Cost-effectiveness ofTobacco Exercise and diet MEssages(TEXT ME), a text message-based intervention for secondary prevention of cardiovascular disease

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Abstract

Background: Cardiovascular disease (CVD) is the leading cause of lost years of healthy life and accounts for a substantial proportion of health care expenditure. Individual risk for cardiovascular events isinfluenced by health behaviours, and interventions which prompt positive behaviour change can be expected to ease the health and economic burden of CVD.

Objective: To estimate the cost-effectiveness of a secondary prevention programmedelivered via mobile phone text messages in an Australian context.

Design:Lifetime Markov model.

Data Sources: The effectiveness of the intervention has beenestablished through a randomised controlled trial. We used evidence from systematic reviews and meta-analyses to link changes in blood pressure, cholesterol levels and smoking statusto risk of future cardiovascular events.

Target Population: Individuals with a history of coronary heart disease (CHD) presenting to Australian hospitals.

Time Horizon: Lifetime.

Perspective: Health system.

Interventions: TEXT ME is a text-message based intervention designed to support CVD secondary prevention consisting of regular messages which provide advice, motivation, information and support to improve health-related behaviours.

Outcome Measures:Major vascular events (myocardial infarctions and strokes)avoided, quality-adjusted life years (QALYs) gained, costs to the health system, and the incremental cost per QALY gained.

Results of base-case analysis:For a target population of 50,000 patients withdocumentedCHD , and with risk factor changes seen in the TEXT ME trial replicated and then attenuated over 5 years,the intervention is expected to lead to 313fewermyocardial infarctions,230fewer strokes and441additional QALYs.Providing TEXT ME to this cohort is expected to cost the health system 1.7 million AUD. This cost, however, would be outweighed by the future cost-savings associated with fewer cardiovascular events and TEXT ME is expected is to lead to an overall saving of 4.6 million AUD for the health system.

Limitations: The effectiveness of TEXT ME was evaluated over 6 months and changes in risk factors observed at this time point needed to be extrapolated into the future. Changes in risk factors were linked to major vascular events based on evidence from elsewhere.

Conclusions: The provision of TEXT ME willlead to better health outcomes for a cost that is far below the willingness-to-pay for such improvements.

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Introduction

Cardiovascular disease (CVD), including coronary heart disease (CHD) and stroke are the leading causes of lost years of healthy life globally.(1) CVD is also associated with substantial economic burden that accounts for about 12 percent of health care expenditure in the European Union and 15 percent in the United States.(2, 3)In Australia, CVD is estimated to cause around a third of all deaths per year andaccount for around 11 percent of health care expenditure, with around half of this spent on hospital-admitted patients.(4, 5)

Smoking, physical inactivity and obesity increase the risk of developing CVD and of repeat cardiovascular events among patients with a history of CVD.(1) While adhering to behavioural recommendations improves health outcomes, (6) the prevalence of healthy behaviours among those with a history of CHD are low,(7) with poor knowledge of risk-factors also reported.(8)

Telehealth interventions arean effective means of delivering behavioural change-based secondary prevention programmes to patients with CVD,(9) and text-message based interventions can achieve behaviour change amongst other chronic disease populations.(10) This prompted the development of the Tobacco, Exercise and Diet Messages (TEXT ME) intervention for patients with CHD, with the messages developed based on behaviour change theory, national guidelines and input from health professionals.(11)TEXT ME has recently been assessed ina randomised controlled trial, where individuals with documented coronary heart disease were recruited through inpatient and outpatient cardiology services at a large tertiary referral centre in Sydney, Australia.(12, 13)

CVD prevention requires scalable approaches which have demonstrated clinical benefit and are affordable.(14) Moreover, all health interventions need to provide value, with benefits justifying the costs incurred.(15) The aim of this study is to estimate the potential scaled up and long-term benefits of the TEXT ME programme, and evaluate the value for money of the program if it was provided in Australia.

Methods

Target population

Based on the TEXT ME study eligibility criteria,(13) the target population for the intervention are individuals with documented CHD, defined as prior myocardial infarction, coronary artery bypass graft surgery, percutaneous coronary intervention or 50% or greater stenosis in at least 1 major epicardial vessel on coronary angiography, who are admitted to Australian public hospitals.For this analysis we considered the cost-effectiveness of the intervention if provided to a target population of 50,000 patients.

Setting and location

There are 728 public acute hospitals across Australia, which are funded by both state and territory governments and the Australian Government,(16) in which TEXT ME could be offered.

Study perspective

A health system perspective is taken, with only those costs being borne by the health system included in the analysis.

Comparators

TEXT ME consists of 4 text messagesvia short message service (SMS)per week for 24 weeks. The messages target multiple risk factors, and provide advice, motivation, information and support to improve health behaviours.(12) As TEXT ME is supplementary to usual care, we compare the costs and health outcomes associated with providing TEXT ME alongside usual care against those from providing usual care alone.

Time horizon

The costs and consequences associated with the provision of TEXT ME and usual care are estimated over the remaining lifetimes of the study population.

Discount rate

In line with guidelines for Australia,(17) both future costs and quality-adjusted life-years (QALYs) have been discounted by 3 percent annually.

Health outcomes

Quality-adjusted life-years (QALYs) are the primary measure of health benefit. By estimating health effects in terms of QALYs, which provide a measure of both quantity and quality of life, the value for money of providing TEXT ME can be compared against that of providing a wide range of interventions across the health system.(18)The number of major vascular eventsfor the cohort are also estimated under usual care and TEXT ME, with these divided into myocardial infarctions (MIs) and strokes.

Measurement of effectiveness

The effectiveness of TEXT ME on risk factor levels is based on the findings of the randomised controlled trial, where 710 participants were enrolled and randomised into receiving the intervention or usual care, and data were collected at baseline and after six months.In the base case analysis it is assumed that the differences in risk factors observed after six months, table 1, would steadily diminish until being entirely mitigated after 5 years.

Systematic reviews and meta-analyses have estimated the relative risk reductions for MI and strokes associated with changes in low-density lipoprotein cholesterol (LDL-C), systolic blood pressure (SBP) and smoking.(19-22)These estimates are used to link the changes in risk factors to health outcomes,see appendix 1, withthe relative risk reductions associated reduced by 25% over the first year to take into account an expected lag in intervention effects.

The risksfor major vascular events under usual care are based on the numbers of events observed in the control arms of randomised trials of LDL cholesterol-lowering statin therapies, with 2.1% and 1.3%risks of MI events observed annuallyfor men and women respectively and 0.8% both genders for strokes.(19)

The risk of deathfollowing major vascular events are based on age-specific survival rates reported for Australia,(23) while in the absence of an event the risk of death wasbased on Australian life tables (24). A risk of death of 1 was assumed if individuals reached 100 years old. These risks are assumed to be unaffected by whether individuals received the intervention or not.

Measurement and valuation of preference based outcomes

The quality-of-life of the study population was based on the trial of TEXT ME.(13) The SF-12 survey was undertaken at baseline and six months, with data collectors blinded to treatment assignment, and responses were transformed into SF-6D using the algorithm provided by Brazier et al.(25) Based on a review of quality-of-life scores reported in trials involving participants with cardiovascular disease, it is assumed that an MI or stroke would reduce quality of life by 20 percent for a six month period.(26)

Estimating resources and costs

The costs associated with the provision of the TEXT ME programme were estimated in consultation with the programme staff. They used their administrative records and experience from undertaking the trial to estimate the volume of resources required and the estimated market prices.As well as the cost of providing the intervention, costs due to health care utilisation are also incorporated. Primary care costs are based on records from the Medicare Benefits Schedule (MBS) and

Pharmaceutical Benefits Scheme (PBS), which contain records of primary care consultations and prescriptions respectively, of the trial participants in 2014. Meanwhile, hospital costs relating to major vascular eventsare based on the age- and gender-specific cost per hospital separation reported for Australia.(27)

Currency, price date, and conversion

All costs are reported in 2014 Australian dollars. Hospital costs relating to an MI or stroke are based on the age- and gender-specific cost per hospital separation reported for Australia for 2008-09,(27)and these were inflated to 2014 price levels. Primary care costs and intervention costs were estimated in 2014 prices.

Decision-analytic model

A lifetimeMarkov model is used to provide the framework for the analysis, as this allows for the extrapolation of trial results to the cohort of interest, risk factors to be linked to future health outcomes, and for a systematic consideration of uncertainty.(28) The model, shown in Figure 1, consists of five types of health state: history of CHD (coronary heart disease), MI (myocardial infarction), stroke, history of MI or strokeanddead. The model has a cycle length of six months. All participants begin in the history of CHD state and either remain there until death, or move to either of the MI or stroke states, after which they either die or move to the history of MI or stroke state, in which they would stay until death.

Quality-adjusted life-years (QALYs) are estimated using the time individuals in the cohort are expected to spend in each health state under TEXT ME and usual care multiplied by the quality-of-life associated with those states. Similarly, health care costs are calculated based on the time spent in each state and the costs associated with each state. The cost for the non-event states is equal to that of the expected primary care costs, while the cost associated with six months in the event states is made up of primary care costs and the cost of the event, given the individual's age and gender.

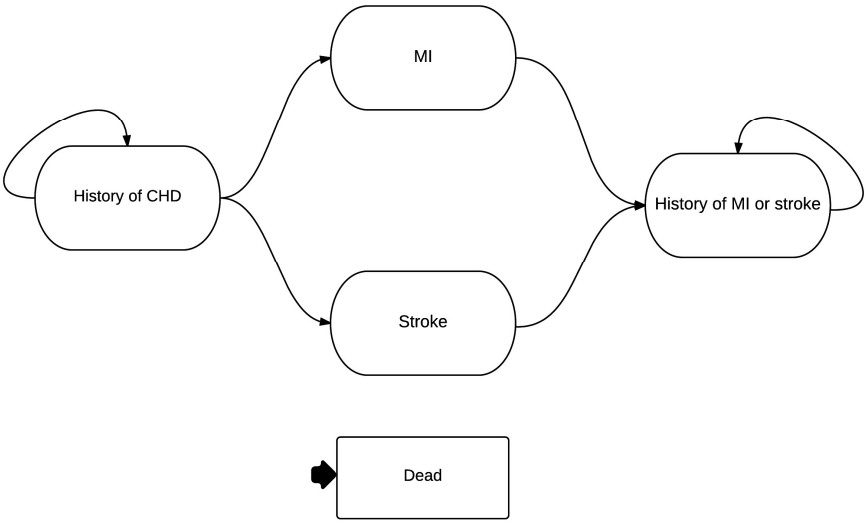

Figure 1. Overview of state-based Markov model (CHD: coronary heart disease, MI: myocardial infarction)

Modelling assumptions

The key simplifying assumption is that individuals can only have one of either aMI or a stroke, after which they move to and then remain in the history of secondary event state until death.

Analytical methods

Both the expected results and the uncertainty around such results are considered. Expected results are given where all parameters are held at their mean values and under baseline structural assumptions.

The timing over which an investment in TEXT ME would become cost-effective is considered using a net benefit curve.(29) This plots the expected net health benefit, which is equal to the expected change in health outcomes minus the change in costs divided by the cost-effectiveness threshold,(18) associated with providing the intervention over the time horizon of the analysis. The cost-effectiveness threshold used is $64,000, which has been estimated to be the willingness to pay for an additional QALY in Australia.(30) When net health benefit is positive it indicates that the intervention is cost-effective over the given time horizon, for example if net benefit is positive at 5 years this implies that the health benefits which accrue over these five years merit the costs incurred up to this point.

Parameter uncertainty is assessed using probabilistic sensitivity analysis, with parameters assigned probability distributions and 1,000 Monte Carlo simulations conducted. The sets of estimated costs and QALYs from each simulations are shown, alongside the expected results, on a cost-effectiveness plane.

Several tests are conductedon the sensitivity of results to changes in structural assumptions. First, intervention costs are increased and reduced by 50%. Second, relative risk reductions are mitigated after one and ten years rather than after five. Third, the risk of major vascular events is increased and reduced by 50%. And fourth, the estimated differences in risk factors are held at their high or low values from 95 percent confidence intervals.

Role of the funding source

None of the funders/sponsors had any role in the design and conduct of the study; collection, management, analysis, and interpretation of the data; preparation, review, or approval of the manuscript; and decision to submit the manuscript for publication.

Institutional review board

Patients provided written informed consent, and ethical approval was obtained from the Western Sydney Local Health Network Human Research Ethics Committee.

Results

Study parameters

The characteristics of the study population are detailed in table 1. Based on data from the trial of TEXT ME, 82% of the patients are expected to be male.Patients are expected to be aged 58 if male and 57 if female with an average SF-6D score of 0.73. Primary care and hospital care costs depend on age and gender, see appendix 2. When aged between 55 and 64 and male, for example, primary care utilisation is expected to cost $2,115 over six months, a stroke is expected to cost $21,312, and a MI $9,434.

The provision of TEXT ME is expected to lead to a reduction in LDL-C, SBP and smoking. For example, for women TEXT ME is associated with an expected reduction in SBP of 8.16 and 0.1 mmol/L for LDL-C, table 1. This can be expected to lead to an expected relative risk of 0.78 for MI and 0.7 for a stroke, see appendix 1, all else equal.

Delivering the intervention involves setting up IT servers and cloud space to manage the data at an expectedannual cost of $75,000.A project manager working full time and a clinical advisor spending a fifth of their time on the intervention would be required, and these are expected to be on salaries of $100,000and $50,000 respectively, both with 30% on-costs. Clinical staff are required to enrol

patients and this is expected to take 15 minutes per participant. Assuming clinical staff receive a salary of $100,000 with 30% on-costs and 4 weeks holiday, each 15 minute would cost $17 and enrolment of the entire cohort would cost $744,707. The expected cost of sending an SMS is $0.10, and with participants receiving 4 messages a week over 24 weeks, the cost of sending SMS messages to the cohort is expected to be $422,352. A further $100,000 is expected to be required for miscellaneous expenses. The intervention as a whole is therefore expected to have an annual cost of $1,498,059, table 1, or $34 per participant.

Table 1: Input parameters for Markov model

	Expected value	Probability distribution
Cohort characteristics		
Number of patients	50,000	-
Gender (male)	82%	β (515,115)
Age		
Male	58	Normal (57.93, 0.40)
Female	57	Normal (57, 0.88)
SF-6D QoL	0.73	β (29,638, 10,830)
Primary care costs†	2,095	γ (147, 14)
Cost per stroke†	21,312	U (13,779, 22,965)
Cost per MI†	9,434	U (7,076, 11,793)
Intervention effects		
Change in SBP (mmHg)[a]		
Male	-7.7 (-10.2 to -5.3)	Normal (-7.7, 1.3)
Female	-8.2 (-13.5 to -2.8)	Normal (-8.1, 2.5)
Change in LDL-C (mmol/L)[a]		
Male	-0.1 (-0.3 to 0)	Normal (-0.1, 0.1)
Female	-0.1 (-0.4 to 0.2)	Normal (-0.1, 0.1)
Change in proportion of cohort smoking[b]		
Male	-15% (-23% to -7%)	Normal (-0.1, 0.0)
Female	-26% (-41%, -11%)	Normal (-0.2, 0.1)
Intervention cost		

Database/ IT infrastructure	75,000	
Project manager	130,000	
Clinical advisor	26,000	
Patient Enrolment	846,354	
Messages	480,000	
Additional (misc. expenses)	100,000	
Total cost	1,657,354	U (1,243,016, 2,071,693)

[a]Analysis of covariance was used and included randomised groups (usual care and TEXT ME) and baseline values.[b]Test of proportions† For 55-64 male, for full primary care and hospital costs see appendix 2. For expected values, parentheses contain the 95% confidence interval used for sensitivity analyses. For probability distributions the first and second values in parentheses correspond to mean and standard error in normal distribution and alpha and beta in beta (β), gamma (γ) and uniform (U) distributions. SBP: systolic blood pressure. LDL-C: Low-density lipoprotein cholesterol. QoL: Quality of life score.

Incremental costs and outcomes

Under base case assumptions, the provision of TEXT ME is expected to lead to 313fewer MIs, 230 fewer strokes and441additional quality-adjusted life-years for the study population over their remaining lifetimes. While the provision of TEXT ME is expected to cost $1.7 million, table 1, the reduction in major vascular events (MIs and strokes) is expected to lead to an overall cost-saving of $4.6 million, table 2.TEXT ME can therefore be considered 'dominant',(18) with it expected to lead to better health outcomes and cost-savings.Indeed, the intervention can be considered cost-effective even after accounting for only the improvements in health outcomes which occur over the first year following its provision, figure 2.

Parameter uncertainty

Parameter uncertainty has little effect on the conclusion that TEXT ME is cost-effective with, under baseline assumptions, all of the sets of simulated costs and effects finding the intervention to be health-improving and cost-saving, figure 3.

Structural uncertainty

Under all but one of the scenario analyses TEXT ME is expected to be cost-saving and health-improving, table 2. And while if relative risk reductions are mitigated after a year the intervention has an incremental cost-effectiveness ratio of $3,250, this is far below the cost-effectiveness threshold used is $64,000, which has been estimated to be the willingness to pay for an additional QALY in Australia.(30)

Table 2. Total and incremental costs and consequences

	Usual care				TEXT ME								
Scenario	Costs (millions)	MIs	Strokes	QALYs	Costs (millions)	MIs	Strokes	QALYs	Δ Costs (millions)	MI avoided	Strokes avoided	QALYs gained	Incremental cost per QALY gain
Base case assumptions	3,257 (2,876 to 3,704)	13,190 (12,760 to 13,639)	6,203 (6,015 to 6,392)	524,012 (508,296 to 539,818)	3,252 (2,872 to 3,700)	12,878 (12,453 to 13,370)	5,974 (5,748 to 6,199)	524,453 (508,775 to 540,274)	-4.61 (-7.04 to -2.5)	313 (188 to 408)	230 (148 to 327)	441 (323 to 563)	TEXT ME dominant
Intervention cost increased by 50%	3,257 (2,871 to 3,705)	13,190 (12,771 to 13,637)	6,203 (6,016 to 6,392)	524,012 (508,438 to 539,793)	3,253 (2,867 to 3,700)	12,878 (12,471 to 13,375)	5,974 (5,756 to 6,196)	524,453 (508,942 to 540,251)	-3.78 (-6.21 to -1.48)	313 (189 to 391)	230 (149 to 326)	441 (322 to 560)	TEXT ME dominant
Intervention cost reduced by 50%	3,257 (2,856 to 3,685)	13,190 (12,775 to 13,644)	6,203 (6,016 to 6,393)	524,012 (508,491 to 539,885)	3,252 (2,851 to 3,680)	12,878 (12,478 to 13,359)	5,974 (5,773 to 6,200)	524,453 (508,846 to 540,397)	-5.43 (-7.82 to -3.21)	313 (190 to 411)	230 (148 to 325)	441 (316 to 564)	TEXT ME dominant
Relative risk reductions mitigated after 1 year	3,257 (2,872 to 3,680)	13,190 (12,775 to	6,203 (6,016 to	524,012 (508,487 to	3,257 (2,872 to 3,680)	13,127 (12,708 to	6,156 (5,966 to	524,112 (508,599 to	0.33 (-.26 to .95)	64 (38 to 85)	47 (32 to 66)	101 (75 to 126)	3,250

		13,637)	6,392)	539,788)		13,576)	6,349)	539,891)					
Relative risk reductionsmitigated after 10 years	3,257 (2,842 to 3,705)	13,190 (12,787 to 13,680)	6,203 (6,017 to 6,396)	524,012 (508,650 to 540,345)	3,247 (2,832 to 3,696)	12,578 (12,181 to 13,147)	5,759 (5,524 to 6,025)	524,776 (509,472 to 541,087)	-10.09 (-14.17 to -6.29)	612 (378 to 783)	444 (295 to 628)	765 (553 to 968)	TEXT ME dominant
Risk of events reduced by 50%	3,315 (2,938 to 3,749)	17,406 (16,886 to 17,920)	8,190 (7,971 to 8,404)	521,495 (505,696 to 537,135)	3,308 (2,931 to 3,743)	17,047 (16,533 to 17,600)	7,899 (7,640 to 8,160)	522,094 (506,262 to 537,757)	-6.24 (-9.33 to -3.63)	359 (209 to 479)	291 (192 to 428)	599 (439 to 778)	TEXT ME dominant
Risk of events increased by 50%	3,183 (2,775 to 3,605)	7,568 (7,285 to 7,869)	3,556 (3,432 to 3,683)	526,962 (511,017 to 543,086)	3,181 (2,773 to 3,603)	7,362 (7,068 to 7,679)	3,418 (3,280 to 3,558)	527,208 (511,234 to 543,344)	-2.11 (-3.48 to -.78)	205 (137 to 264)	139 (96 to 189)	245 (184 to 308)	TEXT ME dominant
Treatment effects high	3,257 (2,857 to 3,710)	13,190 (12,785 to 13,623)	6,203 (6,017 to 6,391)	524,012 (508,628 to 539,619)	3,250 (2,849 to 3,704)	12,737 (12,341 to 13,239)	5,899 (5,687 to 6,120)	524,622 (509,244 to 540,275)	-6.99 (-9.29 to -4.56)	454 (331 to 526)	305 (228 to 389)	611 (505 to 700)	TEXT ME dominant
Treatment effects low	3,257 (2,848 to	13,190 (12,766	6,203 (6,015	524,012 (508,371	3,255 (2,848 to	13,027 (12,604	6,058 (5,858	524,269 (508,610	-1.99 (-3.39 to	164 (94 to	146 (95 to	257 (200	TEXT ME dominant

3,703)	to 13,655)	to 6,393)	to 540,022)	3,700)	to 13,511)	to 6,264)	to 540,297)	-.85)	225)	215)	to 331)

Expected (mean) values with 95% confidence intervals in parentheses. TEXT ME is considered 'dominant' if it is expected to improve health outcomes and reduce health care costs.

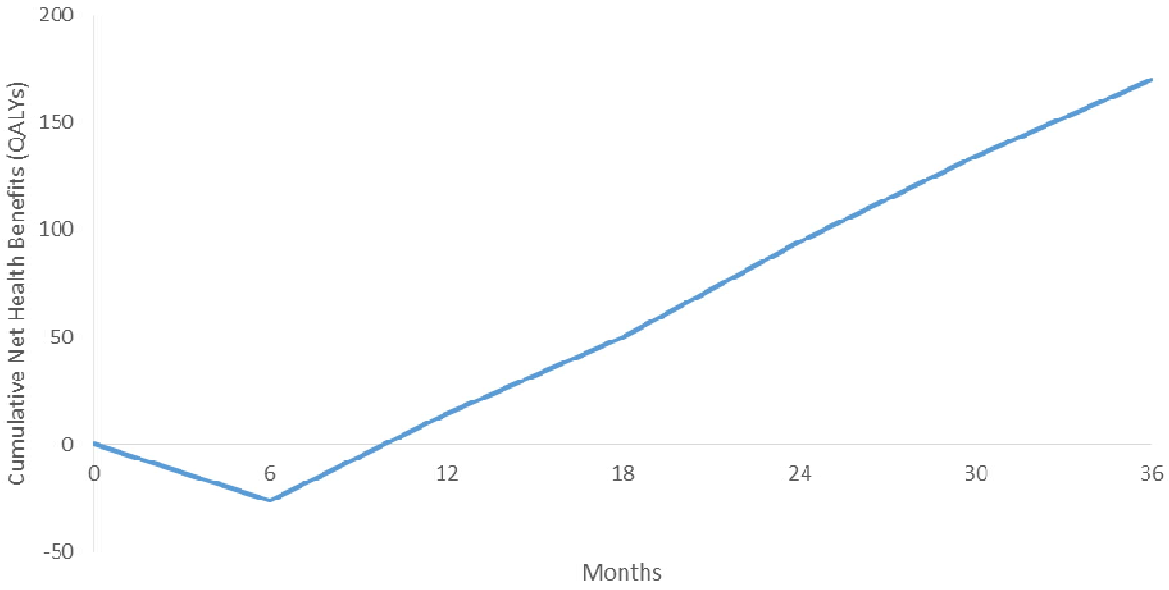

Figure 2. Net benefit curve

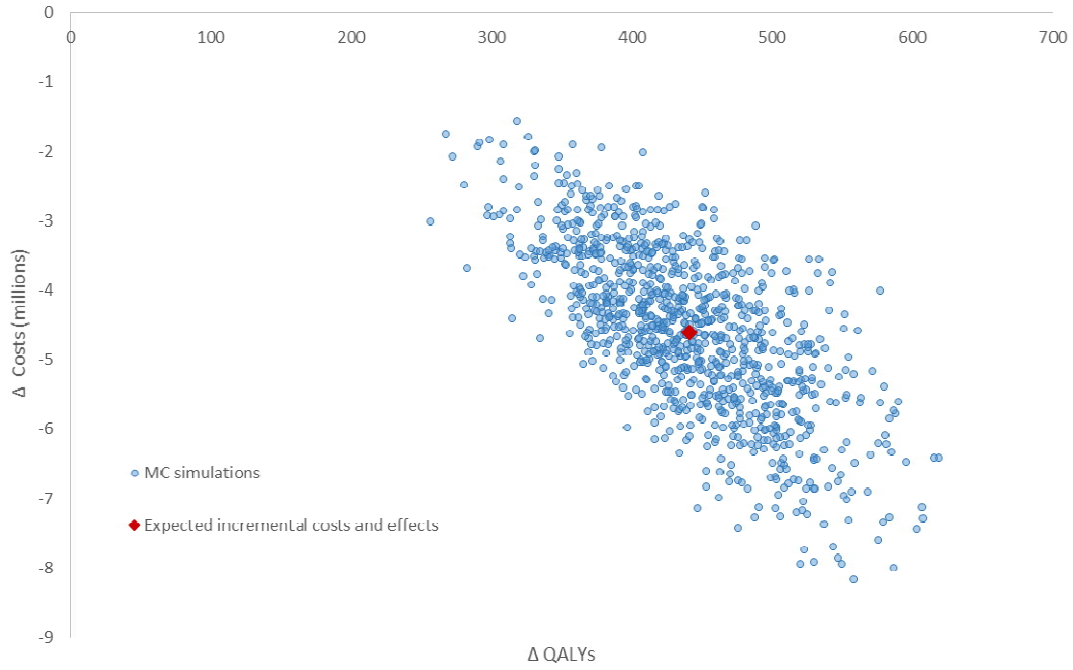

Figure 2. Cost effectiveness plane

Discussion

In Australia, the provision of TEXT ME is expected to lead to 313 fewer MIs, 230 fewer strokesand an additional 441 quality-adjusted life-years over the lifetimes of the study population. Providing the intervention is expected to cost $1.7 million, but once the reduction in major vascular events are taken into account, TEXT ME is expected to generate a cost saving of $4.6 million.Indeed the benefits

of the intervention quickly outweigh the costs, with the intervention expected to be cost-effective after less than a year, and sensitivity analyses have shown sources of uncertainty to have little impact on theconclusion that TEXT ME would both improve health outcomes and reduce health care costs.

Economic evaluations of cardiovascular disease management programmes have varied in methodologies making direct comparisons of other evaluations with TEXT ME difficult, but a number of other evaluations have also found secondary prevention programmes to be cost-effective.(31)While two other telehealth interventions, both of which are based on one-to-one telephone calls, have been found to be health-improving,(32, 33)they have been found to be costly to provide. Text-message based intervention, such as TEXT ME, therefore seem to offer a more cost-effective method of delivering a telehealth intervention for such patients.

The principal limitations of this evaluation are the requirements to extrapolate changes in risk factors observed after six months into the future, and link these changes to risk reductions for major vascular events. There is no way of knowing with certainty how differences will be maintained into the future andwe adopted a conservative basecase assumption that anyrelative risk reductions would steadily diminish until being eliminated after five years. Meanwhile, the relative risks for MI and strokes are based on systematic reviews and meta-analyses.(19-22)Uncertainty undoubtedly surrounds such inputs, however sensitivity analyses have been undertaken which show the conclusions of this evaluation to be robust to changes in these inputs.

The benefits of the intervention may in fact be underestimated given that only two types of vascular events, myocardial infarction and stroke, are included in the model and the effect of differences in BMI and physical activity, which were observed in the trial of TEXT ME,(13) both of which have been shown to have an impact on health outcomes related to cardiovascular disease,(34, 35) were not incorporated in the analysis.As well as reducing the risk of vascular events, changes in these risk factors would likely lead to reduced health care costs, for example with fewer antihypertensives prescribed, and may well increase quality of life. In addition, the included vascular events are only expected to reduce quality of life over the subsequent six months which is likely to underestimate the impact of such events.

The analysis is based on 50,000 individuals opting-in to receiving the intervention. Given that cardiovascular disease is either the principal or an additional diagnosis for over a million patients admitted to hospital annually in Australia(36) this is likely a feasible target. If the intervention were to be provided to more patients then not only would the overall health improvements and cost-savings increase but the intervention would also benefit from greater economies of scale, for example through reductions in the unit costs of sending messages.

TEXT ME has been found here to lead to better health outcomes and reduced health care costs in Australia. Given the low prevalence of healthy behaviours among those with a history of CHD across a wide range of countries(7)and the substantial proportion of the global burden of disease caused by cardiovascular disease(1)the results here are likely to be of relevance for all health systems.Telemedicine and, in particular, SMS-based interventions provide an affordable and scalable means for delivering health interventions.(14, 37) This research suggests they can also provide good value for money.

References

1. Murray CJ, Vos T, Lozano R, Naghavi M, Flaxman AD, Michaud C, et al.Disability-adjusted life years (DALYs) for 291 diseases and injuries in 21 regions, 1990-2010: a systematic analysis for the Global Burden of Disease Study 2010. Lancet. 2012;380(9859):2197-223.
2. Leal J, Luengo-Fernandez R, Gray A, Petersen S, Rayner M**.** Economic burden of cardiovascular diseases in the enlarged European Union. Eur Heart J. 2006;27(13):1610-9.
3. Mozaffarian D, Benjamin EJ, Go AS, Arnett DK, Blaha MJ, Cushman M, et al.Heart disease and stroke statistics--2015 update: a report from the American Heart Association. Circulation. 2015;131(4):e29-322.
4. AIHW**.** Australia's health 2010. Australia's health no. 12. Cat. no. AUS 122. Canberra: AIHW; 2010.
5. Welfare AIoHa**.** Cardiovascular disease: Australian facts 2011. Cardiovascular disease series. Cat. no. CVD 53. Canberra: AIHW; 2011.
6. Chow CK, Jolly S, Rao-Melacini P, Fox KA, Anand SS, Yusuf S**.** Association of diet, exercise, and smoking modification with risk of early cardiovascular events after acute coronary syndromes. Circulation. 2010;121(6):750-8.
7. Teo K, Lear S, Islam S, Mony P, Dehghan M, Li W, et al.Prevalence of a healthy lifestyle among individuals with cardiovascular disease in high-, middle- and low-income countries: The Prospective Urban Rural Epidemiology (PURE) study. JAMA. 2013;309(15):1613-21.
8. Redfern J, Ellis R, Briffa T, Freedman S**.** High risk-factor level and low risk-factor knowledge in patients not accessing cardiac rehabilitation after acute coronary syndrome. Med J Aust. 2007;186(1):21-5.
9. Neubeck L, Redfern J, Fernandez R, Briffa T, Bauman A, Freedman SB**.** Telehealth interventions for the secondary prevention of coronary heart disease: a systematic review. Eur J Cardiovasc Prev Rehabil. 2009;16(3):281-9.
10. Fjeldsoe BS, Marshall AL, Miller YD**.** Behavior change interventions delivered by mobile telephone short-message service. Am J Prev Med. 2009;36(2):165-73.
11. Redfern J, Thiagalingam A, Jan S, Whittaker R, Hackett ML, Mooney J, et al.Development of a set of mobile phone text messages designed for prevention of recurrent cardiovascular events. Eur J Prev Cardiol. 2014;21(4):492-9.
12. Chow CK, Redfern J, Thiagalingam A, Jan S, Whittaker R, Hackett M, et al.Design and rationale of the tobacco, exercise and diet messages (TEXT ME) trial of a text message-based intervention for ongoing prevention of cardiovascular disease in people with coronary disease: a randomised controlled trial protocol. BMJ Open. 2012;2(1):e000606.
13. Chow CK, Redfern J, Hillis GS, Thakkar J, Santo K, Hackett M, et al.Effect of lifestyle-focused text messaging on risk factor modification in patients with coronary heart disease: a randomized clinical trial. JAMA. 2015;314(12).
14. Eapen ZJ, Peterson ED**.** Can Mobile Health Applications Facilitate Meaningful Behavior Change?: Time for Answers. JAMA. 2015;314(12):1236-7.
15. Owens DK, Qaseem A, Chou R, Shekelle P, Clinical Guidelines Committee of the American College of P**.** High-value, cost-conscious health care: concepts for clinicians to evaluate the benefits, harms, and costs of medical interventions. Ann Intern Med. 2011;154(3):174-80.
16. AIHW**.** Australia's hospitals 2013–14: at a glance. Health services series no. 61. Cat. no. HSE 157. . Canberra.; 2015.

17. National Health and Medical Research Council. How to compare the costs and benefits: evaluation of the economic evidence. Canberra: National Health and Medical Research Council; 2001.

18. Drummond MF, Sculpher MJ, Claxton K, Stoddart GL, Torrance GW, Drummond MF, et al. Methods for the Economic Evaluation of Health Care Programmes. Oxford: Oxford: Oxford University Press; 2015.

19. Cholesterol Treatment Trialists C. Efficacy and safety of LDL-lowering therapy among men and women: meta-analysis of individual data from 174 000 participants in 27 randomised trials. The Lancet. 2015;385(9976):1397-405.

20. Law MR, Morris JK, Wald NJ. Use of blood pressure lowering drugs in the prevention of cardiovascular disease: meta-analysis of 147 randomised trials in the context of expectations from prospective epidemiological studies. BMJ. 2009;338:b1665.

21. Critchley JA, Capewell S. Mortality risk reduction associated with smoking cessation in patients with coronary heart disease: a systematic review. JAMA. 2003;290(1):86-97.

22. Peters SA, Huxley RR, Woodward M. Smoking as a risk factor for stroke in women compared with men: a systematic review and meta-analysis of 81 cohorts, including 3,980,359 individuals and 42,401 strokes. Stroke. 2013;44(10):2821-8.

23. Department of Health and Welfare. Age-standardised proportion of people aged 40–90 years surviving a major coronary event by sex, 1994–2009. 2014.

24. Australian Bureau of Statistics. Life Tables, States, Territories and Australia, 2011-2013 3302.0.55.001; 2014.

25. Brazier JE, Roberts J. The estimation of a preference-based measure of health from the SF-12. Med Care. 2004;42(9):851-9.

26. Dyer MTD, Goldsmith KA, Sharples LS, Buxton MJ. A review of health utilities using the EQ-5D in studies of cardiovascular disease. Health and Quality of Life Outcomes. 2010;8(1):13.

27. AIHW. Health care expenditure on cardiovascular diseases. Cat. no. CVD 65. Canberra: AIHW; 2008-09.

28. Sculpher MJ, Claxton K, Drummond M, McCabe C. Whither trial-based economic evaluation for health care decision making? Health economics. 2006;15(7):677-88.

29. McCabe C, Edlin R, Hall P. Navigating time and uncertainty in health technology appraisal: would a map help? Pharmacoeconomics. 2013;31(9):731-7.

30. Shiroiwa T, Sung YK, Fukuda T, Lang HC, Bae SC, Tsutani K. International survey on willingness-to-pay (WTP) for one additional QALY gained: what is the threshold of cost effectiveness? Health Econ. 2010;19(4):422-37.

31. Maru S, Byrnes J, Whitty JA, Carrington MJ, Stewart S, Scuffham PA. Systematic review of model-based analyses reporting the cost-effectiveness and cost-utility of cardiovascular disease management programs. Eur J Cardiovasc Nurs. 2015;14(1):26-33.

32. Datta SK, Oddone EZ, Olsen MK, Orr M, McCant F, Gentry P, et al.Economic analysis of a tailored behavioral intervention to improve blood pressure control for primary care patients. Am Heart J. 2010;160(2):257-63.

33. Miller G, Randolph S, Forkner E, Smith B, Galbreath AD. Long-term cost-effectiveness of disease management in systolic heart failure. Med Decis Making. 2009;29(3):325-33.

34. Prospective Studies C. Body-mass index and cause-specific mortality in 900 000 adults: collaborative analyses of 57 prospective studies. The Lancet. 2009;373(9669):1083-96.

35. Sattelmair J, Pertman J, Ding EL, Kohl HW, 3rd, Haskell W, Lee IM**.** Dose response between physical activity and risk of coronary heart disease: a meta-analysis. Circulation. 2011;124(7):789-95.

36. AIHW**.** Cardiovascular disease, diabetes and chronic kidney disease: Australian facts: morbidity—hospital care. Cardiovascular, diabetes and chronic kidney disease series Canberra: AIHW; 2014.

37. Asch DA**.** The Hidden Economics of Telemedicine. Ann Intern Med. 2015;163(10):801-2.

Appendix 1: Estimation of risk reduction associated with TEXT ME

Table A1 shows predicted relative risk for acute coronary events and stroke, obtained from systematic reviews of relevant trials, for specified reductions achieved in the risk factors of SBP, LDL cholesterol and smoking.

Table A1: Relative risks associated with changes in systolic blood pressure and LDL cholesterol

Risk factor	Risk factor change	RR for ACE	Probability distribution	RR for stroke	Probability distribution
SBP* (20)	10 mmHg reduction	0.76 (0.68 to 0.86)	Normal(0.76, 0.05)	0.65 (0.53 to 0.80)	Normal(0.65, 0.07)
LDL-C (19)**					
Men	1 mmol/l reduction	0.74 (0.70 to 0.78)	Normal(0.74,0.02)	0.83 (0.76 to 0.90)	Normal(0.83, 0.04)
Women	1 mmol/l reduction	0.83 (0.74 to 0.93)	Normal(0.83, 0.05)	0.90 (0.78 to 1.04)	Normal(0.83, 0.07)
Smoking (21, 22)					
Men	Quitting	0.68 (0.57 to 0.82)	Normal(0.68, 0.06)	0.60 (0.53 to 0.67)	Normal(0.60, 0.04)
Women	Quitting	0.68 (0.57 to 0.82)	Normal(0.68, 0.06)	0.55 (0.47 to 0.63)	Normal(0.55, 0.04)

*independent of class of blood pressure loweringdrug. **independent of type of statin. For relative risks (RRs), parentheses contain the 95% confidence interval used for sensitivity analyses. For probability distributions the first and second values in parentheses correspond to mean and standard error in normal distribution.

Relative risks, shown in table A1, are adjusted for the achieved size of the risk factor reduction for continuous variables under TEXT ME, table 1. Proportional RRs due to SBP and LDL change are based on the log-linear relationship that has been demonstrated; for example if trials show X mmHg SBP reduction achieves an RR of Y, then the RR for an SBP reduction of Z is estimated as $Y^{Z/X}$. Due to demonstrated lack of interaction or effect modification of each of these risk factors, RRs achieved for each modality are multiplied in order to estimate an overall RRR expected if both modalities are being adjusted.

Appendix 2. Health care costs

Table 2. Health system costs

	Expected cost ($)	Probability distribution
Six month primary care costs		
Male		
Below 55	1,316	γ (167, 7.89)
55-64	2,096	γ (148, 14.19)
65 and over	2,154	γ (172, 12.53)
Female		
Below 55	1,769	γ (116, 15.29)
55-64	2,272	γ (71,32.09)
65 and over	2,398	γ (87, 27.27)
Cost per MI(27)		
Male		
35–44	10,838	U (8,128, 13,547)
45–54	11,316	U (8,487, 14,145)
55–64	11,877	U (8,908, 14,847)
65–74	12,919	U (9,689, 16,149)
75–84	12,529	U (9,397, 15,661)
85 and over	9,702	U (7,277, 12,128)
Female		
35–44	9,040	U (6,780, 11,300)
45–54	8,446	U (6,334, 10,557)
55–64	9,434	U (7,076, 11,793)
65–74	10,888	U (8,166, 13,610)
75–84	10,729	U (8,047, 13,411)
85 and over	9,397	U (7,048, 11,746)

Cost per stroke (27)		
Male		
35–44	22,890	U (14,800, 24,666)
45–54	20,901	U (13,514, 22,523)
55–64	18,801	U (12,156, 20,260)
65–74	17,632	U (11,400, 19,000)
75–84	16,743	U (10,826, 18,043)
85 and over	16,898	U (10,925, 18,209)
Female		
35–44	24,324	U (15,727, 26,211)
45–54	22,622	U (14,627, 24,378)
55–64	21,312	U (13,779, 22,965)
65–74	19,291	U (12,473, 20,788)
75–84	16,970	U (10,972, 18,286)
85 and over	16,172	U (10,456, 17,426)

For probability distributions the first and second values in parentheses correspond to alpha and beta in gamma (γ) and uniform (U) distributions.