominant	4000	530,000	5600	420	–6900	Likely	–
136	Blood pressure and cholesterol[§]	Polypill $500 to ages 55+	15,000	10,000	22,000	530,000	14,000	390	–6900	Likely	–
137	Osteoporosis	Osteoporosis screening and alendronate for women aged 70–89	Dominant	Dominant	21,000	14,000	420	42	–530	Sufficient	–
138	Osteoporosis	Osteoporosis screening and raloxifene for women aged 70–89	170,000	140,000	230,000	1500	260	26	–7.3	Sufficient	–
139	Osteoporosis	Mass media campaign physical activity targeting women aged 25–60	58,000	Dominant	600,000	130	13	1.3	–5.1	Likely	–
140	Illicit drugs	School-based drug prevention: Gatehouse project	59,000	31,000	180,000	1500	90	30	–4.8	Limited	Feasibility of implement-ation

	Topic area	Intervention	ICER (95% uncertainty interval)			Lifetime DALYs	Lifetime intervention costs (A$ million)	Annual intervention costs (A$ million)	Cost offsets (A$ million)	Strength of evidence	Second filter
			Median	*Lower limit*	*Upper limit*						
141	Illicit drugs	Random roadside drug testing program – scenario 2: achieving 10% deterrence	43,000	38,000	50,000	56	2.8	2.8	–0.4	Limited	Further evidence on deterrence needed
142	Illicit drugs	Random roadside drug testing program – scenario 3: achieving 15% deterrence	28,000	23,000	32,000	81	2.8	2.8	–0.6	Limited	Further evidence on deterrence needed
143	Illicit drugs	Random roadside drug testing program – scenario 1: achieving 5% deterrence	84,000	73,000	96,000	31	2.8	2.8	–0.2	Limited	Further evidence on deterrence needed
Prevention: non-communicable diseases											
144	Cervical cancer	Pap screen 2-yearly for women aged 18+ (current practice)[¶]	41,000	–	–	2100[#]		89[#]	–5.5[#]	Sufficient	–
145	Cervical cancer	Pap screen 2-yearly for women aged 25+**	150,000	–	–	–100[#]		–15[#]	0.1[#]	Sufficient	–
146	Cervical cancer	Pap screen 3-yearly for women aged 18+**	74,000	–	–	–393[#]		–29[#]	0.9[#]	Likely	Acceptability: screening interval from 2 to 3 years
147	Cervical cancer	HPV DNA test screening 3-yearly for women aged 18+	11,000	–	–	59[#]		0.65[#]	–0.2[#]	Likely	Acceptability: screening interval from 2 to 3 years
148	Cervical cancer	Combined Pap and HPV DNA test screen for women 3-yearly aged 18+	84,000	–	–	190[#]		16[#]	–0.5[#]	Likely	–
149	Cervical cancer	Pap screen for women aged 18–29 and HPV DNA screen for women aged 30+, 3-yearly	Dominant	–	–	84[#]		–1.5[#]	–0.3[#]	Likely	–

	Topic area	Intervention	ICER (95% uncertainty interval)			Lifetime DALYs	Lifetime intervention costs (A$ million)	Annual intervention costs (A$ million)	Cost offsets (A$ million)	Strength of evidence	Second filter
			Median	*Lower limit*	*Upper limit*						
150	Cervical cancer	Combined Pap and HPV DNA test screen 3-yearly for women aged 25+	Dominant	–	–	160[#]		–1.9[#]	–0.5[#]	Likely	Acceptability: screening interval from 2 to 3 years.
151	Cervical cancer	HPV vaccination and Pap screen 2-yearly for women aged 18+	46,000	40,000	55,000	790[#]		36[#]	–1.6[#]	Likely	–
152	Cervical cancer	HPV vaccination and Pap screen 2-yearly for women aged 25+	27,000	23,000	34,000	770		21[#]	–1.6[#]	Likely	–
153	Cervical cancer	HPV vaccination and Pap screen 3-yearly for women aged 18+	12,000	9,900	18,000	680		8.5[#]	–1.2[#]	Likely	Acceptability: screening interval from 2 to 3 years
154	Cervical cancer	HPV vaccination and HPV DNA test screening 3-yearly for women aged 18+	41,000	36,000	49,000	830[#]		34[#]	–1.7[#]	Likely	–
155	Cervical cancer	HPV vaccination and combined Pap and HPV DNA test screening 3-yearly for women aged 18+	56,000	51,000	65,000	880[#]		49[#]	–1.8[#]	Likely	–
156	Cervical cancer	HPV vaccination and Pap screen for women aged 18–29 and HPV DNA screen for women aged 30+, 3-yearly	39,000	35,000	46,000	860		34[#]	–1.7[#]	Likely	–
157	Cervical cancer	HPV vaccination and combined Pap and HPV DNA screen 3-yearly for women aged 25+	38,000	34,000	44,000	870		33[#]	–1.8[#]	Likely	–
158	Skin cancer	SunSmart program (with optimal investment)	16,000	12,000	22,000	120,000	2000	100	–270	Limited	–
159	Prostate cancer	Screening with PSA test[‡]	Dominated	–	–	–	–	–	–		–
160	Cancer	Anal cytology for men having sex with men	–	–	–	–	–	–	–		–
161	Cancer and cirrhosis[§]	Universal infant Hepatitis B vaccination (HBV)	600	Dominant	3000	1600[††]		21[††]	–20[††]	Sufficient	–

	Topic area	Intervention	ICER (95% uncertainty interval)			Lifetime DALYs	Lifetime intervention costs (A$ million)	Annual intervention costs (A$ million)	Cost offsets (A$ million)	Strength of evidence	Second filter
			Median	*Lower limit*	*Upper limit*						
162	Cancer and cirrhosis[§]	Universal infant vaccination and immunoglobulin to infants born to carrier mothers	22	–	1500	2200[††]		25[††]	–	Sufficient	–
163	Cancer and cirrhosis[§]	Vaccine and immunoglobulin for infants born to HBV carrier mothers	Dominant	Dominant	Dominant	1900[††]		4.3[††]	–23[††]	Sufficient	–
164	Cancer and cirrhosis[§]	High-risk infant HBV vaccination	Dominant	Dominant	Dominant	910[††]		2.1 [††]	–10[††]	Sufficient	
165	Cancer and cirrhosis[§]	High-risk infant vaccination and immunoglobulin to infants born to carrier mothers	Dominant	Dominant	Dominant	1100[††]		2.5[††]	–	Sufficient	–
166	Cancer and cirrhosis[§]	High-risk selective immunisation (vaccine and immunoglobulin) of infants born to carrier mothers (from high endemic countries)	Dominant	Dominant	Dominant	1100[††]		0.6[††]	–12[††]	Sufficient	–
167	Pre-diabetes	Screen and dietary advice	38,000	23,000	150,000	8200	310	26	–120	Sufficient	–
168	Pre-diabetes	Screen and exercise physiologist	30,000	23,000	89,000	14,000	430	35	–180	Sufficient	–
169	Pre-diabetes	Screen and dietary advice and exercise physiologist	22,000	19,000	35,000	17,000	380	32	–210	Sufficient	–
170	Pre-diabetes	Screen and drug: rosiglitazone	Dominated	Dominated	53,000	–20,060	2100	180	–49	Sufficient	–
171	Pre-diabetes	Screen and drug: metformin	21,000	17,000	36,000	15,000	330	27	–250	Sufficient	–
172	Pre-diabetes	Screen and drug: acarbose	37,000	25,000	130,000	20,000	760	63	–330	Sufficient	–
173	Pre-diabetes	Screen and drug: orlistat	100,000	94,000	130,000	24,000	2500	200	–400	Sufficient	–
174	Kidney disease	Screening and early treatment of chronic kidney disease (non-DM)	13,000	Dominant	41,000	5900	290	24	–219	Sufficient	–
175	Kidney disease	Screening and early treatment of chronic kidney disease (DM)	Dominant	Dominant	8000	4200	110	8.8	–172	Sufficient	–
176	Depression	Screening and bibliotherapy to prevention of adult depression	8,600	–	–	2600	37	–	–27	Likely	–

	Topic area	Intervention	ICER (95% uncertainty interval)			Lifetime DALYs	Lifetime intervention costs (A$ million)	Annual intervention costs (A$ million)	Cost offsets (A$ million)	Strength of evidence	Second filter
			Median	*Lower limit*	*Upper limit*						
177	Depression	Screening and group psychological treatment for prevention of adult depression	20,000	12,000	66,000	1700	38	–	–11	Likely	–
178	Depression	Screening and psychological treatment for prevention of post-partum depression	15,000	–	–	370	6.9	–	–6.0	Limited	–
179	Depression	Screening and psychological intervention for prevention of childhood/adolescent depression	5400	1400	32,000	5800	48	–	–4.0	Sufficient	Feasibility and acceptability in school setting and treatment of children without full-blown disorder
180	Depression	Screening and bibliotherapy for the prevention of childhood/adolescent depression	180	–	–	5800	3.6	–	–0.8	Limited	Feasibility and acceptability in school setting and treatment of children without full-blown disorder
181	Self-harm/suicide	Problem-solving therapy for reduction of deliberate self-harm (suicide)	Dominant	Dominant	Dominant	260	4.0	–	–16	Sufficient	–
182	Self-harm/suicide	Emergency contact cards for the reduction deliberate self-harm (suicide)	–	–	–	–	–	–	–	No evidence of effectiveness	–
183	Self-harm/suicide	Gun ownership legislation and gun buy-back scheme) for reduction in suicide	53,000	38,000	68,000	11,000	560	27	–5.5	May be effective	–
184	Self-harm/suicide	Responsible media reporting for reduction of suicide	170	–	–	1400	1.0	0.05	–	Likely	–

	Topic area	Intervention	ICER (95% uncertainty interval)			Lifetime DALYs	Lifetime intervention costs (A$ million)	Annual intervention costs (A$ million)	Cost offsets (A$ million)	Strength of evidence	Second filter
			Median	*Lower limit*	*Upper limit*						
185	Psychosis	Treatment for individuals at ultra-high risk for psychosis	Dominant	Dominant	Dominant	180	8.4	–	–	Likely	–
186	Anxiety	Parenting intervention for prevention of childhood anxiety disorders	6900	2400	20,000	400	4.0	–	–0.7	Sufficient	–
187	Vision loss	Screening by regular vision testing	–	–	–	–	–	–	–14	No evidence	–
188	Vision loss	Ranibizumab for age-related macular degeneration	240,000	120,000	Dominated	3500	930	37	–1.3	Sufficient	–
189	Oral health	Public water fluoridation for all towns >1000 people (89% coverage)	Dominant	Dominant	Dominant	3700	13	1.1	–	Limited	Acceptability to public
190	Oral health	Public water fluoridation for all towns in Australia (100% coverage)	92,000	34,000	180,000	5,900	680	58	–	Limited	Acceptability to public
191	Oral health	Annual dental check at ages 12–17: oral examination only	54,000	–	–	590	32	6.5	–95	No evidence	–
192	Oral health	Annual dental check at ages 12–17: oral examination and X-ray and clean	220,000	–	–	590	130	27	–150	No evidence	–
193	Oral health	Annual dental check at ages 12–17: oral examination and X-ray and clean and scale and sealant	620,000	–	–	590	370	73	–	No evidence	–
Treatment: non-communicable diseases											
194	Alcohol	Residential treatment and naltrexone	97,000	59,000	160,000	460	50	–	–4.4	Sufficient	Wider social concerns
195	Alcohol	Residential treatment	140,000	90,000	250,000	190	30	–	–1.7	Sufficient	
196	Illicit drugs	CBT for individuals with cannabis dependence	5,400	Dominant	34,000	82	0.9	–	–0.5	Sufficient	Feasibility: workforce capacity
197	Breast cancer[§]	Trastuzumab for early breast cancer, 9-week course	12,000	Dominated	90,000	1800	26	–	–	Sufficient	–

	Topic area	Intervention	ICER (95% uncertainty interval)			Lifetime DALYs	Lifetime intervention costs (A$ million)	Annual intervention costs (A$ million)	Cost offsets (A$ million)	Strength of evidence	Second filter
			Median	*Lower limit*	*Upper limit*						
198	Breast cancer[§]	Trastuzumab for early breast cancer, 1-year course	96,000	73,000	140,000	1400	130	–	–	Sufficient	Not more effective than short course
199	Kidney disease	Current renal replacement therapy versus do nothing	70,000	65,000	76,000	10,000	730	730	–	Sufficient	Feasibility: shortage of donor kidneys
200	Kidney disease	Current renal replacement therapy versus dialysis only	23,000	20,000	26,000	4300	100	100	–	Sufficient	Feasibility: shortage of donor kidneys
201	Kidney disease	Dialysis only	100,000	91,000	120,000	6100	630	630	–	Sufficient	–
202	Depression	TCAs for major depressive episodes plus 6 months continuation	12,000	10,000	15,000	4900	70	–	–9.5	Sufficient	Acceptability: side effects
203	Depression	SSRIs for major depressive episodes plus 6 months continuation	27,000	23,000	33,000	5000	150	–	–10	Sufficient	Acceptability: side effects
204	Depression	Individual CBT treatment of major depressive episodes by psychologist	8600	6900	11,000	11,000	110	–	–10	Sufficient	–
205	Depression	Group CBT treatment of major depressive episodes by psychologist	1300	870	1800	11,000	25	–	–10	Sufficient	–
206	Depression	Bibliotherapy for major depressive episodes	620	380	950	3200	6.1	–	–4.0	Sufficient	–
207	Depression	5-year maintenance therapy with TCAs following a major depressive episode	11,000	9000	13,000	35,000	530	110	–160	Sufficient	Acceptability: side effects
208	Depression	5-year maintenance therapy with SSRIs following a major depressive episode	35,000	30,000	42,000	36,000	1400	290	–160	Sufficient	Acceptability: side effects
209	Depression	Individual maintenance CBT by a psychologist	11,000	9500	13,000	49,000	700	140	–160	Sufficient	–
210	Depression	Group maintenance CBT by a psychologist	850	360	1200	49,000	200	40	–160	Sufficient	–

	Topic area	Intervention	ICER (95% uncertainty interval)			Lifetime DALYs	Lifetime intervention costs (A$ million)	Annual intervention costs (A$ million)	Cost offsets (A$ million)	Strength of evidence	Second filter
			Median	*Lower limit*	*Upper limit*						
211	Psychosis	Early psychosis prevention and intervention centre	Dominant	Dominant	Dominant	–	–0.05	–	–	Likely	–
212	Cardiovascular disease	Early stenting for acute myocardial infarction	16,000	11,000	29,000	6500‡‡	110‡‡	–	–	Sufficient	Feasibility/equity/Indigenous: only in larger hospitals, not rural/remote
213	Cardiovascular disease	Angioplasty coated stents: general population	82,000	Dominant	890,000	160‡‡	23‡‡	23‡‡	–	Sufficient	–
214	Cardiovascular disease	Bypass surgery and stents versus optimal medical treatment	2,134,000	1,468,000	3,527,000	–	–	–	–	Sufficient	No impact on survival
215	Cardiovascular disease	Rehabilitation following acute myocardial infarction	5400	500	18,000	4100	23	–	–	Sufficient	No evidence that >6 weeks adds to effect
216	Cardiovascular disease	Angioplasty with coated stents: diabetic population	25,000	Dominant	600,000	–	–	–	–	Sufficient	–
217	Asthma	Asthma clinic, incl. benefits from emergency department visits and days off from work	31,000	16,000	140,000	8000‡‡		260‡‡	–	No evidence	Ambivalent evidence
218	Asthma	Asthma clinic, incl. benefit from reduced emergency GP visits, emergency department visits, hospitalisation, and days off from work	22,000	9000	91,000	8000‡‡		170‡‡	–	No evidence	Ambivalent evidence
219	Asthma	Asthma clinic, incl. benefit from reduced emergency department visits	NA	NA	NA	NA		260‡‡		No evidence	Ambivalent evidence
220	Osteoarthritis	Hip replacement for osteoarthritis	3600	3200	4200	120,000	1600	160	–1200	Sufficient	–
221	Osteoarthritis	Knee replacement for osteoarthritis	9900	8400	12,000	110,000	2800	280	–1700	Sufficient	–
222	Peptic ulcer disease§§	Eradication with triple therapy in *Helicobacter pylori* and patients with peptic ulcer	Dominant	–	–	–	–	–	–	Sufficient	–

	Topic area	Intervention	ICER (95% uncertainty interval)			Lifetime DALYs	Lifetime intervention costs (A$ million)	Annual intervention costs (A$ million)	Cost offsets (A$ million)	Strength of evidence	Second filter
			Median	*Lower limit*	*Upper limit*						
223	Peptic ulcer disease[§§]	Eradication therapy for *Helicobacter pylori* infection in uninvestigated dyspepsia	–	–	–	–	–	–	–	No evidence	–
224	Peptic ulcer disease[§§]	*Helicobacter pylori* eradication for non-ulcer dyspepsia	–	–	–	–	–	–	–	No evidence	–
225	Shingles[¶¶]	*Varicella zoster* vaccination age 50	140,000	NA	NA	230[¶¶]	NA	32	NA	Limited	–
Infectious disease control											
226	Influenza	Universal influenza vaccination ages 50–64 assuming influenza-like illness incidence 1.79%	110,000	NA	NA	390	43	43	–	Limited	–
227	Influenza	Universal influenza vaccination ages 50–64 assuming influenza-like illness incidence of 5.37% (European rate)	35,000	NA	NA	1100	41	41	–	Limited	–
228	HIV[##]	Needle exchange program for prevention HIV and hepatitis	Dominant	Dominant	Dominant	370,000	24	24	–		–
229	HIV[##]	Intermittent pre-exposure prophylaxis for HIV	5600	Dominant	18,000	95,000	210	210	–	Sufficient	–
230	HIV[##]	Circumcision: all men having sex with men	8900	Dominant	45,000	3400	73	73	–	Sufficient	–
231	HIV[##]	Early antiretrovirals	73,000	3900	160,000	12,000	40	40	–	Sufficient	–
232	HIV[##]	Post-exposure prophylaxis	190,000	170,000	210,000	540	4	4	–	Sufficient	Rule of rescue
Indigenous interventions											
233	Blood pressure and cholesterol (Indigenous)[§]	Looma healthy lifestyle: community-based intervention for remote Indigenous age 20+	390,000	380,000	400,000	1500	600	43	–25	Limited	Enhances equity; non-health benefits

	Topic area	Intervention	ICER (95% uncertainty interval)			Lifetime DALYs	Lifetime intervention costs (A$ million)	Annual intervention costs (A$ million)	Cost offsets (A$ million)	Strength of evidence	Second filter
			Median	*Lower limit*	*Upper limit*						
234	Blood pressure and cholesterol (Indigenous)§	Statins – mainstream health services, ages 20+	82,000	69,000	97,000	3000	290	17	–47	Sufficient	Enhances equity
235	Blood pressure and cholesterol (Indigenous)§	Statins – mainstream health services, ages 35+	59,000	49,000	71,000	1500	–	–	–	Sufficient	Enhances equity
236	Blood pressure and cholesterol (Indigenous)§	Statins – ACCHS, ages 20+	110,000	91,000	130,000	4500	560	33	–70	Sufficient	Enhances equity
237	Blood pressure and cholesterol (Indigenous)§	Statins – ACCHS, ages 35+	80,000	66,000	97,000	2300	–	–	–	Sufficient	Enhances equity
238	Blood pressure and cholesterol (Indigenous)§	ACE inhibitors – mainstream health services, ages 20+	44,000	30,000	77,000	3600	210	12	–48	Sufficient	Enhances equity
239	Blood pressure and cholesterol (Indigenous)§	ACE inhibitors – mainstream health services, ages 35+	31,000	19,000	57,000	1900	–	–	–	Sufficient	Enhances equity
240	Blood pressure and cholesterol (Indigenous)§	ACE inhibitors – ACCHS, ages 20+	69,000	47,000	120,000	5500	460	27	–72	Sufficient	Enhances equity
241	Blood pressure and cholesterol (Indigenous)§	ACE inhibitors – ACCHS, ages 35+	51,000	33,000	89,000	2800	–	–	–	Sufficient	Enhances equity
242	Blood pressure and cholesterol (Indigenous)§	Diuretics – mainstream health services, ages 20+	18,000	7900	36,000	3600	110	7	–49	Sufficient	Enhances equity
243	Blood pressure and cholesterol (Indigenous)§	Diuretics – mainstream health services, ages 35+	11,000	1600	25,000	1800	–	–	–	Sufficient	Enhances equity

	Topic area	Intervention	ICER (95% uncertainty interval)			Lifetime DALYs	Lifetime intervention costs (A$ million)	Annual intervention costs (A$ million)	Cost offsets (A$ million)	Strength of evidence	Second filter
			Median	*Lower limit*	*Upper limit*						
244	Blood pressure and cholesterol (Indigenous)[§]	Diuretics – ACCHS, ages 20+	43,000	27,000	76,000	5400	310	18	–73	Sufficient	Enhances equity
245	Blood pressure and cholesterol (Indigenous)[§]	Diuretics – ACCHS, ages 35+	30,000	17,000	57,000	2700	–	–	–	Sufficient	Enhances equity
246	Blood pressure and cholesterol (Indigenous)[§]	Polypill $50 – mainstream health services, ages 20+	Dominant	Dominant	Dominant	9200	83	5	–130	Sufficient	Enhances equity
247	Blood pressure and cholesterol (Indigenous)[§]	Polypill $50 – mainstream health services, ages 35+	Dominant	Dominant	Dominant	4700	–	–	–	Sufficient	Enhances equity
248	Blood pressure and cholesterol (Indigenous)[§]	Polypill $50 – ACCHS, ages 20+	5500	Dominant	12,000	14,000	270	16	–190	Sufficient	Enhances equity
249	Blood pressure and cholesterol (Indigenous)[§]	Polypill $50 – ACCHS, ages 35+	750	Dominant	6600	7100	–	–	–	Sufficient	Enhances equity
250	Blood pressure and cholesterol (Indigenous)[§]	Polypill $100 – mainstream health services, ages 20+	Dominant	Dominant	2900	9200	110	6	–130	Sufficient	Enhances equity
251	Blood pressure and cholesterol (Indigenous)[§]	Polypill $100 – mainstream health services, ages 35+	Dominant	Dominant	Dominant	4700	–	–	–	Sufficient	Enhances equity
252	Blood pressure and cholesterol (Indigenous)[§]	Polypill $100 – ACCHS, ages 20+	8,300	1800	15,000	14,000	310	18	–190	Sufficient	Enhances equity
253	Blood pressure and cholesterol (Indigenous)[§]	Polypill $100 – ACCHS, ages 35+	3000	Dominant	9000	7100	–	–	–	Sufficient	Enhances equity

	Topic area	Intervention	ICER (95% uncertainty interval)			Lifetime DALYs	Lifetime intervention costs (A$ million)	Annual intervention costs (A$ million)	Cost offsets (A$ million)	Strength of evidence	Second filter
			Median	*Lower limit*	*Upper limit*						
254	Blood pressure and cholesterol (Indigenous)[§]	Polypill $150 – mainstream health services, ages 20+	1100	Dominant	6000	9200	140	8	–130	Sufficient	Enhances equity
255	Blood pressure and cholesterol (Indigenous)[§]	Polypill $150 – mainstream health services, ages 35+	Dominant	Dominant	2100	4700	–	–	–	Sufficient	Enhances equity
256	Blood pressure and cholesterol (Indigenous)[§]	Polypill $150 – ACCHS, ages 20+	11,000	4500	18,000	14,000	350	20	–190	Sufficient	Enhances equity
257	Blood pressure and cholesterol (Indigenous)[§]	Polypill $150 – ACCHS, ages 35+	5300	Dominant	11,000	7100	–	–	–	Sufficient	Enhances equity
258	Blood pressure and cholesterol (Indigenous)[§]	Polypill $200 – mainstream health services, ages 20+	3900	Dominant	9200	9200	160	10	–130	Sufficient	Enhances equity
259	Blood pressure and cholesterol (Indigenous)[§]	Polypill $200 – mainstream health services, ages 35+	Dominant	Dominant	4600	4700	–	–	–	Sufficient	Enhances equity
260	Blood pressure and cholesterol (Indigenous)[§]	Polypill $200 – ACCHS, ages 20+	14,000	7200	22,000	14,000	390	23	–190	Sufficient	Enhances equity
261	Blood pressure and cholesterol (Indigenous)[§]	Polypill $200 – ACCHS, ages 35+	7500	1000	14,000	7100	–	–	–	Sufficient	Enhances equity
262	Blood pressure and cholesterol (Indigenous)[§]	Polypill $500 – mainstream health services, ages 20+	21,000	15,000	29,000	9200	320	19	–130	Sufficient	Enhances equity
263	Blood pressure and cholesterol (Indigenous)[§]	Polypill $500 – mainstream health services, ages 35+	13,000	6800	20,000	4700	–	–	–	Sufficient	Enhances equity

	Topic area	Intervention	ICER (95% uncertainty interval)			Lifetime DALYs	Lifetime intervention costs (A$ million)	Annual intervention costs (A$ million)	Cost offsets (A$ million)	Strength of evidence	Second filter
			Median	*Lower limit*	*Upper limit*						
264	Blood pressure and cholesterol (Indigenous)[§]	Polypill $500 – ACCHS, ages 20+	31,000	23,000	41,000	14,000	630	36	–190	Sufficient	Enhances equity
265	Blood pressure and cholesterol (Indigenous)[§]	Polypill $500 – ACCHS, ages 35+	21,000	14,000	29,000	7100	–	–	–	Sufficient	Enhances equity
266	Cancer and cirrhosis[§] (Indigenous)	Universal infant HBV vaccination	Dominant	Dominant	Dominant	830	0.7	0.7	–8.3	Sufficient	–
267	Cancer and cirrhosis[§] (Indigenous)	Selective hepatitis B vaccination and immunoglobulin for infants born to carrier mothers	Dominant	Dominant	Dominant	790	0.2	0.2	–7.7	Sufficient	–
268	Cancer and cirrhosis[§] (Indigenous)	Universal HBV vaccination, and additional immunoglobulin for infants born to carrier mothers	Dominant	Dominant	Dominant	990	0.9	0.9	–10	Sufficient	–
269	Pre-diabetes (Indigenous)	Screen and dietary advice	38,000	23,000	150,000	8200	310	26	–120	Sufficient	Feasibility/ equity: limited capacity GPs and exercise physiologists, esp. in rural areas.
270	Pre-diabetes (Indigenous)	Screen and exercise physiologist	30,000	23,000	89,000	14,000	430	35	–180	Sufficient	Feasibility/ equity: limited capacity GPs and exercise physiologists, esp. in rural areas.
271	Pre-diabetes (Indigenous)	Screen and dietary advice and exercise physiologist	22,000	19,000	35,000	17,000	380	32	–210	Sufficient	Feasibility/ equity: limited capacity GPs and exercise physiologists, esp. in rural areas.

	Topic area	Intervention	ICER (95% uncertainty interval)			Lifetime DALYs	Lifetime intervention costs (A$ million)	Annual intervention costs (A$ million)	Cost offsets (A$ million)	Strength of evidence	Second filter
			Median	*Lower limit*	*Upper limit*						
272	Pre-diabetes (Indigenous)	Screen and drug: rosiglitazone	Dominated	Dominated	53,000	–21,470	2100	430	–49	Sufficient	–
273	Pre-diabetes (Indigenous)	Screen and drug: metformin	21,000	17,000	36,000	15,000	330	27	–250	Sufficient	–
274	Pre-diabetes (Indigenous)	Screen and drug: acarbose	37,000	25,000	130,000	20,000	760	63	–330	Sufficient	–
275	Pre-diabetes (Indigenous)	Screen and drug: orlistat	100,000	94,000	130,000	25,000	2500	490	–400	Sufficient	–
276	Kidney disease (Indigenous)	Screening and early treatment with ACE inhibitors (remote, non-DM)	Dominant	Dominant	20,000	30	1.1	0.1	–1.5	Sufficient	–
277	Kidney disease (Indigenous)	Screening and early treatment with ACE inhibitors (non-remote, non-DM)	Dominant	Dominant	12,000	60	2.8	0.2	–4.3	Sufficient	–
278	Kidney disease (Indigenous)	Screening and early treatment with ACE inhibitors (remote, DM)	Dominant	Dominant	Dominant	130	3.1	0.3	–6.9	Sufficient	–
279	Kidney disease (Indigenous)	Screening and early treatment with ACE inhibitors (non-remote, DM)	Dominant	Dominant	Dominant	280	6.5	0.5	–16	Sufficient	–
280	Kidney disease (Indigenous)	Current renal replacement therapy versus do nothing	100,000	100,000	100,000	–	–	–	–	Sufficient	–
281	Kidney disease (Indigenous)	Dialysis only	110,000	110,000	110,000	–	–	–	–	Sufficient	–
282	Kidney disease (Indigenous)	Current renal replacement therapy versus dialysis	17,000	10,000	24,000	–	–	–	–	Sufficient	–

ACCHS, Aboriginal controlled community health service; ACE, angiotensin-converting enzyme; BMI, body mass index; CCB, calcium channel blocker; CBT, cognitive behaviour therapy; CVD, cardiovascular disease; DALY, disability-adjusted life year; DM, diabetes mellitus; DWL, dead weight loss; HIV, human immunodeficiency virus; HPV, human papillomavirus; NA, not available; PSA, prostate-specific antigen; TCA, tricyclic antidepressant; SSRI, selective serotonin re-uptake inhibitor

Notes

* Entries in blue indicate scenarios that are considered 'variations' rather than separate interventions and are not included in the results section of the report.

† Interventions were modelled with the Australian population alive in 2003, or those eligible within that population, as the intervention population. This population was followed up over their remaining lifetime. Exceptions are mentioned in the following footnotes. In the estimation of annual intervention costs, it is assumed that interventions of which the effects wear off over time are repeated at regular intervals.

‡ Work in progress.

§ Comparator was no intervention rather than current practice.

¶ As this intervention is the current practice scenario, it is compared to 'do nothing'. The other cervical cancer interventions are compared to current practice (= this intervention).

Modelled with the 2003 cohort of 11-year-olds followed up over their lifetime. Disability-adjusted life years (DALYs) and costs reported here must therefore be interpreted as recurring annually.

** These interventions save costs and cost DALYs compared to current practice. The ICERs are therefore 'inverted'; presented is the amount of money saved for every DALY that is lost.

†† Prevention of cancer and cirrhosis by hepatitis B vaccination was modelled with the birth cohort of 2003 as the intervention population. DALYs and costs reported here must therefore be interpreted as recurring annually.

‡‡ Costs and effects modelled as annually recurring.

§§ Modelled with focus on individuals; no population estimates of health and cost consequences.

¶¶ Modelled with the 2003 cohort of 50-year-olds followed up over their lifetime. DALYs and costs reported here must therefore be interpreted as recurring annually.

Modelled by simulating a period of 20 years and compared to no intervention.

Appendix 3 ACE–Prevention publications, briefing papers and pamphlets

Topic area	Documentation
Methods	**Pamphlet A**: The ACE–Prevention project
	Pamphlet B: ACE approach to priority-setting
	Pamphlet C: Key assumptions underlying the economic analysis
	Pamphlet D: Interpretation of ACE–Prevention cost-effectiveness results
	Pamphlet E: Indigenous Health Service Delivery
Overall Results	**Pamphlet**: League table
	Pamphlet: Combined effects
Alcohol	Cobiac LJ, Vos T, Doran C, Wallace A. Cost-effectiveness of interventions to prevent alcohol-related disease and injury in Australia. Addiction 2009;104:1646–1655.
	Byrnes J, Cobiac L, Doran C, Vos T, Shakeshaft A. The cost-effectiveness of volumetric alcohol taxation in Australia. Medical Journal of Australia 2010;192:439–443.
	Hall W, Wallace A, Cobiac L, Doran C, Vos T. How can we reduce alcohol-related road crashes among young Australians? Medical Journal of Australia 2010;192:464–466.
	Doran C, Hall W, Shakeshaft A, Vos T, Cobiac L. Alcohol policy reform in Australia: what can we learn from the evidence? Medical Journal of Australia 2010;192:468–470.
	Doran C, Cobiac L, Byrnes J, Vos T (2010) Alcohol taxation and distribution of gains. National Drug and Alcohol Research Centre, University of New South Wales; Centre for Burden of Disease and Cost-Effectiveness, The University of Queensland; VicHealth; Public Health Association of Australia.
	Pamphlet 2: Alcohol
Tobacco	Peer-reviewed publications in preparation
	Pamphlet 17: Tobacco
Physical activity	Cobiac LJ, Vos T, Barendregt JJ. Cost-effectiveness of interventions to promote physical activity: a modelling study. PLoS Med 2009;6:e1000110
	Pamphlet 11: Physical activity
Fruit and vegetables	Cobiac LJ, Vos T, Veerman JL. Cost-effectiveness of interventions to promote fruit and vegetable consumption. Under review
	Pamphlet 7: Fruit and vegetables
Salt	Cobiac LJ, Vos T, Veerman JL. Cost-effectiveness of interventions to reduce dietary salt intake. Heart 2010 (in press).
	Pamphlet 15: Salt
Multi-component	Cobiac LJ, Vos T, Veerman JL. Cost-effectiveness of Weight Watchers and the Lighten Up to a Healthy Lifestyle program. Aust N Z J Public Health 2010;34(3):240–247.

Topic area	Documentation
Body mass	Forster M, Veerman JL, Barendregt JJ, Vos T. Cost-effectiveness of diet and exercise interventions to reduce overweight and obesity. Under review
	Veerman JL, Forster M, Barendregt JJ, Vos T. Cost-effectiveness of pharmacological interventions to reduce overweight and obesity. In preparation
	Sacks G, Veerman JL, Moody M, Swinburn B. 'Traffic-light' nutrition labelling and 'junk-food' tax: a modelled comparison of cost-effectiveness for obesity prevention. Under review
	Peer-reviewed publication on gastric banding in preparation
	Pamphlet 9: Obesity
Blood pressure and cholesterol	Magnus A, Lim SS, Vos T, Carter R. Cost-effectiveness of strategies to prevent cardiovascular disease. In preparation
	Magnus A, Vos T, Carter R. The future use of a polypill in the prevention of cardiovascular disease. In preparation
	Pamphlet 3: Blood pressure and cholesterol lowering
Bone mineral density	Peer-reviewed publications in preparation
	Briefing paper Screen + alendronate
	Briefing paper Screen + raloxifene
	Briefing paper Physical activity via mass media campaign
	Pamphlet 10: Osteoporosis
Illicit drugs	Tay-Teo K, Bulfone L, Carter R, Doran C, Hall W. Modelling the public health consequences of cannabis use in Australia. In preparation
	Tay-Teo K, Carter R, Doran C, Pirkis J, Hall W. Evaluating the economic value of the random roadside drug-testing program in Victoria, Australia. In preparation
	Tay-Teo K, Carter R, Doran C, Pirkis J, Hall W. The cost-effectiveness of the Gatehouse intervention. In preparation
	Tay-Teo K, Carter R, Doran C, Pirkis J, Hall W. The cost-effectiveness of CBT for drug dependency. In preparation
	Briefing paper CBT for cannabis use disorders
	Briefing paper School-based drug prevention – Gatehouse
	Briefing paper Roadside drug-testing
	Briefing paper School-based cannabis use prevention
	Pamphlet 4: Cannabis
Cervical cancer	Shih S, Mihalopoulos C, Carter R. Costing on cervical cancer screening and management of screen detected abnormalities based on NHMRC guidelines. In preparation
	Shih S, Barendregt JJ, Mihalopoulos C, Carter R, Vos T. Options for change of cervical cancer screening strategy: cost-effectiveness results from a micro-simulation model. In preparation
	Shih S, Vos T, Magnus A, Carter R. Directions of Australian cervical screening policy in the context of HPV vaccination. In preparation
	Pamphlet 5: Cervical cancer screening, SunSmart and PSA screening

Topic area	Documentation
Skin cancer	Shih S, Carter R, Sinclair C, Mihalopoulos C, Vos T. Economic evaluation of skin cancer prevention in Australia. Preventive Medicine 2009;49:449–453. *Briefing paper* Cervical cancer *Briefing paper* Skin cancer **Pamphlet 5**: Cervical cancer screening, SunSmart and PSA screening
Prostate cancer	Peer-reviewed publication in preparation **Pamphlet 5**: Cervical cancer screening, SunSmart and PSA screening
Anal cancer	Peer-reviewed publication in preparation
Hepatitis B	Peer-reviewed publication in preparation
Pre-diabetes	Bertram MY, Lim SS, Barendregt JJ, Vos T. Assessing the cost-effectiveness of drug and lifestyle intervention following opportunistic screening for pre-diabetes in primary care. Diabetologia 2010 May;53(5):875–881. *Briefing paper* Pre-diabetes **Pamphlet 12**: Pre-diabetes screening
Chronic kidney disease	Higashi H, Barendregt J, Vos T. Cost-effectiveness of screening and early treatment of chronic kidney disease in Australia: general and Indigenous populations. In preparation **Pamphlet 14**: Renal replacement therapy, screening and early treatment of chronic kidney disease
Mental health	Mihalopoulos C, Vos T, Pirkis J, Smit F, Carter R. The cost effectiveness of suicide prevention interventions. In preparation Mihalopoulos C, Vos T, Pirkis J, Smit F, Carter R. The cost-effectiveness of screening and treatment for the prevention of childhood/adolescent depression. In preparation Mihalopoulos C, Vos T, Pirkis J, Smit F, Carter R. The cost-effectiveness of prevention and treatment for post-natal depression. In preparation Mihalopoulos C, Vos T, Pirkis J, Smit F, Carter R. The cost-effectiveness of preventing psychosis. In preparation Mihalopoulos C, Vos T, Pirkis J, Smit F, Carter R. The economic analysis of prevention in mental health programs. In preparation Mihalopoulos C, Vos T, Pirkis J, Smit F, Carter R. The cost-effectiveness of screening and treatment for the prevention of childhood/adolescent anxiety. In preparation Mihalopoulos C, Vos T, Pirkis J, Smit F, Carter R. Does screening and treatment for the prevention of adult depression represent good value for money? ANZJP 2010 (in press) *Briefing paper* Childhood anxiety *Briefing paper* Childhood depression *Briefing paper* Youth psychosis *Briefing paper* Depression screening *Briefing paper* Post-partum depression *Briefing paper* Suicide prevention *Briefing paper* Depression treatment

Topic area	Documentation
	Pamphlet 1: Adult depression
	Pamphlet 6: Childhood mental disorders
	Pamphlet 13: Psychosis
	Pamphlet 16: Suicide prevention
CVD treatment	Peer-reviewed publications on rehabilitation, revascularisation, drug-eluting stents and PCI versus thrombolysis in preparation
Vision loss	*Briefing paper* Vision screening
	Briefing paper Ranibizumab for AMD
Oral health	Cobiac L, Veerman JL, Vos T. Cost-effectiveness of extending the coverage of public water supply fluoridation in Australia. In preparation
	Briefing paper Regular dental checks for adolescents
Peptic ulcer disease	In preparation
Breast cancer	In preparation
Asthma	In preparation
Osteoarthritis	Higashi H, Crawford S, Barendregt J. Cost-effectiveness of total hip and knee replacements for the Australian population with osteoarthritis: modelled analysis. In preparation
	Briefing paper Osteoarthritis hip and knee
Shingles	*Briefing paper Varicella zoster* vaccination
Influenza	Mogasale V, Barendregt JJ. Is universal influenza vaccination program for adults aged 50–64 in Australia really cost-effective? ANZJPH (under revision)
HIV	Peer-reviewed publications in preparation
	Pamphlet 8: HIV
Diarrhoea	In preparation
Indigenous	Ong K, Kelaher M, Anderson I, Carter R. A cost-based equity weight for use in the economic evaluation of primary health care interventions: case study of the Australian Indigenous population. International Journal for Equity in Health 2009, 8:34
	Peer-reviewed publication on Indigenous Health Service Delivery (IHSD) template in preparation
	Peer-reviewed publication on hepatitis B/cirrhosis and liver cancer in preparation
	Peer-reviewed publication on chronic kidney disease in preparation
	Briefing paper Blood pressure and cholesterol Indigenous
	Briefing paper Pre-diabetes
	Pamphlet Indigenous 1: Cardiovascular disease prevention
	Pamphlet Indigenous 2: Diabetes prevention
	Pamphlet Indigenous 3: Screening and early treatment of chronic kidney disease

Assessing Cost-Effectiveness in Prevention

ACE–Prevention

September 2010