NSW Health

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EVIDENCE AND EVALUATION GUIDANCE SERIES

Reviewing Economic Evaluations

A Checklist

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The NSW Ministry for Health acknowledges the traditional custodians of the lands across NSW. We acknowledge that we live and work on Aboriginal lands. We pay our respects to Elders past and present and to all Aboriginal people.

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SHPN (CEE) 230974
ISBN 978-1-76023-701-1

December 2023

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Suggested citation:
Centre for Epidemiology and Evidence. *Reviewing Economic Evaluations: A Checklist*. Evidence and Evaluation Guidance Series, Population and Public Health Division. Sydney: NSW Ministry of Health; 2023.

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Introduction to economic evaluation

Economic evaluation is a tool in which evidence about the costs and outcomes (outputs, impacts and/or benefits) of initiatives is gathered and compared to identify those that represent best value for money. Economic evaluations of health initiatives are designed to support resource allocation decisions. In relation to population health, economic evaluation can be used as one important source of evidence to compare two or more initiatives to determine the optimal investment to achieve a specific health outcome.

The basic tasks of any economic evaluation are to estimate the costs and outcomes of a proposed initiative against an alternative (a 'comparator'), which is typically a status quo or 'usual care' option. To inform decisions, economic evaluations must be rigorous, transparent regarding methods, and conducted ethically.[1] Confidence in adherence to such general principles enables policy makers to make greater use of evidence and promotes better decision making.[2]

The *NSW Treasury Policy and Guidelines: Evaluation (TPG22-22)*[3] sets out mandatory requirements, recommendations and guidance for NSW General Government Sector agencies and other government entities to plan for and conduct the evaluation of policies, projects, regulations and programs. Where relevant, sections in the Treasury Evaluation Policy and Guidelines have been referenced.

Purpose of this checklist

The purpose of this checklist is to assist users across NSW Health to systematically review the quality and relevance of economic evaluations. The checklist focuses on the core principles of economic evaluation and how each can be used in appraising economic methods found in a range of documents such as peer-reviewed journal articles, grey literature, project proposals and reports. The checklist intends to ensure that users consider the main criteria for good economic evaluations and that these studies are assessed in a comprehensive and consistent manner.

This checklist can be used by people at all levels of experience and expertise in economic evaluation. It does not assume formal training in this field but some familiarity with key concepts is helpful.

In addition, NSW Health offers a range of resources to support staff capability in economic evaluation.

Application of this checklist

This checklist may be used when reviewing economic evaluations in the following type of publications:

Document	Review action
Peer-reviewed journal articles and grey literature	Assessing the quality of evidence generated from economic evaluations to consider applying the findings to your own context or setting
Project proposals (e.g. responses to Requests for Tender (RFTs)/Requests for Quote (RFQs)/ Expressions of Interest (EOIs))	Assessing the quality and comprehensiveness of proposals from organisations/ consultants to undertake commissioned economic evaluations
Interim and final economic evaluation reports	Assessing the quality and comprehensiveness of economic evaluation findings for your own initiatives, often provided by external consultants (but may also be provided by internal project teams)

Practical questions and examples are provided to guide you in identifying good practice and what to look out for when reviewing economic evaluations. The checklist should be used in conjunction with *Engaging an Independent Evaluator for Economic Evaluations: A Guide*.[4]

This checklist covers:

- assessing the appropriateness of alternative initiatives (the 'comparators')
- assessing the appropriateness of the method
- assessing the appropriateness of assumptions used in the analysis
- appraising evidence of effectiveness
- accounting for uncertainty
- interpreting results.

If you are seeking guidance on how to **plan** an economic evaluation, refer to the *Planning Economic Evaluations checklist*.

There are a number of core principles that underpin economic evaluation and this review checklist is benchmarked against standard principles for conducting economic evaluations in the health context.[5-9]

NSW Treasury recommends using cost-benefit analysis (CBA) for economic evaluations, particularly for large, complex or risky initiatives. In practice, the type of economic evaluation depends on a range of factors. There is often no one 'correct' way to conduct an economic evaluation, nor is there necessarily one 'correct' decision on the methods selected for an evaluation and thus reviewers need to balance the checklist ideals with pragmatic considerations. Ultimately the question that a reviewer needs to ask is whether the evidence presented in a particular study is good enough to inform the research/policy question at hand.

A note about economic evaluations in population health

Population health initiatives can incur costs and outcomes that are broad-ranging, long term and impact at an individual and community level.[10,11] While not unique to population health settings, these characteristics are often at the forefront of population health programs and pose particular challenges for economic evaluations. For example, to take into account population health outcomes that may only be realised many years into the future, economic evaluations may need to consider extrapolating costs and outcomes through modelling and then adjust (or 'discount') the observed costs and outcomes to account for differential timing. Information on discounting is available in Step 12 of this checklist.

In addition, equity is often an important consideration for population health programs. It may be relevant in some circumstances to assess costs and outcomes according to different population subgroups. Information on equity considerations is available in Step 9 of this checklist

Population health programs can also have an effect on outcomes that are not strictly health-related (e.g. a school-based health promotion program may impact upon students' school performance). They can also impact on multiple dimensions of health (e.g. a program designed to reduce domestic and family violence may lead to improvements in a range of physical and mental health outcomes).

To demonstrate the application of these principles in a population health context, a worked example of this checklist based on a published economic evaluation is provided in Appendix A.

Before you start this checklist

Before starting this checklist, it is recommended you reflect on the following questions which address some aspects fundamental to a well-designed and conducted economic evaluation.

- Is there evidence of the initiative's effectiveness?
- Have study limitations/biases been considered when reviewing evidence of effectiveness?
- Is the observed effectiveness of the initiative likely to be reflective of the situation in your setting? For instance, is there a similar level of baseline risk in your population? Are there major differences in epidemiological and sociodemographic characteristics?
- Has the design and conduct of the economic evaluation involved relevant stakeholders? Has stakeholder engagement been meaningful and did the economic evaluation plan have stakeholder buy-in?

If you respond 'No' to any of the questions, you should consider:

- **For proposal submissions or reports**: whether the initiative of interest is ready for an economic evaluation. Does the project need to take additional time to consider these aspects, or is it acceptable to progress?
- **For peer-reviewed journal articles or grey literature**: whether the economic evaluation evidence is relevant/appropriate to your context or setting.

Meaningful stakeholder engagement and buy-in is important throughout all types of evaluation processes. Ensure that, in relation to your review of documents for your own economic evaluation projects (e.g. proposals submitted in response to RFTs/RFQs/EOIs, and reports of economic evaluation findings), stakeholders have been consulted and engaged in the project, and feedback meaningfully considered within project proposals/reports.

Completing this checklist

The checklist contains a series of steps to guide your review of an economic evaluation. Brief explanatory text is provided with each review question to give you further context.

Note that it may not be necessary in an economic evaluation to address all of the steps, depending on the type and purpose of the evaluation. The relevance of each step should ideally have been considered and agreed upon during the planning stage of the economic evaluation.

To save your inputs, **download and save a copy of the PDF before you begin**. Information entered directly into a web browser will not save.

When conducting your review, use the right-hand column to mark if each step is addressed in the economic evaluation document: 'yes', 'no' or 'unsure/insufficient'. There is also space in this column for recording comments to support your review.

Assess whether you answered 'yes' to the majority of questions. For steps where you have not answered 'yes' you may wish to undertake the following:

- **For reviews of proposal submissions and reports**: based on the information in the checklist, and any other additional resources, discuss with the evaluator any opportunities to strengthen those aspects.
- **For reviews of peer-reviewed journal articles and grey literature**: be aware of limitations and/or continue your research and seek other sources to address those gaps.

Checklist overview

1. Objective of the evaluation
2. Perspective
3. Evidence of effectiveness
4. Description of initiative and comparator/s
5. Time horizon
6. Target group
7. Economic evaluation method
8. Identified costs and outcomes
9. Measurement of costs
10. Measurement of outcomes
11. Equity considerations
12. Discounting
13. Incremental analysis
14. Uncertainty and sensitivity analysis
15. Translation of findings

Reviewing economic evaluations checklist

For more detailed explanation of terminology and concepts used in this checklist, refer to *Engaging an Independent Evaluator for Economic Evaluations: A Guide*.

Clear table

Step	Review questions	Answers
1.	**Does the economic evaluation state a well-defined objective?** A well-defined objective should specify the following elements: • the perspective (i.e. the point of view) • the comparator(s) (i.e. the initiatives to be compared) • the setting(s) in which they are compared • the time horizon (i.e. the timeframe of the evaluation) • the target group • which costs and outcome(s) will be considered.	○ Yes ○ No ○ Unsure/Insufficient What is the stated objective of the economic evaluation?
2.	**Is the perspective of the analysis clearly stated and appropriate? (e.g. societal, health sector, individual payer)** The perspective of an economic evaluation is the point of view through which costs and outcomes will be examined. In practice the perspective of an evaluation defines the scope of costs and outcomes that we include in a study. Adopting a **societal perspective** is the broadest possible scope. This method includes the costs that are incurred to any group in society. For example in delivering a school-based health promotion program, training and materials development costs incurred by the sponsor (Ministry of Health), the costs incurred by the Department of Education in hosting the intervention, and costs to participants (children and parents in adhering to recommended lifestyle changes) may be included. In terms of outcomes, a societal perspective may include health outcomes of participants as well as outcomes in relation to long-term educational attainment such as increased lifetime income. A narrower **health sector perspective** measures only costs incurred in the health sector and outcomes in terms of health or health-related indicators (e.g. change in health risk factors). An even narrower perspective is that of an **individual payer**. For example, only costs and outcomes relevant to the NSW Ministry of Health, Medicare, or a private insurer. A full description of analysis perspectives can be found in Appendix B and *Engaging an Independent Evaluator for Economic Evaluations: A Guide*. The appropriate perspective depends on the underlying policy or investment decision that the economic evaluation is aiming to address. For instance, if the purpose is to inform NSW Health's decision on whether to fund the scale up of a project, an individual payer perspective of NSW Health may be appropriate. Similarly, if the purpose of the evaluation is to inform a NSW Treasury decision regarding funding allocations, a societal perspective might be used to examine the broader impact across NSW. An economic evaluation may consider and compare multiple perspectives.	○ Yes ○ No ○ Unsure/Insufficient The perspective used for the economic evaluation is: ○ Societal ○ Health sector ○ Individual payer ○ Other/multiple:

Step	Review questions	Answers
3.	**Does the economic evaluation include strong evidence of the initiative's effectiveness?** An economic evaluation is generally only useful when there is credible evidence that the initiative of interest is effective at improving the intended outcomes. Evidence of effectiveness is typically gained through a direct evaluation of the initiative such as a randomised controlled trial (RCT), or an evidence review of similar initiatives which may be supplemented by a model that synthesises such evidence. The strength of evidence should be assessed when considering the initiative's effectiveness. Systematic reviews and experimental study designs (such as RCTs, cluster RCTs and stepped-wedge designs) typically offer the strongest form of evidence. However, these study designs are not always feasible when evaluating population-based programs. For more information on study designs, please refer to *Study Design for Evaluating Population Health and Health Service Interventions*.[12]	○ Yes ○ No ○ Unsure/Insufficient User notes
4.	**Is a description of the initiative and the comparator clearly stated and appropriate?** Economic evaluations involve the comparison of an initiative to an alternative, known as a comparator. A range of study designs and methodologies may be appropriate. While not necessary, sometimes more than one comparator may be used, in which case all comparators should be assessed separately. The comparator may also consist of baseline data collected prior to implementation of the initiative. When reviewing an economic evaluation, you should be able to clearly identify the details of the comparator, such as who delivers the comparator to what target group, in what setting, and for what purpose. Any differences between the initiatives being compared should be identified. An economic evaluation should describe why the comparator was chosen, with consideration as to how it is credible and justifiable as a comparator to the initiative of interest. Ideally, for the economic evaluation to be relevant to your setting, the characteristics of the comparator should resemble the usual practice (or usual care) you observe in your setting.	○ Yes ○ No ○ Unsure/Insufficient What is the initiative compared to?
5.	**Is the time horizon selected for the analysis clearly stated and appropriate?** The time horizon (or timeframe) is the duration over which the costs and outcomes are collected and analysed for the economic evaluation. It should be long enough to capture all relevant costs and future outcomes associated with the initiative of interest and the comparator. The time horizon selected depends on when the costs and outcomes are incurred, noting that these can occur at different times. For example, the costs of implementing a population health initiative are often incurred in the short-term while health outcomes attributed to the initiative may occur far into the future. In such cases modelling may be appropriate to project future costs and outcomes. Furthermore, the longer the time horizon, the more sensitive the results are likely to be to the choice of discount rate (see Step 12 for more information).	○ Yes ○ No ○ Unsure/Insufficient What time horizon is used?
6.	**Is the target group selected for the analysis clearly stated and appropriate?** The target group of an economic evaluation is the population who received the initiative of interest. The target group should be outlined in detail including demographic characteristics and relevant information on health conditions. Consider whether subgroups within the target group have been identified, particularly if they are likely to experience costs and outcomes differently. In NSW, this may include Aboriginal and Torres Strait Islander populations and urban/rural populations.	○ Yes ○ No ○ Unsure/Insufficient Who is the target group for the analysis?

Step	Review questions	Answers
7.	**Is the economic evaluation method selected clearly stated and appropriate?** Whether an economic evaluation method was appropriate largely depends on the economic question being addressed, the end user, the outcomes of interest, and what is technically possible and feasible. As a general • cost-benefit analysis (CB social, economic outcom • cost-utility analysis (CUA of interest is measured using a burden of disease metric such as quality-adjusted life-years (QALYs) or disability-adjusted life-years (DALYs) • cost-effectiveness analysis (CEA) may be conducted when there is a clear, single health outcome of interest (such as life years saved or cases prevented) • cost-consequence analysis (CCA) may be conducted when there are multiple outcomes of interest but not all outcomes can be monetised • cost-minimisation analysis (CMA) may be conducted when outcomes are assumed to be equal between alternatives and therefore are not assessed. There are very limited circumstances where this assumption can be made. *Engaging an Independent Evaluator for Economic Evaluations*[4] provides a summary of the key characteristics, strengths and challenges of economic evaluation methods (see page 15). **Quality-adjusted life-years (QALYs)** is a measure of disease burden which includes both the quality and quantity of life lived. It is a score between 0 (equivalent to death) and 1 (full health).	○ Yes ○ No ○ Unsure/Insufficient What economic evaluation method was selected? ○ CBA ○ CUA ○ CEA ○ CCA ○ CMA ○ Other/multiple: To what extent is this method appropriate?
8.	**Are all the relevant costs and outcomes for the initiatives identified?** Economic evaluations are based on comparing the costs and outcomes of the initiative of interest and the comparator. Therefore, the costs and outcomes included in the evaluation should be clearly stated. Keep in mind the perspective of the economic evaluation as this will determine which costs are included. If a health sector perspective is adopted, productivity losses incurred in the wider economy would be excluded from the evaluation. However, they would be included if a societal perspective was taken. To assess whether all relevant costs were included, consider the resources required to implement the initiatives (e.g. personnel, buildings, equipment and consumables) and the healthcare costs that participants may experience during and after the initiative (e.g. GP visits, medication, hospitalisations). Generally, the outcomes included in the evaluation should reflect the primary health outcomes of the initiatives, which in turn reflects the underlying policy/investment decision. Referring to the program logic model of initiatives may be useful to identify their relevant costs and outcomes.	○ Yes ○ No ○ Unsure/Insufficient User notes

Step	Review questions	Answers
9.	**Are costs measured in appropriate units and valued accurately?** It should be clear how costs have been measured and valued for the initiative of interest and the comparator. First, check that costs are measured in terms of the quantity of resources consumed. For example, a hypothetical clinical screening and treatment program could be measured in the following units: • 500 physical examinations performed by physicians • 10 weeks of salaried nursing time • 10 weeks of rent and utility costs for a 100 square metre suite to use as clinic space • individual costs (as appropriate for the perspective chosen) such as the amount of medication purchased, the number of times travel was required for screening and treatment, or the time lost from work while attending the program. Next, examine if these costs can be valued. Commonly used sources to measure and value costs include program budgets and other financial records, routinely collected datasets (e.g. Medicare Benefits Schedule, Pharmaceutical Benefits Schedule and state-held hospital data), participant questionnaires and employee award rates. Costs in the NSW Health context should always be measured in Australian dollars, valued according to the year in which the evaluation was conducted, and discounted if appropriate (see Step 12). See Appendix B for a list of common inclusions for each perspective.	○ Yes ○ No ○ Unsure/Insufficient The following costs are measured and valued:
10.	**Are outcomes measured in appropriate units and valued accurately?** The choice of outcome measure is dependent on the initiative's objectives and the economic evaluation method being undertaken. As a general guide: • if the outcomes relate to mortality, the units of measurement typically include number of life-years gained, number of deaths averted or quality-adjusted life-years • outcomes related to morbidity may be measured in terms of number of cases cured or disease specific measures for chronic conditions • intermediate measures (e.g. blood pressure reduction) may be used where it is not possible to measure actual health outcomes and where there is evidence of a relationship between the intermediate measures and the health outcomes. This especially applies to preventative initiatives when outcomes are significantly downstream, as you may be reliant on data on intermediate measures to have confidence the initiative is on-track to improve the outcomes of interest (as predicted in your program logic) • when conducting a cost-benefit analysis, life-years gained, deaths averted or quality adjusted life-years can be monetised using the value of a statistical life. The data sources used to measure and value outcomes should be clearly provided. Consider also whether these data sources were likely to provide accurate and reliable information.	○ Yes ○ No ○ Unsure/Insufficient The following outcomes are measured and valued:

Step	Review questions	Answers
11.	**Does the economic evaluation adequately account for equity considerations?** Conventional economic evaluation methods tend to focus on efficiency (i.e. maximising health gain) rather than equity (i.e. the distribution of health gain). Ideally, an economic evaluation of a population health initiative should identify and measure the health inequality impacts that may result from the initiatives of interest. To assess this, consider the following questions: • Did the economic evaluation state whether the initiative aimed to address disparities in health across the community? • Do costs incurred by participants in the initiative differ across population subgroups? • Does the initiative have differential impacts across different populations and demographic groups (age, sex, rurality, Aboriginality and socioeconomic status)? Subgroup analysis is one way to account for differences between groups within the initiative's target group. It essentially means breaking down the analysis of costs and outcomes by those differing groups. While there are innovative methods that attempt to incorporate equity considerations alongside an economic evaluation, at this stage they have not been widely used.[13,14] Some of these methods include: • health inequality impact assessment • analysis of the opportunity cost of equity • extended cost-effectiveness analysis • distributional cost-effectiveness analysis. You can find further information on approaches to incorporate equity considerations on page 36 of *Engaging an Independent Evaluator for Economic Evaluations: A Guide*.[4]	○ Yes ○ No ○ Unsure/Insufficient ○ Not applicable (because equity was not required for consideration) Are there issues of equity to consider for the economic evaluation? If so, what are they and were they addressed?
12.	**Are adjustments made for costs and outcomes that occur in the future using a discount rate?** Discount rates should be applied to costs and outcomes that occur beyond the first year of the initiative. Applying a discount rate to future costs and outcomes reflects the loss in value associated with the wait for these costs and outcomes to materialise. The economic evaluation should provide a justification of the discount rate used and conduct a sensitivity analysis to test the rate chosen, including lower and upper rates (see Step 14 for further information). Note that NSW Treasury typically recommends a 5% discount rate which is varied from 3–7% to test how robust the results are at different rates.[15]	○ Yes ○ No ○ Unsure/Insufficient ○ Not applicable (because the time horizon is one year or less) What discount rate has been applied?
13.	**Has an incremental analysis of costs and outcomes of initiatives been performed?** For meaningful comparison, the economic evaluation should examine the difference in costs and outcomes of the initiative of interest compared to the comparators. This is known as incremental analysis. How this analysis is reported depends on the economic evaluation method conducted: • CBA expresses outcomes in terms of net-present value or benefit-cost ratio • CEA and CUA commonly express outcomes in terms of an incremental cost-effectiveness ratio (ICER) • CCA does not provide a cost-outcome ratio (such as an ICER) but monetises all costs and outcomes that can be quantified, and then qualitatively lists all other outcomes separately • CMA only requires a comparison of the costs because outcomes are assumed to be equal in this method. These results should be clearly presented, allowing for interpretation by non-technical audiences.	○ Yes ○ No ○ Unsure/Insufficient User notes

Step	Review questions	Answers
14.	**Is uncertainty in the estimates of costs and outcomes adequately taken into account?** The results of an economic evaluation are only as good as the assumptions and data on which they are based. It is common for economic evaluations to be based on actual cost and outcome data, with additional assumptions where data did not exist. One way to test for uncertainties generated from such assumptions is through sensitivity analysis. This method varies the estimates used in the analysis to assess their impact on results and whether these assumptions made a difference to study conclusions. This is an important step for assessing the robustness of findings of the economic evaluation.	○ Yes ○ No ○ Unsure/Insufficient User notes
15.	***(For reviews of economic evaluations found in peer-reviewed journal articles and grey literature)*** **Are the findings from the economic evaluation translatable to your context or setting?** Findings from an economic evaluation in one setting may not be translatable to another setting. This could be due to differences in population groups, cost structures and health system characteristics. Ask the following questions to assess the relevance of evidence from other economic evaluations, such as those found in peer-reviewed journal articles and grey literature: • Does the comparator resemble the usual practice in your setting? • Are the resource implications of implementing the initiative in your setting likely to be different due to factors such as infrastructure constraints, human resources shortages, supply chains, cultural adaptations, salaries or other costs? • Does the perspective for analysis in the economic evaluation reviewed reflect the policy issue you are addressing in your setting? For instance, the economic evaluation may have been commissioned to examine the perspective of a particular funding agency, but you may be interested in a societal perspective and the broader outcomes which would not have been included in the analysis. • Have the strengths and limitations of the economic evaluation been outlined, and do they give you confidence to apply the findings to your settings? As noted in the 'Application of this checklist' section, there is not necessarily one 'correct' method or decision rule to apply to economic evaluations. While the above questions are important to consider before you apply findings from one context or setting to your own, it is also possible that some of the questions may be of greater/lesser importance to you. Use the above questions in this step as a guide and, regardless of whether your responses to the questions are favourable or mixed, consider all factors broadly when making decisions about the application of findings to your context or setting.	○ Yes ○ No ○ Unsure/Insufficient ○ Not applicable User notes

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Appendix A

Worked example of the checklist

Cost effectiveness of a statewide public health intervention to reduce disease risk*

The Colorado Heart Healthy Solutions was an intervention developed in the state of Colorado, USA that involved deploying community health workers (CHWs) to address cardiovascular risk. The CHWs were based in churches, local businesses, homeless shelters and public health clinics, and with the aid of a screening and decision support tool, screened individuals for cardiovascular risk. Where relevant, CHWs provided medical referrals and lifestyle modification support. Attached is a copy of the modelled economic evaluation that was conducted of the intervention.

In this Appendix we provide a copy of the study and then review it using the *Reviewing Economic Evaluations Checklist*. Note, our assessment of the study has replaced the explanatory text in this example.

Smith et al. BMC Public Health (2019) 19:1234
https://doi.org/10.1186/s12889-019-7573-8

BMC Public Health

RESEARCH ARTICLE Open Access

Cost-effectiveness of a statewide public health intervention to reduce cardiovascular disease risk

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Abstract

Background: The cost-effectiveness of community health worker (CHW)-based cardiovascular disease (CVD) risk-reduction interventions is not well established. Colorado Heart Healthy Solutions is a CHW-based intervention designed to reduce modifiable CVD risk factors. This program has previously demonstrated success, but the cost-effectiveness is unknown. CHW-based interventions are potentially attractive complements to healthcare delivery because laypersons implement the intervention at a lower cost relative to medical care and may be attractive in rural settings with limited clinical resources.

Methods: CHWs performed screenings and provided ongoing participant support within predominantly rural communities. A point-of-service software tool was used to generate 10-year Framingham CVD risk scores and assist CHWs to make medical referrals and provide ongoing individualized support for lifestyle changes. A sample of program participants returned for reassessment of risk factors. We calculated quality-adjusted life years (QALYs) gained and program costs using a Markov model. Transition probabilities were calculated using Framingham risk equations or derived from the literature using the observed mean reduction in 10-year CVD risk score over of 37-months follow-up. Program cost-effectiveness was calculated for both at-risk (abnormal baseline CVD risk factors) and overall program populations.

Results: The base-case scenario evaluating a 52-year-old male participant revealed an incremental cost savings of $3576 and a gain of 0.16 QALYs associated with the intervention. Cost savings were greater in at-risk populations. The economic dominance of the model was robust in multiple sensitivity analyses.

Conclusions: A community-based CVD intervention demonstrated to reduce CVD risk is cost-effective. This suggests that population-based public health programs may have the potential to complement primary care preventative services to improve health and reduce the burden of traditional medical care.

Background

Cardiovascular disease (CVD) is the leading cause of morbidity and mortality in the United States, with approximately 1 in 3 deaths and 15% of U.S. health expenditures in 2011 attributed to CVD [1]. Much of the incidence is attributable to modifiable lifestyle risk factors, with one study estimating that potentially modifiable risk factors account for over 90% of population attributable risk of myocardial infarction [2]. However, interventions addressing lifestyle risk factors, such as promotion of smoking cessation, physical activity programs, and targeting dietary changes, have shown limited effectiveness [3, 4]. A systematic review found mixed effectiveness and small effect sizes in such interventions, though the impact would be potentially substantial at larger population levels [4].

One approach to improving lifestyle and CVD risk factors is the use of community health workers, in which laypersons are trained to implement disease-specific health coaching interventions. Evidence of the effectiveness of community health worker (CHW)-based interventions has been mixed [5–7]. A recent systematic review, however, found community health worker-based interventions to be effective in improving health among

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vulnerable individuals with chronic disease [8]. Of the 26 studies reviewed that targeted cardiovascular disease, 60% were found to decrease risk factor burden. Information on the cost-effectiveness of CHW-based interventions remains limited, particularly among studies focused on CVD risk reduction. The key effects in successful studies were improvements in lipid profile, blood pressure, hemoglobin A1C and global CVD risk. Despite the dearth of cost-effectiveness studies, CHW-based interventions may augment healthcare delivery by providing ongoing support outside of the confines of the clinic. This may be particularly important in rural areas where geographic and financial barriers limit ongoing preventive care. There is some evidence that a community health worker-based intervention is cost-effective in controlling diabetes [9].

Colorado Heart Healthy Solutions, a CHW-based intervention was previously demonstrated to reduce global cardiovascular disease risk among vulnerable individuals [10]. Although there is an extensive literature regarding the cost effectiveness of healthcare interventions, less is known about the cost effectiveness of population health programs. Because hospitals and accountable care organizations are beginning to accept financial risk for the health of large populations of patients, there is new momentum for the development of public health-clinical care delivery models that aim to reduce preventable illness [11]. Given this background, we sought to determine the cost-effectiveness of Colorado Heart Healthy Solutions in reducing CVD burden by assessing program costs and projected reductions in CVD events.

Methods

Intervention and sample

Recruitment sites include churches, local businesses, homeless shelters, and local public health clinics. Health screenings are performed on-site, and include blood pressure, weight, height, and point-of-service cholesterol and diabetes screenings (Cholestech, Inverness Medical, Hayward CA) [10]. This information, combined with targeted CVD health history, access to care, diet and physical activity data, is input into a central data support module, the Outreach Screening and Referral (OSCAR) system. OSCAR is a screening and decision support tool (CPC Community Health, Aurora CO) used to generate 10-year CVD risk scores and provide cues for appropriate healthcare referrals, incorporating national guidelines based upon participant's risk factors. The OSCAR system is tablet based and synchronizes to a master database using a web server to provide access to screening results and reporting. CHWs create action plans with individual participants and based upon CVD risk, initiate medical referrals, provide smoking cessation aids, and navigate interested individuals into nutritional and exercise programs. Subsequently, CHWs schedule follow-up calls for ongoing participant support to ensure follow-through with health-promotion action plans. Participants were reminded to return, > 3 months following the initial screening for retesting.

A total of 698 individuals received the intervention. Colorado Heart Healthy Solutions led to a 0.8% reduction Framingham Risk Score among the overall population and a 2.0% Framingham Risk Score reduction among at-risk individuals, defined as those participants with elevated baseline risk factor values upon initial screening [10].

Analysis

A Markov model was constructed to calculate costs and outcomes. We used a cost-utility analysis, comparing quality-adjusted life years (QALYs) gained to the net costs. The Markov model includes seven mutually exclusive states: normal health, acute myocardial infarction (MI), post-MI, stroke (ischemic and hemorrhagic), post-stroke, congestive heart failure (CHF), and death (Fig. 1). All participants begin in normal health state, and then move through the model based on transition probabilities calculated from their risk factors. If an acute event (MI or stroke) occurs, the subject can move either to a post-event state or death. Subjects cannot return to a healthy state following an adverse event. Because MI is the leading cause of CHF in the US [1], a subject can also move from the healthy and post-MI states to the CHF state. If the individual moves to the CHF state, they remain in this state until death. Additionally, subjects can move from the normal health state directly to death, due to non-cardiovascular related mortality. The cycle length is 1 year, and the time horizon is 30 years. The comparison to the Colorado Heart Healthy Solutions intervention was to those not receiving the intervention, which assumes that individuals receive standard medical care and progress between health states based on the probabilities given in the Framingham study (described below).

Model inputs: transition probabilities

Transition probabilities were calculated using risk estimates based on the Framingham Heart Study, which were converted to one-year event probabilities [12, 13]. The model's risk factors were populated from Colorado Heart Healthy Solutions participants screened between February 2010 and June 2015. Only participants who had full test/retest values available were included (n = 698). We defined at-risk participants as any individual with an uncontrolled risk factor or having a Framingham Risk Score of 10% or greater.

Risk factors used to calculate the transition probabilities into and out of the health states described

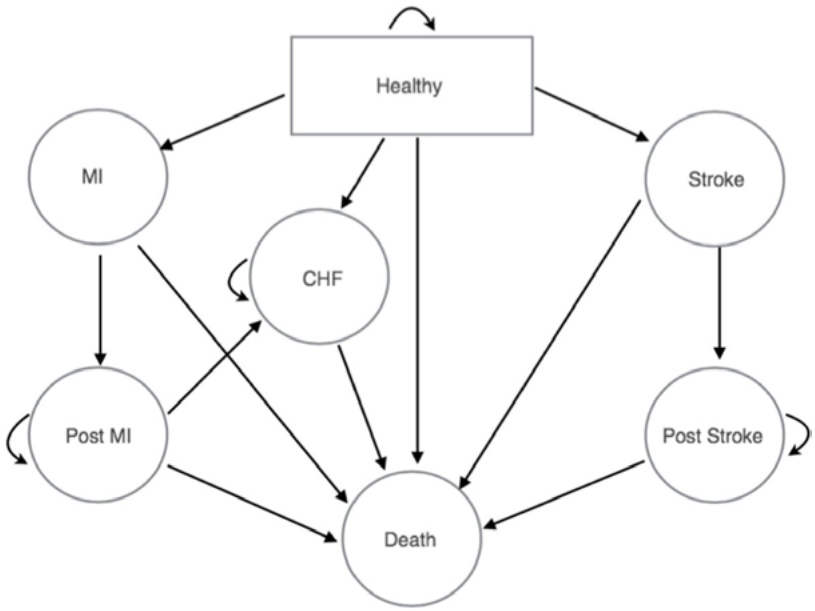

Fig. 1 Markov model. All patients start in the healthy state and can transition to myocardial infarction (MI), stroke, or congestive heart failure (CHF) states. Subsequent transitions are indicated by arrows. Model cycles on a one-year timeframe

previously include age, sex, systolic blood pressure, total cholesterol, high-density lipoprotein cholesterol, diabetes status and smoking status. Left ventricular hypertrophy and valvular heart disease status were not available in the dataset, so participants were assumed to be without these diseases in the main analysis. Transition probability calculations based on the Framingham Heart Study were used [18]. Recurrent CVD events are not used because these events in those with incident (new) CVD are relatively low in contemporary practice.

All risk factors were held constant, other than age, which increased yearly. Transition probabilities from the healthy state to each of the adverse outcome states were calculated for each year of age, as aging substantially modifies global CVD risk. An age-specific calibration factor was subsequently applied to bring the model's incidence rates in line with expected rates. The calibration factor was determined by age group, using published incidence rates for each CVD event outcomes [14]. The published incidence rates were divided by the observed incidence rates calculated by the model. This number was rounded down to the nearest whole number to provide a conservative calculation of expected incidence rates. Transition probabilities for other event outcomes in the model were drawn from a review of the literature (see Table 1).

Model inputs: costs

Costs were calculated by summing program costs and costs associated with adverse events (see Table 1). These values were used to calculate incremental costs and benefits for analysis. Costs were calculated in 2015 U.S. Dollars, and discounted at a rate of 3%. Costs for acute events (stroke and MI) occur once, while costs for continuous event states (post-MI, post-stroke and CHF) were applied annually. For deaths associated with an acute cardiac event, a value consisting of a weighted average of costs associated with fatal MI, ischemic and hemorrhagic stroke was applied. Program costs represented a year's cost for program operation. These costs include staff time for program directors and managers, infrastructure costs associated with hosting and maintaining the OSCAR system, and other expenses, such as travel costs, educational materials, and testing supplies. Site-specific costs were included in the total program costs. A sample budget for an individual site is provided in Table 2 and includes both site-specific costs and costs for program services that span multiple sites. The overall program costs were divided by the number of clients served in fiscal year 2015, creating a cost per-client, per-year of $126.95. This value was applied to the Colorado Heart Healthy Solutions intervention group for the first 2 years of the model, assuming the average participant would be enrolled for 2 years. To account for potential bias created by including only participants with both test and retest screening data, an intention-to-treat approach was taken. The cost per-client, per-year figure was applied twice in the first year of the model to account costs associated with participants who were screened but excluded from the analysis data set due to not having returned for follow-up or having missing values. The societal perspective was used in this analysis.

Table 1 Input Parameters

Parameter	Base Case Value	Range	Reference
Variable Input parameters			
Transition Probabilities			
Healthy to Stroke	Calculated by age and sex	–	[12]
Healthy to MI	Calculated by age and sex	–	[12]
Healthy to CHF	Calculated by age and sex	–	[13]
Healthy to Death	Varies by age and sex	–	[15]
Invariable Input parameters			
Transition Probabilities			
Acute MI to Death	0.071328306	0.057–0.086	[16]
Acute MI to Post-MI	0.928671694	–	Calculated
Post-MI to CHF	0.021759765	0.017–0.026	[16]
Post-MI to Death	0.028583536	0.023–0.034	[16]
Remain in Post-MI	0.9496567	–	Calculated
Stroke to Death	0.069	0.055–0.083	[17]
Stroke to Post-Stroke	0.931	–	Calculated
Post-Stroke to Death	0.236	0.189–0.283	[17]
Remain in Post-Stroke	0.236	–	Calculated
CHF to Death	0.43	0.344–0.516	[18]
Remain in CHF	0.57	–	Calculated
Costs ($)[a]			
Program Costs	127	102–152	Calculated
Stroke (once)	33,216	26,573-39,859	[19]
Post-Stroke (annually)	32,550	26,040-39,060	[20]
MI (once)	63,791	51,032–76-549	[21]
Post-MI (annually)	4106	3285-4927	[22]
CHF (annually)	13,619	10,895 – 16,342	[23]
Death	15,020	12,016-15,020	[21]
Utilities			
Stroke	0.64	0.512–0.768	[24]
Post-Stroke	0.66	0.528–0.792	[24]
MI	0.7	0.56–0.84	[25]
Post-MI	0.88	0.704–0.95	[26]
CHF	0.71	0.568–0.852	[27]

Costs represented in 2015 U.S. Dollars

Model inputs: utilities

Quality adjusted life-years (QALYs) were calculated using utility data drawn from the literature (Table 1). QALYs are a standard measure of health used in health economics; QALYs are a continuous measure ranging from 1 (which represents full health) to 0 (which typically represents death). The "disutility value" represents the decline in health associated with the state. Total QALYs were calculated by multiplying the length of time spent in the health state by the utility value associated with each state. Future QALYs were discounted at the same discount rate as the costs.

Analyses

In all analyses, risk factors were calculated from sample averages of participants' initial screening values (i.e., the parameters in the model). The primary analysis included both the overall population and at-risk populations. Values from the initial screening were used for analysis of the no-intervention group. The values used to represent the treatment scenario were the final re-screening

Table 2 Program Costs

Program Costs	
Staffing Salary	
Program Director	31,934
Medical Director	30,019
Senior Program Manager	79,334
Associate Program Manager	31,380
Infrastructure	
Maintenance of OSCAR data system	22,142
Hosting OSCAR	28,000
General Costs	
Travel	7828
Community Health Worker Training	8985
Testing Supplies	78,264
Educational Materials	19,398
Postage	922
Site Costs (Sample Budget)	
Staffing Salary	
Community Health Worker	32,854
Supervisor	5265
Walking Club Coordinator	2335
Pass-Through Costs	
Travel for trainings and screenings/retests	2598
Cell Phone	600
Office/Medical Supplies	600
Walking Club Supplies	500
Postage/Shipping	360
Promotion/Printing	400
Indirect costs	
Indirect Rate (10%)	4551
Site Total	50,063
Total Cost Per Client Per Year	126.95

values of Colorado Heart Healthy Solutions participants following intervention. It was assumed that participants that received initial screening but did not return for follow-up received no health benefits from the screening. Secondary analysis was also performed using screening values from only the at-risk population [10]. See Table 3 for an overview of the values utilized for each scenario stratified by gender.

In a series of one-way sensitivity analyses, the assumptions of the model were individually tested to determine if the model outputs were sensitive to any of the parameters. Transition probabilities, utilities, costs and discount values were varied one at a time. In the main analysis, the treatment effect was held constant for the length of the model. To determine the timeframe that the treatment effect must last for the program to break even, an analysis was performed in which the persistence of the treatment effect varied. In this analysis, after the treatment effect expired, the transition probabilities for adverse events in the treatment group became equal to those of the no intervention group. The year in which the treatment effect expired was varied, starting with a persistence length of 2 years (the length of program participation). The discount rate was varied from 0 to 6%. The baseline total cholesterol level was varied between 185 and 205 mg/dL. The cycle year when the incremental costs were closest to zero, while still being cost saving, was identified. This scenario analysis determined the impact the persistence of the treatment effect had on the outcome of the model. The break-even analysis calculated how long the treatment effect must persist for the program to break even for males and females.

Finally, return on investment was calculated, which was defined as the net returns from the program divided by the investment in the program [28] where the incremental costs of the model were divided by the program costs for the first 2 years.

Results

Base case results

In the base case of a 52-year-old male participant, individuals in the Colorado Heart Healthy Solutions intervention had lower estimated discounted total costs ($26,538) than the comparison scenario of no intervention, in which the baseline risk factors did not change ($30,114). Overall, total spending, including both increases in spending due to the program costs ($366) and reductions in spending due to averted medical care costs ($3942), were approximately $3576 less for the Colorado Heart Healthy Solutions intervention than for the comparison scenario.

Participants in the program had 15.53 QALYs, while the comparison scenario yielded 15.37 QALYs, for a gain of 0.16 QALYs. With both lower costs and a positive incremental QALY gained, the Colorado Heart Healthy Solutions strategy was dominant for males. Similarly, for the 52-year-old female base case, Colorado Heart Healthy Solutions showed discounted total costs of $19,570 and 16.04 QALYs. The comparison scenario of no intervention showed discounted costs of $21,458 and 15.95 QALYs. The incremental cost savings of Colorado Heart Healthy Solutions were $1889, with 0.08 QALYs gained.

At-risk population results

The analysis was then estimated using a scenario of a 52-year-old male considered at-risk for developing CVD. Among at-risk participants, Colorado Heart Healthy Solutions had total discounted costs of $27,305 and 15.49 QALYs. In the comparison scenario, the resulting

Table 3 Base Case and At-Risk Scenario Analyses

Parameter	Base Case Male		Base Case Female		At-Risk Male		At-Risk Female	
	Standard	CHHS	Standard	CHHS	Standard	CHHS	Standard	CHHS
Age	52	52	52	52	52	52	52	52
Baseline systolic BP, mm HG	131	128	125	123	134	129	131	127
Total Cholesterol	195	189	199	195	199	191	207	200
HDL cholesterol	41	44	53	55	40	44	51	53
Heart Rate	80	80	80	80	80	80	80	80
Smoke	No	No	No	No	No	No	No	No
Diabetes	No	No	No	No	No	No	No	No
CVD	No	No	No	No	No	No	No	No
LVH	No	No	No	No	No	No	No	No
Valvular Disease	No	No	No	No	No	No	No	No
Total Costs ($)[a]	30,114	26,538	21,458	19,570	33,002	27,305	27,401	16,923
Total QALYs	15.37	15.53	15.95	16.04	15.24	15.49	15.65	16.01
Incremental Cost ($)[b]	-3576		-1889		−5697		−10,478	
Incremental QALYs[c]	0.16		0.08		0.26		0.36	
ROI[d]	9.39		4.96		14.96		27.51	

Costs represented in 2015 U.S. Dollars b Incremental cost represents cost of Colorado Heart Healthy Solutions intervention minus cost of no intervention c Incremental QALYs represent QALYs associated with Colorado Heart Healthy Solutions intervention minus QALYs of no intervention d Return on investment represents net returns of the program divided by investment in program costs

discounted costs were $33,002 and 15.24 QALYs yielding an incremental cost savings of $5697, and incremental effectiveness of 0.26 QALYs gained. For the at-risk 52-year-old female scenario, Colorado Heart Healthy Solutions had total discounted costs of $16,923 and 16.01 QALYs. Without intervention, the at-risk female scenario resulted in discounted costs of $27, 401 and 15.65 QALYs. The incremental cost of Colorado Heart Healthy Solutions was a savings of $10, 478 and the incremental effectiveness was 0.36 QALYs gained.

One-way sensitivity and break-even analyses

All one-way sensitivity analyses continued to show Colorado Heart Healthy Solutions as dominant over the comparison scenario for all inputs. Smoking cessation, discount rate, and baseline total cholesterol level had the largest influence on the incremental cost of the intervention. For the incremental benefits, smoking cessation, discount rate, and smoking status had the largest impacts on the model. Smoking cessation created cost savings of $28,317 and created 1.26 QALYs. Varying the discount rate from 0 to 6% resulted in a range of cost savings from $6034 to $2230, and generated QALYs from .29 to .09. Varying the baseline total cholesterol level between 185 and 205 mg/dL created a range of cost savings from $1310 to $3741. None of the input variations changed the outcome from cost saving to cost spending, nor did they cause the benefits to change from creating QALYs to losing QALYs.

The break-even analysis showed that in the base case male scenario, the treatment effect must persist for 4 years for the program to break even. In the base case female scenario, the treatment effect must persist for 6 years. In the at-risk scenarios, the break-even point was 3 years for the male group and 2 years for the female group.

Return on investment

The return on investment calculations for the base case male scenario showed an ROI of 9.39.

In the base case female scenario, the ROI was 4.96. The at-risk male scenario had an ROI of 14.96, and the at-risk female scenario showed an ROI of 27.51.

Conclusions

Colorado Heart Healthy Solutions has been previously shown to be effective in reducing risk factors associated with global cardiovascular disease risk [10]. To our knowledge, this is the first study demonstrating that a public health program was a cost-effective method of reducing CVD risk. We found that Colorado Heart Healthy Solutions is a cost-effective strategy, which generated cost savings through averted CVD events and suggests that community-based programs may have a role improving population health beyond traditional healthcare delivery.

The models showed small gains in QALYs, but combined with the incremental cost savings of the program, the program was dominant compared with no

intervention. In the base case of a 52-year-old male participant with standard risk factors, the intervention was associated with a cost savings of $3576 and a gain of 0.16 QALYs. For a female participant of the same age with average risk factors, participation was associated with a cost savings of $1889 and a gain of 0.08 QALYs. This gender difference was expected due to the lower overall cardiovascular disease risk among women; a lower starting risk translates into less overall benefit. While there is a smaller incremental cost/benefit among female participants, the program is still cost-effective. As expected, program impact and cost-effectiveness was magnified among at-risk populations. For a 52-year-old male determined to be at-risk for cardiovascular disease, the program was associated with cost savings of $5697 and generated 0.26 QALYs. For a woman of the same age who is at-risk, the intervention saved $10,478 and had an incremental benefit of 0.36 QALYs gained.

Discussion

This study provides evidence supporting the cost-effectiveness of community health worker-based interventions. Previous studies of CHW-based interventions have provided insufficient evidence regarding cost-effectiveness, and limit comparison to other intervention types [7]. By providing incremental cost and benefit information, this study adds to the literature regarding the feasibility of implementing CHW-based interventions for reducing CVD risk.

The study has several important limitations. First, the Markov model does not include recurrent CVD events. A patient was assumed to experience a single stroke or MI, which may have led to underestimating total outcome events and cost savings of the program. We attempted to address this issue by applying age-specific calibration factors to the model to bring the number of observed outcomes closer to published incidence rates. The model may still have underestimated the number of events, as calibration factors used were conservative. This would likely minimize the observed effect, making the program potentially more effective. Second, our model held CVD risk factors constant over time. The transition probabilities were recalculated by age, but systolic blood pressure, total cholesterol and high-density lipoprotein cholesterol were held constant, even though risk factors generally worsen over time given expected temporal increases in body mass index. Our model did not account for additional prescription drug costs that a program participant might incur. We performed a scenario analysis in which a cost of $100 per year was applied to the treatment group for the life of the model, to account for additional prescription drug costs given widespread availability of generic lipid-lowering and anti-hypertensive drugs. In the base case male scenario, the program realized a cost savings of $1616, a difference of $1960 in cost savings from the primary analysis. However, the program remains cost saving, even with the prescription drug costs included. Arguably, the base case could have included the prescription drug costs, however the conclusions of the study would not change. Third, in a controlled setting such as this study, it is possible there could have been an improvement in the unobserved control arm due to secular trends. Fourth, the model used calculations based on the Framingham Heart Study instead of the newer atherosclerotic cardiovascular disease (ASCVD) Risk Estimates [29], as the OSCAR system was developed prior to this formula being published. Finally, the cost of office space was not available to the research team and is not included. Also, although this study takes a societal perspective, given the inputs and costs included in the model, the results are very similar to results from a payer perspective.

One distinguishing feature of the program is the repeated follow-ups performed by CHWs, which served to reinforce the intervention, effectuate behavior change, and have previously been shown in multi-variable analysis to be associated with greater improvements in CVD risk [10]. While data are not available on long-term persistence of the interventions effect on risk-factor control, the break-even analysis showed that the intervention effect does not need to persist very long after the intervention for the program to be cost neutral, particularly among at-risk participants.

Programs such as the one reported herein have faced several obstacles to widespread adoption. One obstacle is a lack of evidence about not just about effectiveness, but also about cost effectiveness. We show that a population-based prevention program can be cost saving from the societal perspective, with even greater savings if the program is targeted toward high risk populations. A second obstacle is a payment system that rewards volume rather than value. As the health system transitions toward value-based rewards for healthcare systems, interest in ways to promote health will become important. Evidence of the type presented here may encourage more widespread adoption of community-based prevention programs.

Conclusions

We find that the use of community health workers to improve lifestyle and reduce CVD risk factors both increases quality adjusted life years and reduces net spending. Savings are dependent on both age and gender, with incremental cost savings of $3576 for a 52-year-old man and $1889 for a woman of the same age. This suggests that population based health programs have the potential to complement primary care preventative services and both improve health and reduce total medical care costs.

Abbreviations
BP: Blood pressure; CHF: Congestive heart failure; CHW: Community health worker; CVD: Cardiovascular disease; HDL: High-density lipoprotein; LVH: Left ventricular hypertrophy; MI: Acute myocardial infarction; OSCAR: Outreach Screening and Referral; QALY: Quality-adjusted life years; ROI: Return on investment

Acknowledgements
We thank the community health workers for their dedicated service implementing the program in Colorado Communities.

Authors' contributions
LS performed the analysis and drafted the manuscript. AA, JC and MK aided in the Conception and design of analysis and critically revised the manuscript. NF and SC aided in analysis and implications. All authors have read and approved the manuscript.

Funding
This project was funded by Caring for Colorado. The funding body played no role in the design of the study and collection, analysis, interpretation of data and in writing the manuscript.

Availability of data and materials
The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Ethics approval and consent to participate
This project was approved by the University of Colorado Institutional Review Board.

Consent for publication
Not applicable

Competing interests
The authors declare that they have no competing interests.

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Received: 25 September 2018 Accepted: 30 August 2019
Published online: 06 September 2019

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Publisher's Note

Step	Review questions	Answers
1.	**Does the economic evaluation state a well-defined objective?** The stated objective was to determine the cost-effectiveness of Colorado Heart Healthy Solutions, a community health worker (CHW) intervention, compared to standard care, from a societal perspective. The intervention was offered statewide in Colorado (USA) to the general population but was predominantly targeted at rural communities. Costs considered included program costs as well as costs associated with adverse events (e.g. costs associated with stroke, post-stroke, myocardial infarction (MI), congestive heart failure (CHF), death). The outcome considered was QALYs gained. The time horizon for analysis was 30 years.	◉ Yes ○ No ○ Unsure/Insufficient
2.	**Is the perspective of the analysis clearly stated and appropriate?** (e.g. societal, health sector, individual payer) The analysis was stated as having a **societal perspective**. However, it is not clear that the study includes costs and outcomes that occur beyond the health sector. The costs that were included were those involved in developing and running the intervention, and the long-term costs of health care associated with hospitalisations due to cardiovascular events. A societal perspective would include non-health sector costs and outcomes such as productivity gains to the community. There is an item 'indirect costs' (in Table 2) which is a term sometimes used to refer to productivity losses, but it is unclear whether this refers to societal costs in this case. Since Table 2 is based on financial statements from a sample site it is more likely to be an accounting adjustment as no details are given about this item. It seems more accurate to describe this study as having a health sector perspective.	○ Yes ◉ No ○ Unsure/Insufficient
3.	**Does the economic evaluation include strong evidence of the initiative's effectiveness?** The effectiveness of the intervention was established from a **previously published intervention study** in which estimates of improvement in cardiovascular risk (based on Framingham Risk Scores) were determined through a before-and-after design. Krantz MJ, Coronel SM, Whitley EM, Dale R, Yost J, Estacio RO. Effectiveness of a community health worker cardiovascular risk reduction program in public health and health care settings. *Am J Public Health* 2013; 103(1): e19-27. doi: 10.2105/AJPH.2012.301068. Epub 2012 Nov 15.	◉ Yes ○ No ○ Unsure/Insufficient
4.	**Is a description of the initiative and the comparator clearly stated and appropriate?** The initiative is a CHW-based initiative. CHWs were hired locally and trained on a standard curriculum, which included motivational interview techniques. Recruitment of participants occurred at churches, local businesses, homeless shelters and local public health clinics. Health screenings were performed on site and included blood pressure, weight, height, cholesterol, and diabetes screenings. Information was inserted in a screening and decision support tool that generated a 10-year cardiovascular disease (CVD) risk score and provided cues for action at the point-of-service based on the person's risk score. CHWs created action plans with individuals based on their CVD risk, including initiation of medical referrals, provision of smoking cessation aids, and navigation of individuals into nutritional and exercise programs. CHWs then scheduled follow-up calls to provide ongoing support to participants. Participants were reminded to return after 3 months following the initial screening for retesting. Whilst there was a good description given of the intervention, limited information was provided regarding the comparator. Part of the reason for this was that the intervention study on which this evaluation was based was a before and after study, without a control group and as such the care received by participants in the absence of this intervention was not explicitly defined.	○ Yes ○ No ◉ Unsure/Insufficient
5.	**Is the time horizon selected for the analysis clearly stated and appropriate?** The time horizon was **30 years** which involved extrapolating from the timeframe of the original study (2 years) through the development of a Markov model (used to calculate costs and outcomes). This is appropriate because the 2 years of the original study would not have been enough time to manifest the impact of the intervention in terms of improvements in cardiovascular risk on survival, quality of life and costs of the intervention.	◉ Yes ○ No ○ Unsure/Insufficient

Step	Review questions	Answers
6.	**Is the target group selected for the analysis clearly stated and appropriate?** The target group for the analysis is people who received the intervention between February 2010 and June 2015. It evaluated the impact on both the entire population and a subgroup of high-risk individuals. High-risk individuals were defined as people with abnormal baseline CVD risk factors.	◉ Yes ○ No ○ Unsure/Insufficient
7.	**Is the economic evaluation method selected clearly stated and appropriate?** The authors mostly use the generic term 'cost-effectiveness analysis' (this can also be referred to as a 'cost-utility analysis' due to the use of QALYs as an outcome measure). The method was appropriate as the health implications of preventing cardiovascular events (such as stroke, CHF and MI) are reflected in not only survival but quality of life.	◉ Yes ○ No ○ Unsure/Insufficient What economic evaluation method was selected? ○ CBA ○ CUA ◉ CEA ○ CCA ○ CMA ○ Other/multiple:
8.	**Are all the relevant costs and outcomes for the initiatives identified?** The constructed Markov model predicted individuals' costs and outcomes over time as they transition each year through different health states (e.g. normal health, acute MI, post-MI, stroke, post-stroke, CHF, death). The probability of transition between these different health states was based on evidence drawn from the literature. The estimates of outcomes from the intervention were based on the quality of life associated with each of the health states (drawn from the literature) and survival, as determined by the probability of death. Costs include program costs (such as salaries, technological infrastructure, travel, training, testing supplies, educational materials, site costs, office costs and assumed indirect costs) and cost of each health state (acute MI, post-MI, stroke, post-stroke, CHF, death) through which each individual transitions over the time duration of the model.	◉ Yes ○ No ○ Unsure/Insufficient
9.	**Are costs measured in appropriate units and valued accurately?** Program costs included staff, infrastructure and supplies identified through program data. Cost offsets associated with disease events (stroke, post-stroke survival, MI, post-MI survival and CHF) were factored into the Markov model based on the estimates drawn from the literature. Costs were valued at 2015 $USD.	◉ Yes ○ No ○ Unsure/Insufficient
10.	**Are outcomes measured in appropriate units and valued accurately?** The outcome was measured in QALYs and was based on utility data and survival estimates derived from the literature. These were ascertained for modelled disease events (stroke, post-stroke survival, MI, post-MI survival and CHF) and, using a Markov model, extrapolated over a 30 year timeframe for both the intervention cohort and comparator group based on initial observed improvement in cardiovascular risk.	◉ Yes ○ No ○ Unsure/Insufficient
11.	**Does the economic evaluation adequately account for equity considerations?** The economic evaluation to some extent accounts for equity considerations as it undertook a **subgroup analysis** of high-risk individuals. It could also be argued that the overall population targeted were relatively disadvantaged. However, there was no explicit account given of equity in the analysis. In addition, due to this study and intervention taking place in the United States, it does not include any equity considerations specific to the Australian or NSW context.	○ Yes ○ No ◉ Unsure/Insufficient ○ Not applicable

Step	Review questions	Answers
12.	**Are adjustments made for costs and outcomes that occur in the future using a discount rate?** The discount rate was 3% and applied to costs and QALYs occurring after one year. The discount rate was varied from 0 to 6%.	(•) Yes ( ) No ( ) Unsure/Insufficient
13.	**Has an incremental analysis of costs and outcomes of initiatives been performed?** The base-case scenario revealed an incremental cost saving of USD$3,576 and a gain of 0.16 QALYs associated with the intervention. In other words, the intervention was found to be 'dominant' – the intervention is both effective and cost-saving (benefits of the intervention outweighed the costs). Cost savings were greater in at-risk populations. However, it may be challenging to apply this conclusion more widely due to the comparator not being defined in detail.	( ) Yes ( ) No (•) Unsure/Insufficient
14.	**Is uncertainty in the estimates of costs and outcomes adequately taken into account?** Sensitivity analyses were undertaken on: • transition probabilities from a healthy state to an adverse outcome • utilities or the 'disability weight' used to calculate the QALYs • costs • discount rates Smoking status, discount rates and baseline total cholesterol level had the largest impacts on the model. None of the input variations changed the outcome from being cost saving or having positive incremental QALYs.	(•) Yes ( ) No ( ) Unsure/Insufficient
15.	***(For reviews of economic evaluations found in peer-reviewed journal articles and grey literature)*** **Are the findings from the economic evaluation translatable to your context or setting?** Below are a few considerations worth noting regarding this intervention as a worked example: • The intervention may not be completely generalisable as it was conducted in the US health system. • Resource implications in implementing a NSW-based initiative vary from this study, given how the NSW health system is organised, differing cost structures and local epidemiology. • There are some limitations with this study, as the Markov model doesn't include recurrent events and thus provides a potentially conservative estimate of the cost savings and health gains from the intervention.	( ) Yes ( ) No (•) Unsure/Insufficient

Appendix B

Evaluation perspectives

When performing an economic evaluation, consideration needs to be given to the perspective for the study. This will be informed by the underlying policy or investment decision that the economic evaluation aims to address for the end user. For instance, if the study is commissioned by State Government they may only be interested in an 'individual payer perspective' in which the only relevant costs are those incurred by them.

Costs and outcomes for different perspectives		
Individual payer	**Health sector**	**Societal**
Only includes costs and outcomes relevant to a particular agency (e.g. State Treasury, State Ministry of Health, Medicare or a private insurer). Examples of items that could be costed using this perspective include: • drugs • medical devices • procedures • equipment • facilities • staff • organisational overhead costs. Examples of outcomes that may be included using this perspective include individual health outcomes and reduced usage of other services provided by the agency as a result of improved health outcomes (e.g. reduced length of hospital stays).	Costs and outcomes incurred across the entire health sector irrespective of the agency to which they incur. For instance, an early hospital discharge program that involves recovery at home supplemented by GP visits will incur costs to both the NSW Ministry of Health (hospital costs of initial hospitalisation) and Medicare (costs of GP visits). Both types of costs need to be counted when adopting a health sector perspective. A health sector perspective rather than individual payer perspective may provide more detail on whether an intervention is cost saving (i.e. genuinely uses less resources) rather than one that shifts costs between different payers such as levels of government (e.g. state government to Medicare). Using a health sector perspective, all costs and outcomes (irrespective of health sector agency) are included in the analysis.	Includes costs and outcomes incurred across all actors in society as a result of an intervention. This includes costs and outcomes within the health sector, as well as costs and outcomes in the wider community by individuals (e.g. workers, students) and organisations (e.g. employers, other government departments). Examples of non-health sector costs and outcomes include patient time spent for travel and receiving treatment, changes to productivity at work, work attendance, costs to employers to hire and train replacement workers, and costs and outcomes in other sectors (e.g. social services, criminal justice, and the voluntary sector). As in the previous example an argument for a societal perspective over a narrower health sector perspective is that the latter can fail to distinguish between a cost saving intervention from one that shifts costs from the health sector onto patients and the community. Using a societal perspective, all costs and outcomes, irrespective to whom they are incurred, count.