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The cost-effectiveness of the *MobileMums* intervention to increase physical activity among mothers with young children

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ABSTRACT

Objectives

To determine the cost-effectiveness of the *MobileMums* intervention. *MobileMums* is a 12-week programme which assists mothers with young children to be more physically active, primarily through the use of personalised SMS text-messages

Design

A cost-effectiveness analysis using a Markov model to estimate and compare the costs and consequences of *MobileMums* and usual care.

Setting

This study considers the cost-effectiveness of *MobileMums* in Queensland, Australia.

Participants

A hypothetical cohort of over 36,000 women with a child under one year old is considered. These women are expected to be eligible and willing to participate in the intervention in Queensland, Australia.

Data sources

The model used is informed by the effectiveness results from a 9-month two-arm community-based randomised controlled trial undertaken in 2011. Baseline characteristics for the model cohort, treatment effects, and resource utilisation were all informed by this trial.

Main outcome measures

The incremental cost per quality-adjusted life year (QALY) of *MobileMums* compared with usual care.

Results

The intervention is estimated to lead to an increase of 252 QALYs for an additional cost to the health system of 1.1 million AUD. The expected incremental cost-effectiveness ratio for *MobileMums* is 4,348 AUD per QALY gained. *MobileMums* has a 98% probability of being cost-effective at a cost-effectiveness threshold of 64,000 Australian dollars (AUD). Varying modelling assumptions has little effect on this result.

Conclusions

At a cost-effectiveness threshold of 64,000 AUD, *MobileMums* would likely be a cost-effective use of health care resources in Queensland, Australia.

ARTICLE SUMMARY

Article focus

- This paper estimates the cost-effectiveness of the *MobileMums* intervention for Queensland, Australia.

Key messages

- *MobileMums* is likely a cost-effective use of health care resources in Queensland, Australia.

Strengths and limitations of the study

- The analysis is informed by the results from a recent two-arm randomised controlled trial of *MobileMums* and usual care.
- Uncertainty around the costs and consequences of *MobileMums* and usual care has been quantified and has little effect on the conclusions of the analysis.
- The simplicity of the model means that some potentially important effects may have been missed. As physical activity levels were split into only two categories, small changes in an individual's activity would likely not be valued.

INTRODUCTION

Physical inactivity is a leading cause of lost years of healthy life in high-income countries, where chronic diseases are a leading cause of mortality and morbidity.[1] An insufficient level of physical activity, defined as less than 30 minutes of moderate- to vigorous-intensity physical activity on at least five days a week, is directly associated with a number of diseases including coronary heart disease, type 2 diabetes, breast cancer and colon cancer.[2] Physical inactivity is also indirectly linked to the negative health consequences of high body mass and high blood pressure, which include many of the aforementioned chronic conditions.

Fifty-seven percent of Australia's adult population were insufficiently active in 2011–12.[3] Begg et al.[4] estimate that 6.6% of the total disease burden in Australia is caused by physical inactivity, explaining around 24% of both cardiovascular disease and diabetes, and around 6% of all cancers. Based on these results, Cadilhac et al.[5] estimate that each year insufficient physical activity causes 45,000 new cases of disease which are associated with a loss of 174,000 disability-adjusted life-years in Australia. Inequalities in activity levels exist, with inactivity more likely in older people, those of lower socioeconomic status, those outside of major cities, and women.[6] Indeed, women with young children are more likely to be physically inactive than both women with no children[7, 8] and women with older children,[9, 10] and it is this group who are the focus of the *MobileMums* intervention evaluated here.

The *MobileMums* programme is a 12-week intervention which designed to assist women with young children increase their physical activity. The intervention's development has previously been discussed.[11] *MobileMums* is initiated with a face to face consultation between the participant and a trained behavioural counsellor. The consultation is used to establish rapport between the participant and counsellor, to gather information required to tailor text-message content and to initiate process of behaviour change through personalised goal setting.[11] Participants receive five text-messages per week during weeks 1 to 4 of the intervention and four messages per week during weeks 5 to 12. The messages are personalised based on the participant's name, the name of their counsellor, the participant's goals and their expected rewards and outcomes for achieving these goals. In addition to receiving the text-messages, participants also have access to a programme handbook, an on-line exercise directory and a Facebook© group. They also receive a refrigerator magnet for self-monitoring and various information brochures on physical activity. As well as requiring behavioural counsellors, delivering the intervention requires programme coordinators to manage the counsellors, assign participants to a counsellor, oversee the text-messages being sent and received, and organise the delivery of other programme materials to participants.

In Australia health resources are generally allocated on a state or territory basis[12] and so a decision on whether to fund *MobileMums* would be made by individual states or territories. The alternative course of action would be to provide usual care. The purpose of this paper is to consider this decision of whether to provide *MobileMums* or usual care from the perspective of Queensland Health, the government department responsible for managing the public health system in Queensland, Australia.

It is assumed that the overarching objective of Queensland Health is to maximise population health subject to their budget. This, therefore, supports the need for an economic evaluation of *MobileMums* to consider the intervention's value for money. While this evaluation is specific to the funding decision faced by Queensland Health, it can be expected that the results reported here will be directly applicable to similar decisions in other Australian states and territories. The generalisability of the results to other high-income countries may be more limited, for example because of differences in the volume and cost of resource use between countries,[13] but the results are likely to be of relevance for all countries experiencing high levels of physical inactivity.

METHODS

Study population

It is expected that *MobileMums* would be offered to all women with children under one year old in Queensland, Australia. With 61,020 women giving birth in Queensland in 2010 and with 413 fetal deaths,[14] the number of women eligible for the intervention in 2011 was 60,607. Based on the randomised control trial conducted in 2011,[15] where of the 511 women assessed for eligibility 306 commenced the baseline assessment, we can expect around 60% of those women who are offered the intervention to participate. This gives 36,364 women in Queensland who would be eligible and willing to participate in the *MobileMums* intervention in 2011, and this is the baseline cohort size considered for this study. This participation estimate is likely conservative as the program would not include the time-consuming assessments that were undertaken purely for research purposes

Modelling health outcomes and costs

A state-based Markov model provides the framework for this analysis and is used to estimate the costs and consequences associated with *MobileMums* and usual care. The development of the model has been informed by the effectiveness results from a 9-month two-arm community-based randomised controlled trial undertaken in 2011. 263 women from around Caboolture, Queensland, received usual care (n=130) or the *MobileMums* intervention (n=133).[15] Data were collected prior to the intervention being received (time 1 – T1: 0 months), after the 12-week *MobileMums* programme was completed (T2: 3 months) and again after a further 6 month no-contact maintenance period (T3: 9 months). The main efficacy findings from the trial have been reported in detail by Fjeldsoe et al.[15] Briefly, while the intervention had a large and statistically significant beneficial effect on activity levels between T1 and T2, there was no statistically significant effect at T3, although the estimated increase in activity remained positive.

These results suggest that *MobileMums* can only be expected to have an effect on activity levels in the short-term. Under the assumption that only long-term changes in activity levels affect the risk of an individual developing future chronic health conditions, the time horizon of the model used here is two years. There are just two states in the model with participants either 'physically inactive' or 'physically active', and an individual is required to be undertaking 30 minutes of moderate- to vigorous-intensity physical activity on at least five days a week to be classified as active. An effective physical inactivity intervention increases the likelihood that inactive individuals become active (tpImprove) and/or reduces the likelihood that active individuals become inactive (tpRegress). Individuals move between states using monthly cycles, and spending a month as active or inactive has a cost and health outcome associated with it (described below). An outline of the model is in figure 1.

Health effects

To allow the value for money of *MobileMums* to be compared against interventions across the health system, health effects are expressed in terms of quality-adjusted life-years (QALYs). Given the design of the model used, *MobileMums* can only affect health-related quality-of life, with no mortality effects. The health-related quality-of-life associated with being physically active or inactive was estimated from participants' responses to SF-12 questionnaires at T1, T2 and T3. Missing questionnaire data at each time period (1% of participants at T1, 13% at T2, and 32% at T3) was excluded under the assumption that the missing data bore no relation to observed or unobserved factors in the population. A couple of errors were made in the printing of the SF-12 questionnaires. First, at T1 one question from the SF-12 was omitted in error, and so scores were randomly generated for this dimension. Second, one of the questions offered one too many potential

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3 responses at all time periods, and so those who selected this superfluous response were evenly split
4 and moved into either the next best or next worst choice.

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6 Questionnaire were transformed into the EQ-5D, a standardised measure of health outcomes, using
7 an algorithm provided by Gray et al.[16] This provided health-related quality-of-life scores associated
8 with spending a year as physically active or inactive which could range between 0 (equivalent to
9 death) and 1 (equivalent to perfect health). Monthly scores were simply one-twelfth of this. QALYs
10 and costs in the second year were discounted at 5% following the relevant guidelines.[17, 18]
11

12 **Costing perspective**

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14 This study is intended to inform decision making regarding resource allocation across the health
15 system in Queensland. While costs and benefits falling outside of the health system, such as the cost
16 to participants of purchasing goods or services related to undertaking exercise, may be of relevance,
17 there are significant methodological issues in incorporating these effects into the analysis.[19]
18 Consequently, a health system perspective is taken here, with only the costs borne by the health
19 system included. All costs reported are in 2011 AUD and any costs accruing in the second year of the
20 model have been discounted at 5% in line with guidelines for submission to the Medical Services
21 Advisory Committee[17] and the Pharmaceutical Benefits Advisory Committee[18] in Australia.
22

23
24 The estimated cost of providing *MobileMums* across Queensland is based on the costs of delivering
25 the intervention in the randomised controlled trial. [15] To extrapolate these costs assumptions
26 have been required concerning number of behavioural counsellors and programme coordinators
27 required for widespread dissemination. It is assumed that counsellors could be assigned to 30
28 participants per week while coordinators could cover five counsellors and their participants per
29 week. Counsellors and coordinators are assumed to be health practitioners with, on average, 2 years
30 in their current role and, in terms of Queensland Health's salary scale,[20] paid at a HP3 and a HP4
31 level, respectively. The costs of developing the computer programme to send text-messages,
32 sending the text- messages and providing other programme materials are assumed to be the same
33 as in the trial.
34

35
36 In addition to the costs of delivering the intervention, the costs relating to participants health care
37 use have also been incorporated. If the intervention reduces future health care use then the cost
38 saving associated with this can be compensate at least part of the cost of delivering *MobileMums*.
39 Participants' reported their use of health care services at T1, T2 and T3 and the average use of those
40 who were physically active and inactive were estimated. As with the SF-12, missing data was
41 excluded (0% of participants at T1, 12% at T2, and 31% at T3). The associated costs were estimated
42 using the Medicare Benefits Schedule for July 2011[21] and Australian hospital statistics.[22]
43

44 **Expected effects**

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46 If *MobileMums* is expected to improve health and reduce costs or reduce health and increase costs
47 then the implications are clear, with the intervention 'dominant' and 'dominated' respectively.[23]
48 However, if *MobileMums* is expected to improve health but increase costs, or reduce health but also
49 reduce costs, then this motivates the estimation of the expected incremental cost effectiveness ratio
50 for *MobileMums* compared against usual care. This ratio is given by the change in costs caused by
51 the intervention divided by the change in QALYs. This can then be compared against the cost-
52 effectiveness threshold. The threshold used here is 64,000 AUD which is based on the estimate by
53 Shiroiwa et al.[24] of the willingness-to-pay for an additional QALY in Australia. If the cost
54 effectiveness ratio for *MobileMums* falls below 64,000 AUD then the intervention can be deemed
55 'cost-effective'.
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57 **Uncertainty**

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Parameter uncertainty was quantified using Monte Carlo simulations, with the model evaluated 10,000 times, with each simulation involving random draws from each parameter distribution. These distributions are based on the trial data, with transition probabilities and QALYs given beta distributions, while health use and costs are assigned gamma distributions and uniform distributions, respectively. This produces 10,000 sets of incremental costs and effects, and these are presented on a cost-effectiveness plane along with the expected costs and effects and the cost-effectiveness threshold. The probability that *MobileMums* is cost-effective is given by the proportion of sets of costs and benefits at which the intervention would be considered cost-effective. The proportion of sets where the change in QALYs is positive and the change in effect is negative is equal to the probability that *MobileMums* is cost-saving. It is also possible to estimate credible intervals around the expected change in costs and QALYs by taking percentiles of the costs and QALYs produced in the Monte Carlo analysis.[25]

Uncertainty also exists surrounding the modelling assumptions. In particular, three areas stand out for particularly onerous assumptions: transition probabilities after nine months (T3), the number of programme counsellors and coordinators required, and the number of women who would be eligible and willing to participate in the trial. The assumptions used for these areas are the subject of scenario analyses. First, the model is reassessed under the assumption that after T3 all programme activity effects are mitigated entirely, and then again under the assumption that the estimated treatment effect observed at T3 is maintained for a further 15 months, at which point the treatment effect is entirely mitigated. Second, the number of counsellors and coordinators required is increased by 50% and reduced by 50%. And lastly, increasing the cohort size by 50% and reducing it by 50% is considered.

RESULTS

Average effects

The input variables are detailed in Table 1. Around 70% of the women entering the model at T1 are expected to be physically inactive. Under usual care there is a small and gradual expected positive net movement from inactive to active over time, and after 24 months around 35 percent of the initial cohort are expected to be in the active state. The expected effect of *MobileMums* is to cause a substantial increase in physical activity over the duration of the 12-week intervention, with 50 percent of the participants expected to be in the active state at T2. Following the intervention gradual reduction in the proportion of active participants each month is expected, until after 16 months whereby the effect of *MobileMums* has been mitigated entirely. These expected changes in activity levels are presented in figure 2.

		Mean	Distribution
Probability of being inactive at T1		0.71	Beta
	Usual Care (T1 to T2)	0.21	Beta
Probability of moving from inactive to active	MobileMums (T1 to T2)	0.36	Beta
(tpImprove)	Usual Care (T2 to T3)	0.15	Beta
	MobileMums (T2 to T3)	0.28	Beta
Probability of moving from active to inactive	Usual Care (T1 to T2)	0.44	Beta

(tpRegress)	MobileMums (T1 to T2)	0.18	Beta
	Usual Care (T2 to T3)	0.29	Beta
	MobileMums (T2 to T3)	0.44	Beta
Yearly health care costs (AUD per participant)	Physically active	56.25	Uniform
	Physically inactive	76.24	Uniform
Cost of delivering MobileMums (AUD per participant)		58.65	Uniform
EQ5D score	Inactive	0.76	Beta
	Active	0.82	Beta

Table 1 Input variables for the Markov model

Time spent in the active state is expected to provide slightly higher utility than time spent in the inactive state, with a year spent as physically active associated with a health-related quality-of-life score of 0.79 compared with 0.76 for a year spent as physically inactive. As *MobileMums* is expected to increase the total number of months spent by the cohort in the active state, the intervention can therefore also be expected to improve health-related quality-of-life. Over 24 months, *MobileMums* is estimated to lead to an increase of 252 QALYs across the cohort of 36,364 women or, equivalently, 0.0069 QALYs per person.

The expected cost of delivering *MobileMums* to the cohort is 2,132,912 AUD, or 59 AUD per person. The breakdown for this cost is shown in Table 2. Almost half the cost is due to the behavioural counsellors. While there are significant costs associated with setting up the programme, such as the development of a computer programme to send personalised text-messages, these costs are of little consequence with a cohort of 36,364 women.

	Total cost (AUD)	Cost per participant (AUD)
Development of the computer program for sending automated text-messages	13,300	0.37
Sending text-messages	581,460	15.99
Providing additional programme materials	581,824	16.00
Behavioural counsellors (24 required)	Salaries	410,700
	Equipment	33,924
	Travel costs	363,640
Programme coordinators (5 required)	Salaries	114,464
	Office costs	33,600
Total	2,132,912	58.65

Table 2 Estimated costs of delivering MobileMums in Queensland, Australia

Based on data from the trial it is estimated that active individuals cost the health system 56 AUD a month on average, while inactive individuals cost 76 AUD per month. As *MobileMums* reduces the average number of months spent in the inactive state, the cost of delivering the intervention is partly offset by an expected reduction in health care costs. As a result, the total expected incremental cost to the health system from introducing *MobileMums* is 1,125,706 million AUD, or 31 AUD per person.

With an expected (mean) incremental cost of 1,125,706 million AUD and an incremental improvement in health outcomes of 252 QALYs, the cost-effectiveness ratio for *MobileMums* is approximately 4,348 AUD per QALY gained. At a cost-effectiveness threshold of 64,000 AUD, the intervention can therefore be expected to be cost-effective.

Uncertainty

The incremental costs and consequence produced by the Monte Carlo simulations are in figure 3. *MobileMums* has a 98% probability of being cost-effective at a threshold of 64,000 AUD (98% of simulations are below the sloped threshold line). The intervention has around a 20% probability of being cost-saving and health-improving (20% of simulations in the south-east quadrant).

The results from the scenario analysis are presented in Table 3. None of the changes in assumptions had any substantial effect on the probability that *MobileMums* is cost-effective at a threshold of 64,000 AUD, which remained over 95% under all scenarios. Changes in the assumption surrounding the maintenance of changes in activity levels into the future did, however, have a substantial effect on the probability that *MobileMums* is cost-saving. If changes were entirely mitigated after 9 months (T3) then the intervention would only have a 1% chance of being cost-saving while if the observed difference in activity levels at T3 was maintained for up to 24 months *MobileMums* would have a 35% probability of being cost-saving.

Scenario	Mean change (95% credible interval) caused by <i>MobileMums</i>		Expected (mean) ICER	Probability <i>MobileMums</i> is	
	Total costs (AUD)	QALYs		Cost-effective*	Cost-saving
Base case	1,125,705 (1,101,935 to 1,149,475)	252 (247 to 257)	4,466	98%	20%
Changes in activity levels entirely mitigated at 9 months (T3)	1,309,558 (1,300,044 to 1,319,072)	206 (204 to 208)	6,358	97%	1%
Changes in activity levels maintained from 9 months to 24 months	1,085,903 (1,060,112 to 1,111,693)	262 (257 to 267)	783	94%	35%
Number of counsellors and coordinators required increased by 50%	1,422,049 (1,398,018 to 1,446,080)	252 (247 to 257)	5,642	97%	16%
Number of counsellors and coordinators required reduced by 50%	829,361 (805,626 to 853,096)	252 (247 to 257)	3,290	98%	24%
Cohort size increased by 50%	1,648,576 (1,612,503 to 1,684,649)	378 (370 to 386)	4,360	98%	21%
Cohort size reduced by 50%	584,309 (572,414 to 596,204)	126 (124 to 128)	4,636	97%	17%

ICER: incremental cost-effectiveness ratio

* at a threshold of 64,000 AUD

Table 3 Results from the scenario analysis to examine whether the intervention remains cost-effective for a range of assumptions.

DISCUSSION

Principal findings

The results from this study suggest the *MobileMums* intervention would be a cost-effective use of health resources in Queensland, Australia. While the expected health benefits of the intervention are only 0.0069 QALYs per person, the intervention is expected to cost just 31 AUD per person. Consequently, the expected cost-effectiveness ratio is 4,465 AUD per QALY is far below the estimated willingness to pay for an additional QALY in Australia of 64,000 AUD.[24] Neither parameter nor modelling uncertainty have a substantial effect on this conclusion.

Study strengths and limitations

This study has been largely informed by the results of a recent 9-month randomised controlled trial. By using a decision-analytic model, it has been possible to extrapolate these findings to consider the costs and consequences of *MobileMums* if it were offered in practice to a large cohort of women and to take into account those costs and consequences that can be expected to occur beyond the trial's time horizon. And while such an approach does require a number of assumptions, these assumptions have been the subject of sensitivity analyses which have shown them to have little effect on the overall conclusion that the intervention is likely cost-effective.

With the effect of *MobileMums* on activity levels expected to last for less than two years, and under the conservative assumption that only longer-term changes in activity will affect the risk of an individual developing future chronic health conditions, the model used here is only required to have a short-time horizon. The simplicity of the model used, with only two health states, has advantages, particularly for ease of exposition. However, there are limitations. In particular, only those changes in activity enough to move participants between the two states of the model are captured, with any changes of activity levels within a state overlooked.

Comparison with other studies

While a number of economic evaluations of physical activity interventions have been undertaken, there is significant methodological heterogeneity making direct comparisons difficult in many cases. Of those studies which use a similar methodology to this one, i.e. using a decision-analytic model as a framework for analysis with the cost per quality-adjusted (or disability-adjusted) life-year, many of the interventions analysed are found to be cost-effective. For example, the 'green prescription' programme in New Zealand is found to have an incremental cost of 3,000 AUD per QALY,[26] while the '10,000 Steps Ghent' intervention is found to be cost-saving.[27] However, the cost-effectiveness of such physical activity intervention is by no means guaranteed. Cobiac et al.[28] find that a GP referral to exercise scheme has an incremental cost of 100,000 AUD per QALY, while a 8-week social support programme is found by Roux et al.[29] to have an incremental cost of 95,000 AUD per QALY.

Interestingly, while these other studies typically assumed that the benefit from physical activity interventions was only through reducing the incidence of future chronic diseases, this study demonstrates that there is also likely an immediate improvement in health-related quality-of-life. Active participants in the trial of *MobileMums* reported higher health-related quality-of-life than those who were physically inactive, which made it possible for *MobileMums* to be expected to be cost-effective even without any long-term changes in activity levels. With this immediate improvement in quality-of-life missed in most analyses of physical activity interventions, these studies may well have underestimated the full benefits from effective physical activity interventions.

Policy implications

Health prevention programmes in Queensland, and across Australia, have recently been going through a period of disinvestment. However, if the goal of the health system is to maximise health outcomes then there seems little reason for prevention health interventions to be treated any

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3 differently than a curative intervention. Health care resources should be directed to those uses
4 which provide best value for money, i.e., the greatest improvement in health outcomes for a given
5 level of cost. *MobileMums* can be expected to provide good value for money and is likely a cost-
6 effective use of resource given the estimated willingness-to-pay for an additional QALY in Australia.
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8 There seems little reason to expect that this conclusion would be different in other states and
9 territories in Australia. Levels of physical inactivity can be expected to be similar across Australia as
10 can the effects of the intervention. In addition, costs, such as those associated with the counsellors
11 and coordinators should be comparable. While differences in costs such as these make it more difficult
12 to generalise these results to other countries, the results of this study are still likely to be of
13 relevance in many high-income countries with similarly high levels of physical inactivity.
14

15 CONCLUSION

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17 *MobileMums* can be expected to be a cost-effective use of health resources in Queensland,
18 Australia. If the objective of Queensland Health is to maximise population health outcomes given
19 their budget, *MobileMums* should be freely provided.
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23 Figure 1 Outline of the Markov model used to estimate the costs and effects of *MobileMums*
24 and usual care
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26 Figure 2 The expected (mean) effect of *MobileMums* on activity levels
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28 Figure 3 Cost-effectiveness plane for *MobileMums* versus usual care with 1,000 sets of
29 incremental costs and effects randomly drawn from the 10,000 Monte Carlo simulations along with
30 the expected (mean) incremental costs and effects and a cost-effectiveness threshold of 64,000 AUD
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41

42 AUTHOR CONTRIBUTIONS

43
44 Conceived and designed the experiments: AM, YM, BF, NG
45

46 Performed the experiments: AM, YM, AB, BF, NG
47

48 Analysed the data: EB, NG
49

50 Wrote the paper: EB, AM, YM, AB, NG
51

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53
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56

57 COMPETING INTERESTS

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3 None

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5 **ETHICS APPROVAL**

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7 The trial used to inform this analysis was registered with the Australian Clinical Trials Registry
8 (ACTRN12611000481976). Ethical clearance was obtained through the Queensland University of
9 Technology Human Research Ethics Committee (Application number 0900001407).

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11 **PROVENANCE AND PEER REVIEW**

12 Not commissioned; externally peer reviewed

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14 **DATA SHARING STATEMENT**

15 The full data set is available by emailing the first author of the study.
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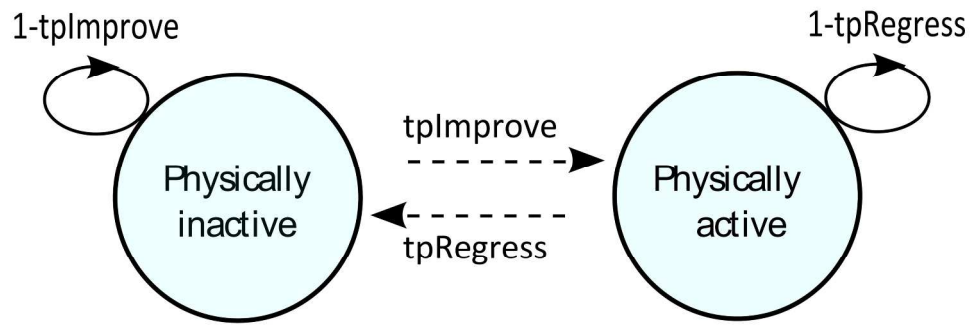
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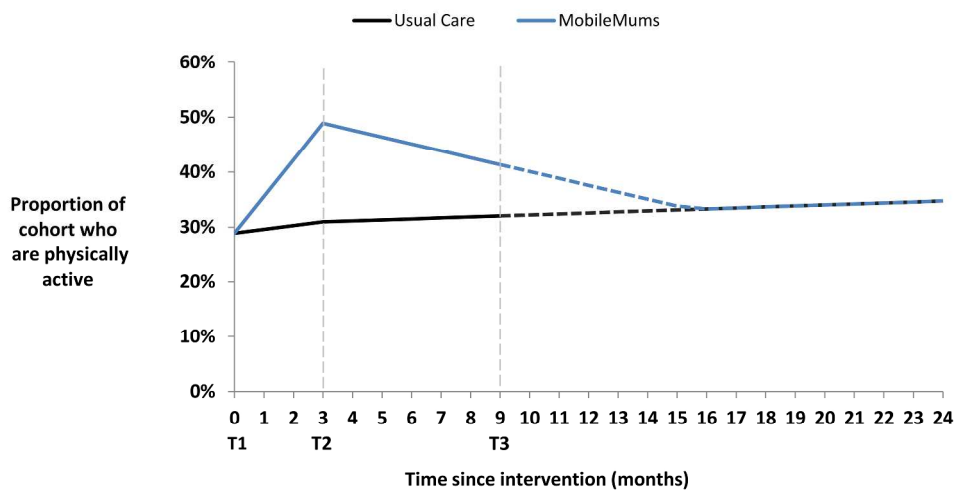
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Outline of the Markov model used to estimate the costs and effects of MobileMums and usual care
115x41mm (600 x 600 DPI)

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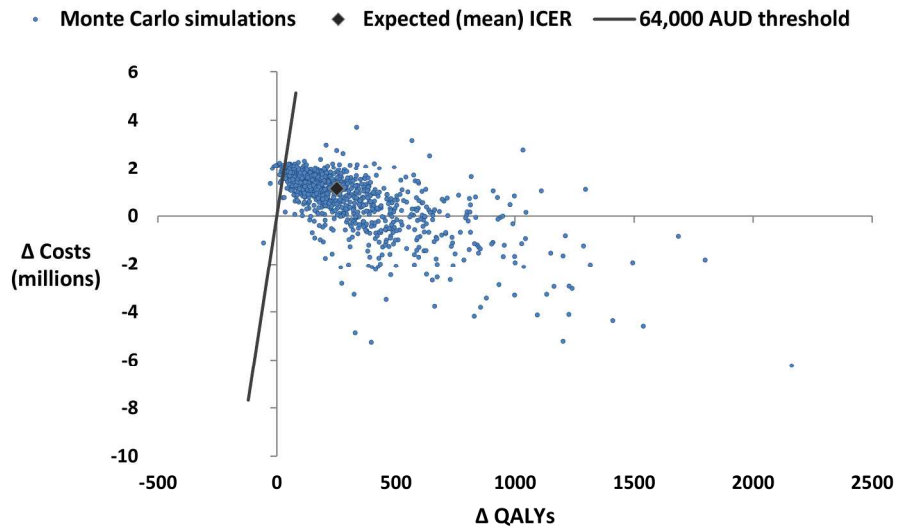


The expected (mean) effect of MobileMums on activity levels
146x79mm (600 x 600 DPI)

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Cost-effectiveness plane for MobileMums versus usual care with 1,000 sets of incremental costs and effects randomly drawn from the 10,000 Monte Carlo simulations along with the expected (mean) incremental costs and effects and a cost-effectiveness threshold of 64,000 AUD
147x87mm (600 x 600 DPI)

Review only

The CHEERS Checklist is part of the CHEERS Statement. The CHEERS Statement has been endorsed and co-published by the following journals:

- BJOG: An International Journal of Obstetrics and Gynaecology
- [BMC Medicine 2013; 11:80](#)
- [BMJ 2013;346:f1049](#)
- [Clinical Therapeutics 27 March 2013 \(Article in Press DOI: 10.1016/j.clinthera.2013.03.003\)](#)
- [Cost Effectiveness and Resource Allocation 2013 11:6.](#)
- [The European Journal of Health Economics 2013 Mar 26. \[Epub ahead of print\]](#)
- International Journal of Technology Assessment in Health Care
- [Journal of Medical Economics 2013 Mar 25. \[Epub ahead of print\]](#)
- [Pharmacoeconomics 2013 Mar 26. \[Epub ahead of print\]](#)
- [Value in Health 2013 March - April;16\(2\):e1-e5](#)

CHEERS Checklist

Items to include when reporting economic evaluations of health interventions

Section/item	Item No	Recommendation	Reported on page No/line No
Title and abstract			
Title	1	Identify the study as an economic evaluation or use more specific terms such as “cost-effectiveness analysis”, and describe the interventions compared.	Page 1, Line 3-4
Abstract	2	Provide a structured summary of objectives, perspective, setting, methods (including study design and inputs), results (including base case and uncertainty analyses), and conclusions.	Page 2, Line 3-47
Introduction			
Background and objectives	3	Provide an explicit statement of the broader context for the study. Present the study question and its relevance for health policy or practice decisions.	Page 4, Line 42-57
Methods			
Target population and subgroups	4	Describe characteristics of the base case population and subgroups analysed, including why they were chosen.	Page 5, Line 5-16
Setting and location	5	State relevant aspects of the system(s) in which the decision(s) need(s) to be made.	Page 4, Line 42-
Study perspective	6	Describe the perspective of the study and relate this to the costs being evaluated.	Page 1, Line 12-42
Comparators	7	Describe the interventions or strategies being compared and state why they were chosen.	Page 4, Line 42-44
Time horizon	8	State the time horizon(s) over which costs and consequences are being evaluated and say why appropriate.	Page 5, Line 32-43
Discount rate	9	Report the choice of discount rate(s) used for costs and	Page 6, Line 19-21



1		outcomes and say why appropriate.	
2			Page 5,6
3	Choice of health	10 Describe what outcomes were used as the measure(s) of	Line 45- 57, 3-11
4	outcomes	benefit in the evaluation and their relevance for the type of	
5		analysis performed.	
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7	Measurement of	11a <i>Single study-based estimates</i> : Describe fully the design	Page 5
8	effectiveness	features of the single effectiveness study and why the single	Line 17-43
9		study was a sufficient source of clinical effectiveness data.	
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11		11b <i>Synthesis-based estimates</i> : Describe fully the methods used for	
12		identification of included studies and synthesis of clinical	
13		effectiveness data.	
14	Measurement and	12 If applicable, describe the population and methods used to	Page 6
15	valuation of preference	elicit preferences for outcomes.	Line 6-11
16	based outcomes		
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18	Estimating resources	13a <i>Single study-based economic evaluation</i> : Describe approaches	
19	and costs	used to estimate resource use associated with the alternative	
20		interventions. Describe primary or secondary research methods	
21		for valuing each resource item in terms of its unit cost.	
22		Describe any adjustments made to approximate to opportunity	
23		costs.	
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26		13b <i>Model-based economic evaluation</i> : Describe approaches and	Page 6
27		data sources used to estimate resource use associated with	Line 12-42
28		model health states. Describe primary or secondary research	
29		methods for valuing each resource item in terms of its unit	
30		cost. Describe any adjustments made to approximate to	
31		opportunity costs.	
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34	Currency, price date,	14 Report the dates of the estimated resource quantities and unit	
35	and conversion	costs. Describe methods for adjusting estimated unit costs to	Page 6
36		the year of reported costs if necessary. Describe methods for	Line 12- 42
37		converting costs into a common currency base and the	
38		exchange rate.	
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40	Choice of model	15 Describe and give reasons for the specific type of decision-	Page 5
41		analytical model used. Providing a figure to show model	Line 17- 43
42		structure is strongly recommended.	
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44	Assumptions	16 Describe all structural or other assumptions underpinning the	Page 7
45		decision-analytical model.	Line 17-27
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47	Analytical methods	17 Describe all analytical methods supporting the evaluation. This	
48		could include methods for dealing with skewed, missing, or	Page 5, 6
49		censored data; extrapolation methods; methods for pooling	Line 50-56, 40-42
50		data; approaches to validate or make adjustments (such as half	
51		cycle corrections) to a model; and methods for handling	
52		population heterogeneity and uncertainty.	
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55	Results		
56	Study parameters	18 Report the values, ranges, references, and, if used, probability	Page 7,8
57		distributions for all parameters. Report reasons or sources for	Line 45- 57, 3-18
58		distributions used to represent uncertainty where appropriate.	
59		Providing a table to show the input values is strongly	
60		recommended.	

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23	Incremental costs and outcomes	19	For each intervention, report mean values for the main categories of estimated costs and outcomes of interest, as well as mean differences between the comparator groups. If applicable, report incremental cost-effectiveness ratios.	Page 7,8,9 Line 30-57, 3-57, 3-7
24 25 26 27 28 29 30 31	Characterising uncertainty	20a	<i>Single study-based economic evaluation:</i> Describe the effects of sampling uncertainty for the estimated incremental cost and incremental effectiveness parameters, together with the impact of methodological assumptions (such as discount rate, study perspective).	
32 33 34 35 36 37 38 39 40 41	Characterising heterogeneity	20b	<i>Model-based economic evaluation:</i> Describe the effects on the results of uncertainty for all input parameters, and uncertainty related to the structure of the model and assumptions.	Page 8 Line 8-52,
42 43 44 45	Discussion	21	If applicable, report differences in costs, outcomes, or cost-effectiveness that can be explained by variations between subgroups of patients with different baseline characteristics or other observed variability in effects that are not reducible by more information.	N/A
46 47 48 49 50 51 52 53 54	Study findings, limitations, generalisability, and current knowledge	22	Summarise key study findings and describe how they support the conclusions reached. Discuss limitations and the generalisability of the findings and how the findings fit with current knowledge.	Page 10, 11 Line 3-58, 3-14
55 56 57 58 59 60	Other			
	Source of funding	23	Describe how the study was funded and the role of the funder in the identification, design, conduct, and reporting of the analysis. Describe other non-monetary sources of support.	Page 11 Line 52-55
	Conflicts of interest	24	Describe any potential for conflict of interest of study contributors in accordance with journal policy. In the absence of a journal policy, we recommend authors comply with International Committee of Medical Journal Editors recommendations.	Page 11,12 Line 57, 3

For consistency, the CHEERS Statement checklist format is based on the format of the CONSORT statement checklist

The CHEERS Statement may be accessed by the publication links above.

The **ISPOR CHEERS Task Force Report** provides examples and further discussion of the 24-item CHEERS Checklist and the CHEERS Statement. It may be accessed via the *Value in Health* link or via the ISPOR Health Economic Evaluation Publication Guidelines – CHEERS: Good Reporting Practices webpage: <http://www.ispor.org/TaskForces/EconomicPubGuidelines.asp>

The citation for the CHEERS Task Force Report is:

Husereau D, Drummond M, Petrou S, et al. Consolidated health economic evaluation reporting standards (CHEERS)—Explanation and elaboration: A report of the ISPOR health economic evaluations publication guidelines good reporting practices task force. *Value Health* 2013;16:231-50.



BMJ Open

The cost-effectiveness of the MobileMums intervention to increase physical activity among mothers with young children: a Markov model informed by a randomised controlled trial



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Primary Subject Heading:	Sports and exercise medicine
Secondary Subject Heading:	Public health, Health economics, Health services research
Keywords:	Exercise, Economic evaluation, Cost effectiveness, mHealth, behaviour change

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1 **The cost-effectiveness of the *MobileMums* intervention to increase physical activity among**
2 **mothers with young children: a Markov model informed by a randomised controlled trial**

3 Edward Burn¹, Alison Marshall¹, Yvette Miller¹, Adrian G Barnett¹, Brianna Fjeldsoe², Nicholas
4 Graves¹

5 ¹ Queensland University of Technology (QUT), School of Public Health and Social Work and Institute
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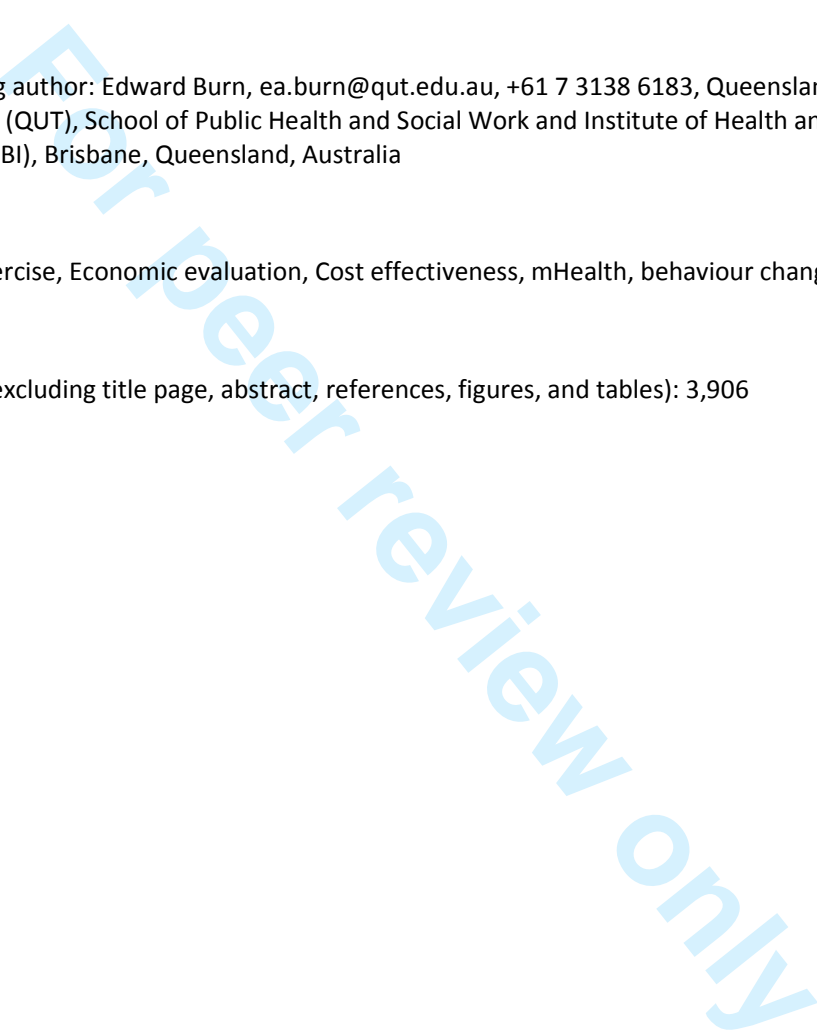
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12

13 Keywords: Exercise, Economic evaluation, Cost effectiveness, mHealth, behaviour change

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3 1 **ABSTRACT**

4
5 2 **Objectives**

6
7 3 To determine the cost-effectiveness of the *MobileMums* intervention. *MobileMums* is a 12-week
8 4 programme which assists mothers with young children to be more physically active, primarily
9 5 through the use of personalised SMS text-messages.

10
11 6 **Design**

12
13 7 A cost-effectiveness analysis using a Markov model to estimate and compare the costs and
14 8 consequences of *MobileMums* and usual care.

15
16 9 **Setting**

17
18 10 This study considers the cost-effectiveness of *MobileMums* in Queensland, Australia.

19
20 11 **Participants**

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22 12 A hypothetical cohort of over 36,000 women with a child under one year old is considered. These
23 13 women are expected to be eligible and willing to participate in the intervention in Queensland,
24 14 Australia.

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26 15 **Data sources**

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28 16 The model was informed by the effectiveness results from a 9-month two-arm community-based
29 17 randomised controlled trial undertaken in 2011. Baseline characteristics for the model cohort,
30 18 treatment effects, and resource utilisation were all informed by this trial.

31
32 19 **Main outcome measures**

33
34 20 The incremental cost per quality-adjusted life year (QALY) of *MobileMums* compared with usual
35 21 care.

36
37 22 **Results**

38
39 23 The intervention is estimated to lead to an increase of 131 QALYs for an additional cost to the health
40 24 system of 1.1 million Australian dollars (AUD). The expected incremental cost-effectiveness ratio for
41 25 *MobileMums* is 8,608 AUD per QALY gained. *MobileMums* has a 98% probability of being cost-
42 26 effective at a cost-effectiveness threshold of 64,000 AUD. Varying modelling assumptions has little
43 27 effect on this result.

44
45 28 **Conclusions**

46
47 29 At a cost-effectiveness threshold of 64,000 AUD, *MobileMums* would likely be a cost-effective use of
48 30 health care resources in Queensland, Australia.

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1 ARTICLE SUMMARY

2 Article focus

- 3 • This paper estimates the cost-effectiveness of the *MobileMums* intervention for Queensland,
4 Australia.

5 Key messages

- 6 • *MobileMums* is likely a cost-effective use of health care resources in Queensland, Australia.

7 Strengths and limitations of the study

- 8 • The analysis is informed by the results from a recent two-arm randomised controlled trial of
9 *MobileMums* and usual care.
- 10 • Uncertainty around the costs and consequences of *MobileMums* and usual care has been
11 quantified and has little effect on the conclusions of the analysis.
- 12 • The model's simplicity, with physical activity levels split into only two categories, means that
13 small changes in an individual's activity would likely not be valued.

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1 INTRODUCTION

2 Physical inactivity is a leading cause of lost years of healthy life in high-income countries, where
3 chronic diseases are a leading cause of mortality and morbidity.[1] An insufficient level of physical
4 activity, defined as less than 30 minutes of moderate- to vigorous-intensity physical activity on at
5 least five days a week, is directly associated with a number of diseases including coronary heart
6 disease, type 2 diabetes, breast cancer and colon cancer.[2] Physical inactivity is also indirectly linked
7 to the negative health consequences of high body mass and high blood pressure, which include
8 many of the aforementioned chronic conditions.[1]

9 Fifty-seven percent of Australia's adult population were insufficiently active in 2011–12.[3] Begg et
10 al.[4] estimate that 6.6% of the total disease burden in Australia is caused by physical inactivity,
11 explaining around 24% of both cardiovascular disease and diabetes, and around 6% of all cancers.
12 Based on these results, Cadilhac et al.[5] estimate that each year insufficient physical activity causes
13 45,000 new cases of disease which are associated with a loss of 174,000 disability-adjusted life-years
14 in Australia. Inequalities in activity levels exist, with inactivity more likely in older people, those of
15 lower socioeconomic status, those outside of major cities, and women.[6] Indeed, women with
16 young children are more likely to be physically inactive than both women with no children[7, 8] and
17 women with older children,[9, 10] and it is this group who are the focus of the *MobileMums*
18 intervention evaluated here.

19 The *MobileMums* programme is a 12-week intervention designed to assist women with young
20 children increase their physical activity. The intervention's development has previously been
21 discussed.[11] *MobileMums* is initiated with a face-to-face consultation between the participant and
22 a trained behavioural counsellor. The consultation is used to establish rapport between the
23 participant and counsellor, to gather information required to tailor and personalise text-message
24 content and to initiate the process of behaviour change through personalised goal setting.[11]
25 Participants receive five text-messages per week during weeks 1 to 4 of the intervention and four
26 text-messages per week during weeks 5 to 12. The messages are personalised based on the
27 participant's name, the name of their counsellor, the participant's goals and their expected rewards
28 and outcomes for achieving these goals. In addition to receiving the text-messages, participants also
29 have access to a programme handbook, an on-line exercise directory and a Facebook® group. They
30 also receive a refrigerator magnet for self-monitoring and standard information brochures on
31 physical activity. As well as requiring behavioural counsellors, delivering the intervention requires
32 programme coordinators to manage the counsellors, assign participants to a counsellor, oversee the
33 text-messages being sent and received, and to organise sending other programme materials to
34 participants.

35 In Australia health resources are generally allocated on a state or territory basis[12] and so a
36 decision on whether to fund *MobileMums* would be made by individual states or territories. The
37 alternative course of action would be to provide usual care. The purpose of this paper is to consider
38 this decision of whether to provide *MobileMums* or usual care from the perspective of Queensland
39 Health, the government department responsible for managing the public health system in
40 Queensland, Australia.

41 It is assumed that the overarching objective of Queensland Health is to maximise population health
42 subject to their budget. This, therefore, supports the need for an economic evaluation of
43 *MobileMums* to consider the intervention's value for money. While this evaluation is specific to the
44 funding decision faced by Queensland Health, it can be expected that the results reported here will
45 be directly applicable to similar decisions in other Australian states and territories. The
46 generalisability of the results to other high-income countries may be more limited, for example
47 because of differences in the volume and cost of resource use between countries,[13] but the results
48 are likely to be of relevance for all countries experiencing high levels of physical inactivity.

1 METHODS

2 Study population

3 It is expected that *MobileMums* would be offered to all women with children under one year old in
4 Queensland, Australia, regardless of their current level of physical activity. With 61,020 women
5 giving birth in Queensland in 2010 and with 413 fetal deaths,[14] the number of women eligible for
6 the intervention in 2011 was 60,607. We expect around 60% of women who were offered the
7 intervention would participate. This is based on the randomised control trial conducted in 2011,[15,
8 16] where of the 511 women assessed for eligibility 306 commenced the baseline assessment. This
9 gives 36,364 women in Queensland who would be eligible and willing to participate in the
10 *MobileMums* intervention in 2011, and this is the baseline cohort size considered for this study. This
11 participation estimate of 60% is likely conservative, as the program would not include the time-
12 consuming assessments that were undertaken purely for research purposes. Given the uncertainty
13 around this estimate, we consider the effects of reducing this cohort size by 50% to 18,182 women,
14 and increasing it by 50% to 54,546 women.

15 Modelling health outcomes and costs

16 A state-based Markov model provides the framework for this analysis and is used to estimate the
17 costs and consequences associated with *MobileMums* and usual care. The development of the
18 model has been informed by the effectiveness results from a 9-month two-arm community-based
19 randomised controlled trial undertaken in 2011.[15] 263 women from around Caboolture,
20 Queensland, received usual care (n=130) or the *MobileMums* intervention (n=133).[16] Data were
21 collected prior to the intervention being received (time 1 – T1: 0 months), after the 12-week
22 *MobileMums* programme was completed (T2: 3 months) and again after a further 6 month no-
23 contact maintenance period (T3: 9 months). The main efficacy findings from the trial have been
24 reported in detail by Fjeldsoe et al.[15] Briefly, while the intervention had a large and statistically
25 significant beneficial effect on activity levels between T1 and T2, there was no statistically significant
26 effect at T3, although the estimated increase in activity remained positive.

27 These results suggest that *MobileMums* can only be expected to have an effect on activity levels in
28 the short-term. Under the assumption that only long-term changes in activity levels affect the risk of
29 an individual developing future chronic health conditions, the time horizon of the model used here is
30 two years. There are just two states in the model with participants either 'physically inactive' or
31 'physically active', and an individual is required to be undertaking 30 minutes of moderate- to
32 vigorous-intensity physical activity on at least five days a week to be classified as active. An effective
33 physical inactivity intervention increases the likelihood that inactive individuals become active
34 (tpImprove) and/or reduces the likelihood that active individuals become inactive (tpRegress).
35 Individuals move between states using monthly cycles, and spending a month as active or inactive
36 has a cost and health outcome associated with it (described below). An outline of the model is
37 shown in figure 1.

38 Health effects

39 To estimate the value for money of *MobileMums*, health effects are expressed in terms of quality-
40 adjusted life-years (QALYs). Given the design of the model used, *MobileMums* can only affect health-
41 related quality-of life, with no mortality effects. The health-related quality-of-life associated with
42 being physically active or inactive was estimated from participants' responses to SF-12
43 questionnaires at T1, T2 and T3. Mean imputation was used for missing questionnaire data at each
44 time period (1% of participants at T1, 13% at T2, and 32% at T3). Two errors were made in the
45 printing of the SF-12 questionnaires. First, at T1 one question from the SF-12 was omitted in error,
46 and so scores were randomly generated for this dimension. Second, one of the questions offered

1 one too many potential responses at all time periods, and so those who selected this superfluous
2 response were evenly split and moved into either the next best or next worst choice.

3 Questionnaire responses were transformed into the EQ-5D, a standardised measure of health
4 outcomes, using an algorithm provided by Gray et al.[17] which provides utility scores close to group
5 means, especially for individuals not in poor health. This approach generates health-related quality-
6 of-life scores associated with spending a year as physically active or inactive which could range
7 between 0 (equivalent to death) and 1 (equivalent to perfect health). Monthly scores were simply
8 one-twelfth of this. QALYs and costs in the second year were discounted at 5% following the relevant
9 guidelines.[18, 19]

10 Costing perspective

11 This study is intended to inform decision making regarding resource allocation across the health
12 system in Queensland. Consequently, a health system perspective is taken, with only the costs borne
13 by the health system included.[20] While costs falling outside of the health system, such as the cost
14 to participants of purchasing goods or services related to undertaking exercise, may be of interest,
15 they are not are not of direct relevance given the perspective taken here and so have been excluded.
16 All costs reported have been inflated to 2014 AUD and any costs accruing in the second year of the
17 model have been discounted at 5% in line with guidelines for submission to the Medical Services
18 Advisory Committee[18] and the Pharmaceutical Benefits Advisory Committee[19] in Australia.

19 The estimated cost of providing *MobileMums* across Queensland is based on the costs of delivering
20 the intervention in the randomised controlled trial.[16] To extrapolate these costs, assumptions
21 have been required concerning number of behavioural counsellors and programme coordinators
22 required for widespread dissemination. It is assumed that counsellors could be assigned to 30
23 participants per week, while coordinators could cover five counsellors and their participants per
24 week. Counsellors and coordinators are assumed to be health practitioners with, on average, 2 years
25 in their current role and, in terms of Queensland Health's salary scale,[21] paid at a HP3 (6,092 AUD
26 per month) and a HP4 (8,150 AUD per month) level, respectively. The costs of developing the
27 computer programme to send text-messages, sending the text- messages and providing other
28 programme materials are assumed to be the same as in the trial.

29 In addition to the costs of delivering the intervention, the costs relating to participants health care
30 use have also been incorporated. If the intervention reduces future health care use then the cost
31 saving associated will counterbalance the cost of providing *MobileMums*. Participants' reported their
32 use of health care services at T1, T2 and T3 and the average use of those who were physically active
33 and inactive were estimated. As with the SF-12, mean imputation was used for missing data (0% of
34 participants at T1, 12% at T2, and 31% at T3). The associated costs were estimated using the
35 Medicare Benefits Schedule for July 2011[22] and Australian hospital statistics.[23]

36 Expected effects

37 The purpose of this evaluation is to estimate the expected value for money of the *MobileMums*
38 intervention, which is indicated by the incremental cost effectiveness ratio (ICER) for *MobileMums*.
39 This ratio is given by the expected (mean) change in costs associated with the intervention divided
40 by the expected change in QALYs.[24] This ratio can then be compared against a cost-effectiveness
41 threshold. The threshold used here is 64,000 AUD which is based on the estimate by Shirowa et
42 al.[25] of the willingness-to-pay for an additional QALY in Australia. If the cost effectiveness ratio for
43 *MobileMums* falls below 64,000 AUD then the intervention can be expected to be 'cost-effective'.

45 Uncertainty

Parameter uncertainty was quantified using Monte Carlo simulations, with the model evaluated 10,000 times, with each simulation involving random draws from each parameter distribution. These distributions are based on the trial data, with transition probabilities and QALYs given beta distributions, while health care utilisation and its associated costs assigned gamma distributions and uniform distributions respectively. This produces 10,000 pairs of incremental costs and effects, and these are presented on a cost-effectiveness plane along with the expected costs and effects and the cost-effectiveness threshold. The probability that *MobileMums* is cost-effective is given by the proportion of pairs of incremental costs and benefits at which the intervention would be considered cost-effective. The percentage of pairs where the change in QALYs is positive and the change in costs is negative is equal to the probability that *MobileMums* is cost-saving. It is also possible to estimate credible intervals around the expected change in costs and QALYs by taking percentiles of the costs and QALYs produced in the Monte Carlo analysis.[26]

Uncertainty also exists surrounding the modelling assumptions. In particular, three areas stand out for particularly onerous assumptions: transition probabilities after nine months (T3), the number of programme counsellors and coordinators required, and the number of women who would be eligible and willing to participate in the trial. The assumptions used for these areas are the subject of scenario analyses. First, the model is reassessed under the assumption that after T3 all programme activity effects are mitigated entirely, and then again under the assumption that the estimated treatment effect observed at T3 is maintained for a further 15 months, at which point the treatment effect is entirely mitigated. Second, the number of counsellors and coordinators required is increased by 50% and reduced by 50%. And lastly, increasing the cohort size by 50% and reducing it by 50% is considered.

RESULTS

Average effects

The input variables are detailed in Table 1. Around 70% of the women entering the model at T1 are expected to be physically inactive. Under usual care there is a small and gradual expected positive net movement from inactive to active over time, and after 24 months around 35 percent of the initial cohort are expected to be in the active state. The expected effect of *MobileMums* is to cause a substantial increase in physical activity over the duration of the 12-week intervention, with 50 percent of the participants expected to be in the active state at T2. Following the intervention gradual reduction in the proportion of active participants each month is expected, until after 16 months whereby the effect of *MobileMums* has been mitigated entirely. These expected changes in activity levels are presented in figure 2.

		Mean	Standard error	Distribution
Probability of being inactive at T1		0.71	0.03	Beta
	Usual Care (T1 to T2)	0.20	0.04	Beta
Probability of moving from inactive to active (tplmprove)	MobileMums (T1 to T2)	0.35	0.05	Beta
	Usual Care (T2 to T3)	0.14	0.04	Beta
	MobileMums (T2 to T3)	0.26	0.05	Beta
	Usual Care (T1 to T2)	0.43	0.08	Beta

Probability of moving from active to inactive (tpRegress)	MobileMums (T1 to T2)	0.18	0.06	Beta
	Usual Care (T2 to T3)	0.33	0.07	Beta
	MobileMums (T2 to T3)	0.45	0.06	Beta
Monthly health care utilisation costs (2014 AUD per participant)	Physically active	53.30	39.20	Uniform and Gamma*
	Physically inactive	75.40	32.62	Uniform and Gamma*
Cost of delivering MobileMums (2014 AUD per participant)		62.64	13.08	Uniform
EQ5D score	Inactive	0.78	0.01	Beta
	Active	0.81	0.01	Beta

* A uniform distribution for health care costs and a gamma distribution for health care utilisation

Table 1 Input variables for the Markov model

Time spent in the active state is expected to provide slightly higher utility than time spent in the inactive state, with a year spent as physically active associated with a health-related quality-of-life score of 0.81 compared with 0.78 for a year spent as physically inactive. As *MobileMums* is expected to increase the total number of months spent by the cohort in the active state, the intervention can therefore also be expected to improve health-related quality-of-life. Over 24 months, *MobileMums* is estimated to lead to an increase of 131 QALYs across the cohort of 36,364 women or, equivalently, 0.0036 QALYs per person.

The expected cost of delivering *MobileMums* to the cohort is 2,277,950 AUD, or 63 AUD per person. The breakdown for this cost is shown in Table 2. Almost half the cost is due to the behavioural counsellors. While there are significant costs associated with setting up the programme, such as the development of a computer programme to send personalised text-messages, these costs are of little consequence with a cohort of 36,364 women.

		Total cost (AUD)	Cost per participant (AUD)
Development of the computer program for sending automated text-messages		14,204	0.39
Sending text-messages		620,999	17.08
Providing additional programme materials		621,388	17.08
Behavioural counsellors (24 required)	Salaries	438,628	12.06
	Equipment	36,231	0.99
	Travel costs	388,368	10.68
Programme coordinators (5 required)	Salaries	122,248	3.36
	Office costs	35,885	0.98
Total		2,277,950	62.64

Table 2 Estimated costs of delivering MobileMums in Queensland, Australia, in 2014 AUD

Based on data from the trial it is estimated that active individuals cost the health system 53 AUD a month on average, while inactive individuals cost 75 AUD per month. As *MobileMums* reduces the average number of months spent in the inactive state, the cost of delivering the intervention is

1 partly offset by an expected reduction in these health care costs. As a result, the total expected
2 incremental cost to the health system from introducing *MobileMums* is 1,124,209 million AUD, or 31
3 AUD per person.

4 With an expected (mean) incremental cost of 1,124,209 million AUD and an incremental
5 improvement in health outcomes of 130 QALYs, the cost-effectiveness ratio for *MobileMums* is
6 approximately 8,608 AUD per QALY. At a cost-effectiveness threshold of 64,000 AUD, the
7 intervention can therefore be expected to be cost-effective.

8 **Uncertainty**

9 The pairs of incremental costs and consequences produced by the Monte Carlo simulation are
10 shown in figure 3. *MobileMums* has a 98% probability of being cost-effective at a threshold of 64,000
11 AUD (98% of simulations are below the sloped threshold line). The intervention has around a 19%
12 probability of being cost-saving and health-improving (19% of simulations are in the south-east
13 quadrant).

14 The results from the scenario analyses are presented in Table 3. None of the changes in assumptions
15 had any substantial effect on the probability that *MobileMums* is cost-effective at a threshold of
16 64,000 AUD, which remained over 95% under all scenarios. Changes in the assumption surrounding
17 the maintenance of changes in activity levels into the future did, however, have a substantial effect
18 on the probability that *MobileMums* is cost-saving. If changes were entirely mitigated after 9 months
19 (T3) then the intervention would only have a 1% chance of being cost-saving, while if the observed
20 difference in activity levels at T3 was maintained for up to 24 months *MobileMums* would have a
21 39% probability of being cost-saving.

Scenario	Mean change (95% credible interval) caused by <i>MobileMums</i>		Expected (mean) ICER	Probability <i>MobileMums</i> is	
	Total costs (AUD)	QALYs		Cost- effective*	Cost- saving
Base case	1,124,209 (1,102,044 to 1,146,374)	131 (126 to 135)	8,608	98%	19%
Changes in activity levels entirely mitigated at 9 months (T3)	1,363,736 (1,363,736 to 1,372,716)	103 (102 to 105)	13,186	97%	1%
Changes in activity levels maintained from 9 months to 24 months	240,173 (217,066 to 263,281)	232 (227 to 236)	1,037	97%	39%
Number of counsellors and coordinators required increased by 50%	1,456,518 (1,434,365 to 1,478,670)	131 (126 to 135)	11,152	98%	15%
Number of counsellors and coordinators required reduced by 50%	823,527 (802,374 to 844,680)	130 (127 to 134)	6,306	98%	24%
Cohort size increased by 50% to 54,546 women	1,643,613 (1,610,282 to 1,676,943)	196 (190 to 202)	8,390	98%	20%
Cohort size reduced by 50% to 18,182	585,020 (574,005 to 596,035)	65 (63 to 67)	8,959	98%	17%

22 ICER: incremental cost-effectiveness ratio

23 * at a threshold of 64,000 AUD

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3 **Table 3 Results from the scenario analyses which examine whether the intervention remains cost-**
4 **effective for a range of assumptions.**

5
6 **DISCUSSION**

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8 **Principal findings**

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10 The results from this study suggest the *MobileMums* intervention would be a cost-effective use of
11 health resources in Queensland, Australia. While the expected health benefits of the intervention
12 are modest, with an average health improvement of only 0.0036 additional QALYs, the cost of the
13 intervention, after taking into account reduced health care utilisation, is low at just 31 AUD per
14 person. Consequently, the expected cost-effectiveness ratio is 8,608 AUD per QALY, which is far
15 below the estimated willingness to pay for an additional QALY in Australia of 64,000 AUD.[5] Neither
16 parameter nor modelling uncertainty have a substantial effect on this conclusion.

17
18 **Study strengths and limitations**

19
20 This study has been largely informed by the results of a recent 9-month randomised controlled trial.
21 By using a decision-analytic model, it was possible to extrapolate these findings to consider the costs
22 and consequences of *MobileMums* if it were offered in practice to a large cohort of women and to
23 account for expected costs and consequences beyond the trial's time horizon. Although several
24 assumptions underpin this approach, they were subjected to sensitivity analyses which have shown
25 them to have little effect on the overall conclusion that the intervention is likely cost-effective.

26
27 With the effect of *MobileMums* on activity levels expected to last for less than two years, and under
28 the conservative assumption that only longer-term changes in activity will affect the risk of an
29 individual developing future chronic health conditions, the model used here is only required to have
30 a short-time horizon. However, if *MobileMums* does prompt some long-term improvements in
31 physical activity then the benefits of the intervention will be understated. In addition, while the
32 simplicity of the model used has advantages, particularly for ease of exposition, there are
33 limitations. In particular, only those changes in activity enough to move participants between the
34 two states of the model are captured, with any changes of activity levels within a state overlooked.

35
36 **Comparison with other studies**

37
38 While a number of economic evaluations of physical activity interventions have been undertaken,
39 there is significant methodological heterogeneity making direct comparisons difficult in many cases.
40 Of those studies which use a similar methodology, i.e. using a decision-analytic model as a
41 framework for analysis with the cost per quality-adjusted (or disability-adjusted) life-year estimated,
42 many of the interventions are found to be cost-effective. For example, the 'green prescription'
43 programme in New Zealand is found to have an incremental cost of 3,000 AUD per QALY,[27] while
44 Cobiac et al.[28] found a pedometer intervention in Australia to be cost-saving and an internet-
45 based intervention to have an incremental cost of 4,000 AUD per QALY. However, the cost-
46 effectiveness of such physical activity intervention is by no means guaranteed. Cobiac et al.[28] find
47 that a referral to exercise scheme has an incremental cost of 100,000 AUD per QALY, while a 8-week
48 social support programme was found by Roux et al.[29] to have an incremental cost of 95,000 AUD
49 per QALY.

50
51 Interestingly, while these other studies typically assumed that the benefit from physical activity
52 interventions was only through reducing the incidence of future chronic diseases, this study
53 demonstrates that they are also likely to produce an immediate improvement in health-related
54 quality-of-life. Active participants in the trial of *MobileMums* reported higher health-related quality-
55 of-life than those who were physically inactive, so that *MobileMums* is expected to be cost-effective
56 even without any long-term changes in activity levels. With this immediate improvement in quality-
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of-life missed in most analyses of physical activity interventions, these studies may well have underestimated the full benefits from effective physical activity interventions.

Policy implications

Health prevention programmes in Queensland, and across Australia, have recently been going through a period of disinvestment. However, if the goal of the health system is to maximise health outcomes then there seems little reason for prevention health interventions to be treated any differently to a curative intervention. While the *MobileMums* intervention can only be expected to provide a modest improvement in health-related quality of life for the average participant, it does provide a meaningful improvement in terms of population health. Health care resources should be directed to those uses which provide best value for money, i.e., the greatest improvement in health outcomes for a given level of cost. Given the relatively low cost of delivering *MobileMums*, the intervention can be expected to provide good value for money and is likely a cost-effective use of health care resources given the estimated willingness-to-pay for an additional QALY in Australia.

Providing the intervention across Australia can be expected to provide a similar level of value for money. Levels of physical inactivity are similar across Australia[3] and costs, such as those associated with the counsellors and coordinators, should also be comparable. While differences in costs make it more difficult to generalise our results to other countries, the results of this study are still likely to be of relevance in many high-income countries with similarly high levels of physical inactivity. It would seem likely that a programme such as *MobileMums* would provide good value for money if provided in such countries. However, this is an area where further research is required.

CONCLUSION

MobileMums can be expected to be a cost-effective use of health resources in Queensland, Australia. If the objective of Queensland Health is to maximise population health outcomes given a finite budget, then *MobileMums* should be freely provided.

Figure 1 Outline of the Markov model used to estimate the costs and effects of *MobileMums* and usual care

Figure 2 The expected (mean) effect of *MobileMums* on activity levels

Figure 3 Cost-effectiveness plane for *MobileMums* versus usual care with 1,000 sets of incremental costs and effects randomly drawn from the 10,000 Monte Carlo simulations along with the expected (mean) incremental costs and effects and a cost-effectiveness threshold of 64,000 AUD

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AUTHOR CONTRIBUTIONS

Conceived and designed the experiments: AM, YM, BF, AB, NG

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1 Performed the experiments: AM, YM, AB, BF, NG

2 Analysed the data: EB, NG

3 Wrote the paper: EB, AM, YM, AB, NG

4 **FUNDING INTERESTS**

5 This study was supported by a National Health and Medical Research Council project grant number
6 614244.

7 **COMPETING INTERESTS**

8 None

9 **ETHICS APPROVAL**

10 The trial used to inform this analysis was registered with the Australian Clinical Trials Registry
11 (ACTRN12611000481976). Ethical clearance was obtained through the Queensland University of
12 Technology Human Research Ethics Committee (Application number 0900001407).

13 **PROVENANCE AND PEER REVIEW**

14 Not commissioned; externally peer reviewed

15 **DATA SHARING STATEMENT**

16 The full data set is available by emailing the first author of the study.

For peer review only

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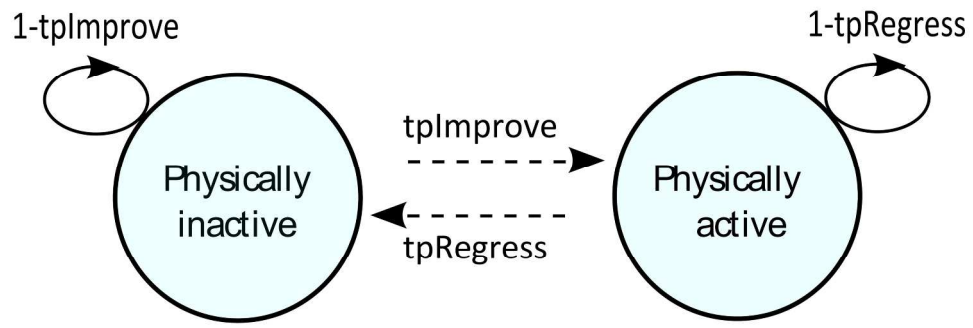


Figure 1 Outline of the Markov model used to estimate the costs and effects of MobileMums and usual care
115x41mm (600 x 600 DPI)

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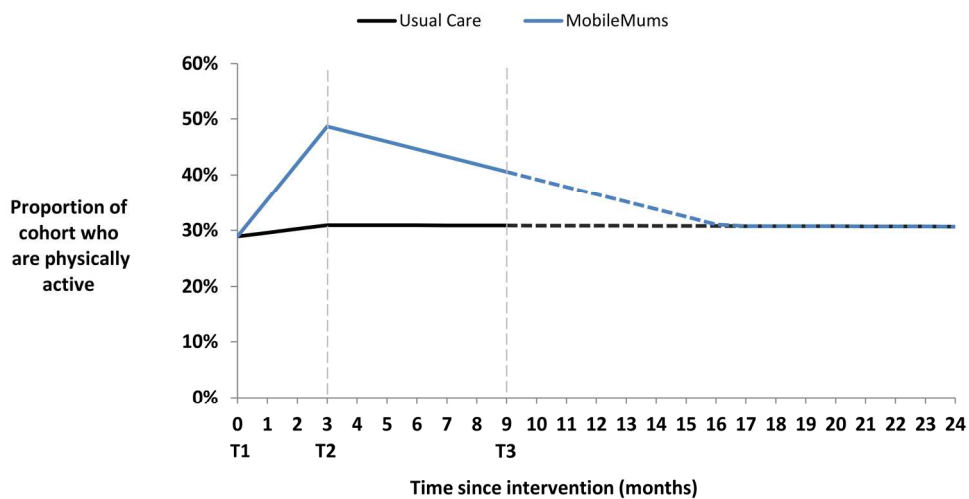


Figure 2 The expected (mean) effect of MobileMums on activity levels
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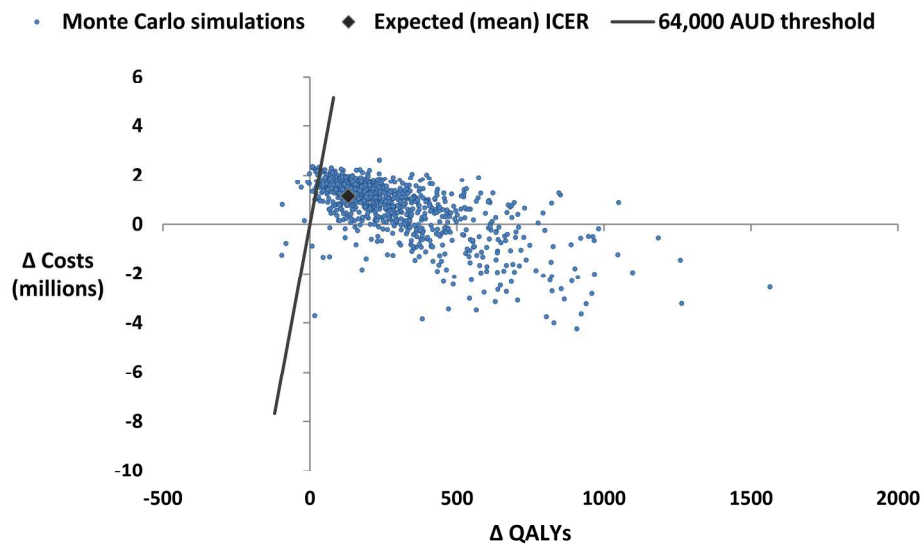


Figure 3 Cost-effectiveness plane for MobileMums versus usual care with 1,000 sets of incremental costs and effects randomly drawn from the 10,000 Monte Carlo simulations along with the expected (mean) incremental costs and effects and a cost-effectiveness threshold of 64,000 AUD
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Review only

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The CHEERS Checklist is part of the CHEERS Statement. The CHEERS Statement has been endorsed and co-published by the following journals:

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- [BMC Medicine 2013; 11:80](#)
- [BMJ 2013;346:f1049](#)
- [Clinical Therapeutics 27 March 2013 \(Article in Press DOI: 10.1016/j.clinthera.2013.03.003\)](#)
- [Cost Effectiveness and Resource Allocation 2013 11:6.](#)
- [The European Journal of Health Economics 2013 Mar 26. \[Epub ahead of print\]](#)
- International Journal of Technology Assessment in Health Care
- [Journal of Medical Economics 2013 Mar 25. \[Epub ahead of print\]](#)
- [Pharmacoeconomics 2013 Mar 26. \[Epub ahead of print\]](#)
- [Value in Health 2013 March - April;16\(2\):e1-e5](#)

CHEERS Checklist

Items to include when reporting economic evaluations of health interventions

Section/item	Item No	Recommendation	Reported on page No/ line No
Title and abstract			
Title	1	Identify the study as an economic evaluation or use more specific terms such as “cost-effectiveness analysis”, and describe the interventions compared.	Page 1 Lines 1,2
Abstract	2	Provide a structured summary of objectives, perspective, setting, methods (including study design and inputs), results (including base case and uncertainty analyses), and conclusions.	Page 2-3 Lines 16-42
Introduction			
Background and objectives	3	Provide an explicit statement of the broader context for the study. Present the study question and its relevance for health policy or practice decisions.	Pages 4-5 Lines 61-109
Methods			
Target population and subgroups	4	Describe characteristics of the base case population and subgroups analysed, including why they were chosen.	Page 6 Lines 111-121
Setting and location	5	State relevant aspects of the system(s) in which the decision(s) need(s) to be made.	Page 3 Lines 96-109
Study perspective	6	Describe the perspective of the study and relate this to the costs being evaluated.	Page 8 Lines 164-189
Comparators	7	Describe the interventions or strategies being compared and state why they were chosen.	Page 5 Lines 96-98
Time horizon	8	State the time horizon(s) over which costs and consequences are being evaluated and say why appropriate.	Pages 6-7 Lines 134-137
Discount rate	9	Report the choice of discount rate(s) used for costs and	Pages 8, Lines 162-163, 171-172



1		outcomes and say why appropriate.	
2			
3	Choice of health	10 Describe what outcomes were used as the measure(s) of	Page 9
4	outcomes	benefit in the evaluation and their relevance for the type of	Lines 194-200
5		analysis performed.	
6	Measurement of	11a <i>Single study-based estimates</i> : Describe fully the design	Pages 6,7
7	effectiveness	features of the single effectiveness study and why the single	Lines 123-144
8		study was a sufficient source of clinical effectiveness data.	
9		11b <i>Synthesis-based estimates</i> : Describe fully the methods used for	
10		identification of included studies and synthesis of clinical	
11		effectiveness data.	
12	Measurement and	12 If applicable, describe the population and methods used to	Pages 7,8
13	valuation of preference	elicit preferences for outcomes.	Lines 150-163
14	based outcomes		
15	Estimating resources	13a <i>Single study-based economic evaluation</i> : Describe approaches	
16	and costs	used to estimate resource use associated with the alternative	
17		interventions. Describe primary or secondary research methods	
18		for valuing each resource item in terms of its unit cost.	
19		Describe any adjustments made to approximate to opportunity	
20		costs.	
21		13b <i>Model-based economic evaluation</i> : Describe approaches and	
22		data sources used to estimate resource use associated with	
23		model health states. Describe primary or secondary research	Pages 8,9
24		methods for valuing each resource item in terms of its unit	Lines 173-189
25		cost. Describe any adjustments made to approximate to	
26		opportunity costs.	
27	Currency, price date,	14 Report the dates of the estimated resource quantities and unit	
28	and conversion	costs. Describe methods for adjusting estimated unit costs to	Page 8
29		the year of reported costs if necessary. Describe methods for	Lines 170-172
30		converting costs into a common currency base and the	
31		exchange rate.	
32	Choice of model	15 Describe and give reasons for the specific type of decision-	Page 9
33		analytical model used. Providing a figure to show model	Lines 122-144
34		structure is strongly recommended.	
35	Assumptions	16 Describe all structural or other assumptions underpinning the	Pages 6,8
36		decision-analytical model.	Lines 135-136,
37			174-176
38	Analytical methods	17 Describe all analytical methods supporting the evaluation. This	
39		could include methods for dealing with skewed, missing, or	Page 7,9
40		censored data; extrapolation methods; methods for pooling	Lines 148-163,
41		data; approaches to validate or make adjustments (such as half	187-189
42		cycle corrections) to a model; and methods for handling	
43		population heterogeneity and uncertainty.	
44	Results		
45	Study parameters	18 Report the values, ranges, references, and, if used, probability	
46		distributions for all parameters. Report reasons or sources for	Page 11
47		distributions used to represent uncertainty where appropriate.	Line 236
48		Providing a table to show the input values is strongly	
49		recommended.	
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1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41	Incremental costs and outcomes Characterising uncertainty Characterising heterogeneity Discussion Study findings, limitations, generalisability, and current knowledge Other Source of funding Conflicts of interest	19 20a 20b 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41	For each intervention, report mean values for the main categories of estimated costs and outcomes of interest, as well as mean differences between the comparator groups. If applicable, report incremental cost-effectiveness ratios. <i>Single study-based economic evaluation:</i> Describe the effects of sampling uncertainty for the estimated incremental cost and incremental effectiveness parameters, together with the impact of methodological assumptions (such as discount rate, study perspective). <i>Model-based economic evaluation:</i> Describe the effects on the results of uncertainty for all input parameters, and uncertainty related to the structure of the model and assumptions. If applicable, report differences in costs, outcomes, or cost-effectiveness that can be explained by variations between subgroups of patients with different baseline characteristics or other observed variability in effects that are not reducible by more information. Summarise key study findings and describe how they support the conclusions reached. Discuss limitations and the generalisability of the findings and how the findings fit with current knowledge. Describe how the study was funded and the role of the funder in the identification, design, conduct, and reporting of the analysis. Describe other non-monetary sources of support. Describe any potential for conflict of interest of study contributors in accordance with journal policy. In the absence of a journal policy, we recommend authors comply with International Committee of Medical Journal Editors recommendations.	Page 12 Lines 256-259 Pages 12,13 Lines 260-276 N/A Page 13-16 Lines 277-344 Page 17 Lines 367-369 Page 17 Lines 370-371
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For consistency, the CHEERS Statement checklist format is based on the format of the CONSORT statement checklist

The CHEERS Statement may be accessed by the publication links above.

The **ISPOR CHEERS Task Force Report** provides examples and further discussion of the 24-item CHEERS Checklist and the CHEERS Statement. It may be accessed via the *Value in Health* link or via the ISPOR Health Economic Evaluation Publication Guidelines – CHEERS: Good Reporting Practices webpage: <http://www.ispor.org/TaskForces/EconomicPubGuidelines.asp>

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The cost-effectiveness of the MobileMums intervention to increase physical activity among mothers with young children: a Markov model informed by a randomised controlled trial



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1 **The cost-effectiveness of the *MobileMums* intervention to increase physical activity among**
2 **mothers with young children: a Markov model informed by a randomised controlled trial**

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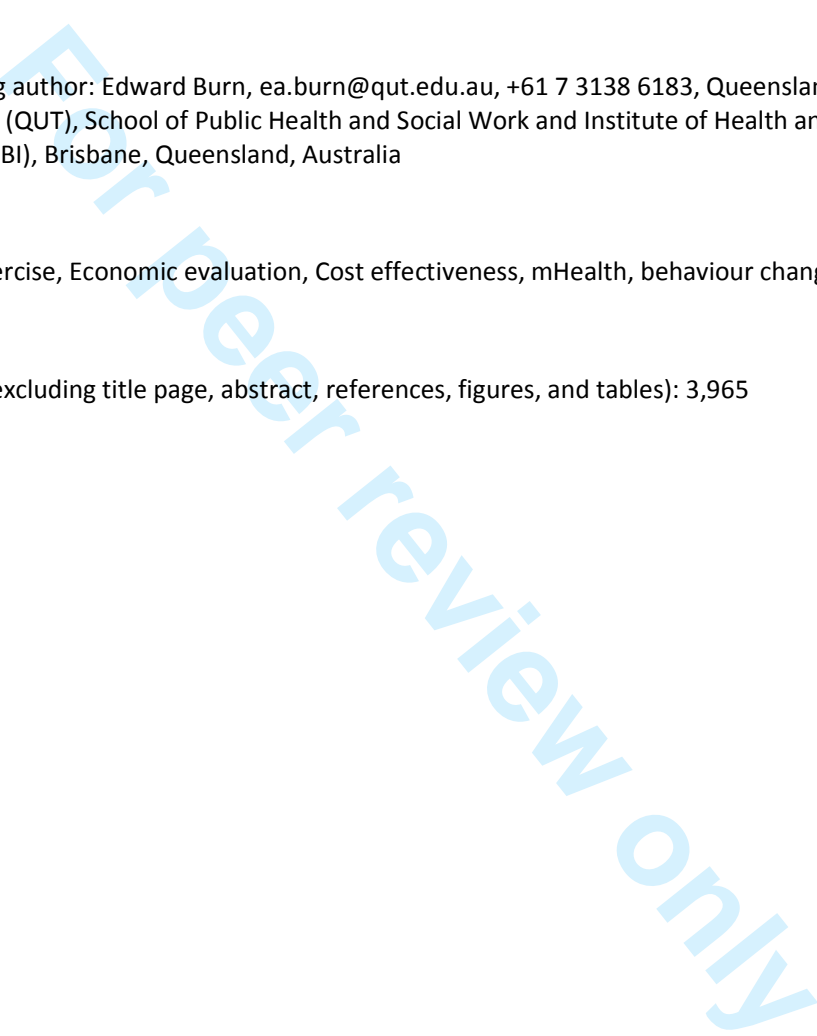
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13 Keywords: Exercise, Economic evaluation, Cost effectiveness, mHealth, behaviour change

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1
2
3 1 **ABSTRACT**

4
5 2 **Objectives**

6
7 3 To determine the cost-effectiveness of the *MobileMums* intervention. *MobileMums* is a 12-week
8 4 programme which assists mothers with young children to be more physically active, primarily
9 5 through the use of personalised SMS text-messages.

10
11 6 **Design**

12
13 7 A cost-effectiveness analysis using a Markov model to estimate and compare the costs and
14 8 consequences of *MobileMums* and usual care.

15
16 9 **Setting**

17
18 10 This study considers the cost-effectiveness of *MobileMums* in Queensland, Australia.

19
20 11 **Participants**

21
22 12 A hypothetical cohort of over 36,000 women with a child under one year old is considered. These
23 13 women are expected to be eligible and willing to participate in the intervention in Queensland,
24 14 Australia.

25
26 15 **Data sources**

27
28 16 The model was informed by the effectiveness results from a 9-month two-arm community-based
29 17 randomised controlled trial undertaken in 2011 and registered retrospectively with the Australian
30 18 Clinical Trials Registry (ACTRN12611000481976). Baseline characteristics for the model cohort,
31 19 treatment effects, and resource utilisation were all informed by this trial.

32
33 20 **Main outcome measures**

34
35 21 The incremental cost per quality-adjusted life year (QALY) of *MobileMums* compared with usual
36 22 care.

37
38 23 **Results**

39
40 24 The intervention is estimated to lead to an increase of 131 QALYs for an additional cost to the health
41 25 system of 1.1 million Australian dollars (AUD). The expected incremental cost-effectiveness ratio for
42 26 *MobileMums* is 8,608 AUD per QALY gained. *MobileMums* has a 98% probability of being cost-
43 27 effective at a cost-effectiveness threshold of 64,000 AUD. Varying modelling assumptions has little
44 28 effect on this result.

45
46 29 **Conclusions**

47
48 30 At a cost-effectiveness threshold of 64,000 AUD, *MobileMums* would likely be a cost-effective use of
49 31 health care resources in Queensland, Australia.

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1 **ARTICLE SUMMARY**

2 **Article focus**

- 3 • This paper estimates the cost-effectiveness of the *MobileMums* intervention for Queensland,
4 Australia.

5 **Key messages**

- 6 • *MobileMums* is likely a cost-effective use of health care resources in Queensland, Australia.

7 **Strengths and limitations of the study**

- 8 • The analysis is informed by the results from a recent two-arm randomised controlled trial of
9 *MobileMums* and usual care.
10 • Uncertainty around the costs and consequences of *MobileMums* and usual care has been
11 quantified and has little effect on the conclusions of the analysis.
12 • The model's simplicity, with physical activity levels split into only two categories, means that
13 small changes in an individual's activity would likely not be valued.

Peer review only

1 INTRODUCTION

2 Physical inactivity is a leading cause of lost years of healthy life in high-income countries, where
3 chronic diseases are a leading cause of mortality and morbidity.[1] An insufficient level of physical
4 activity, defined as less than 30 minutes of moderate- to vigorous-intensity physical activity on at
5 least five days a week, is directly associated with a number of diseases including coronary heart
6 disease, type 2 diabetes, breast cancer and colon cancer.[2] Physical inactivity is also indirectly linked
7 to the negative health consequences of high body mass and high blood pressure, which include
8 many of the aforementioned chronic conditions.[1]

9 Fifty-seven percent of Australia's adult population were insufficiently active in 2011–12.[3] Begg et
10 al.[4] estimate that 6.6% of the total disease burden in Australia is caused by physical inactivity,
11 explaining around 24% of both cardiovascular disease and diabetes, and around 6% of all cancers.
12 Based on these results, Cadilhac et al.[5] estimate that each year insufficient physical activity causes
13 45,000 new cases of disease which are associated with a loss of 174,000 disability-adjusted life-years
14 in Australia. Inequalities in activity levels exist, with inactivity more likely in older people, those of
15 lower socioeconomic status, those outside of major cities, and women.[6] Indeed, women with
16 young children are more likely to be physically inactive than both women with no children[7, 8] and
17 women with older children,[9, 10] and it is this group who are the focus of the *MobileMums*
18 intervention evaluated here.

19 The *MobileMums* programme is a 12-week intervention designed to assist women with young
20 children increase their physical activity. The intervention's development has previously been
21 discussed.[11] *MobileMums* is initiated with a face-to-face consultation between the participant and
22 a trained behavioural counsellor. The consultation is used to establish rapport between the
23 participant and counsellor, to gather information required to tailor and personalise text-message
24 content and to initiate the process of behaviour change through personalised goal setting.[11]
25 Participants receive five text-messages per week during weeks 1 to 4 of the intervention and four
26 text-messages per week during weeks 5 to 12. The messages are personalised based on the
27 participant's name, the name of their counsellor, the participant's goals and their expected rewards
28 and outcomes for achieving these goals. In addition to receiving the text-messages, participants also
29 have access to a programme handbook, an on-line exercise directory and a Facebook® group. They
30 also receive a refrigerator magnet for self-monitoring and standard information brochures on
31 physical activity. As well as requiring behavioural counsellors, delivering the intervention requires
32 programme coordinators to manage the counsellors, assign participants to a counsellor, oversee the
33 text-messages being sent and received, and to organise sending other programme materials to
34 participants.

35 In Australia health resources are generally allocated on a state or territory basis[12] and so a
36 decision on whether to fund *MobileMums* would be made by individual states or territories. The
37 alternative course of action would be to provide usual care. The purpose of this paper is to consider
38 this decision of whether to provide *MobileMums* or usual care from the perspective of Queensland
39 Health, the government department responsible for managing the public health system in
40 Queensland, Australia.

41 It is assumed that the overarching objective of Queensland Health is to maximise population health
42 subject to their budget. This, therefore, supports the need for an economic evaluation of
43 *MobileMums* to consider the intervention's value for money. While this evaluation is specific to the
44 funding decision faced by Queensland Health, it can be expected that the results reported here will
45 be directly applicable to similar decisions in other Australian states and territories. The
46 generalisability of the results to other high-income countries may be more limited, for example
47 because of differences in the volume and cost of resource use between countries,[13] but the results
48 are likely to be of relevance for all countries experiencing high levels of physical inactivity.

1 METHODS

2 Study population

3 It is expected that *MobileMums* would be offered to all women with children under one year old in
4 Queensland, Australia, regardless of their current level of physical activity. With 61,020 women
5 giving birth in Queensland in 2010 and with 413 fetal deaths,[14] the number of women eligible for
6 the intervention in 2011 was 60,607. We expect around 60% of women who were offered the
7 intervention would participate. This is based on the randomised control trial conducted in 2011,[15,
8 16] where of the 511 women assessed for eligibility 306 commenced the baseline assessment. This
9 gives 36,364 women in Queensland who would be eligible and willing to participate in the
10 *MobileMums* intervention in 2011, and this is the baseline cohort size considered for this study. This
11 participation estimate of 60% is likely conservative, as the program would not include the time-
12 consuming assessments that were undertaken purely for research purposes. Given the uncertainty
13 around this estimate, we consider the effects of reducing this cohort size by 50% to 18,182 women,
14 and increasing it by 50% to 54,546 women.

15 Modelling health outcomes and costs

16 A state-based Markov model provides the framework for this analysis and is used to estimate the
17 costs and consequences associated with *MobileMums* and usual care. The development of the
18 model has been informed by the effectiveness results from a 9-month two-arm community-based
19 randomised controlled trial undertaken in 2011.[15] 263 women from around Caboolture,
20 Queensland, received usual care (n=130) or the *MobileMums* intervention (n=133).[16] Data were
21 collected prior to the intervention being received (time 1 – T1: 0 months), after the 12-week
22 *MobileMums* programme was completed (T2: 3 months) and again after a further 6 month no-
23 contact maintenance period (T3: 9 months). Due to an administrative error the trial was registered
24 retrospectively with the Australian Clinical Trials Registry (ACTRN12611000481976) and 26 of the
25 trial participants were already receiving *MobileMums* or usual care by the time of registration.
26 However, none of these participants had passed T2 when the trial was registered.

27 The main efficacy findings from the trial have been reported in detail by Fjeldsoe et al.[15] Briefly,
28 while the intervention had a large and statistically significant beneficial effect on activity levels
29 between T1 and T2, there was no statistically significant effect at T3, although the estimated
30 increase in activity remained positive. These results suggest that *MobileMums* can only be expected
31 to have an effect on activity levels in the short-term. Under the assumption that only long-term
32 changes in activity levels affect the risk of an individual developing future chronic health conditions,
33 the time horizon of the model used here is two years.

34 There are just two states in the model with participants either ‘physically inactive’ or ‘physically
35 active’, and an individual is required to be undertaking 30 minutes of moderate- to vigorous-
36 intensity physical activity on at least five days a week to be classified as active. An effective physical
37 inactivity intervention increases the likelihood that inactive individuals become active (tpImprove)
38 and/or reduces the likelihood that active individuals become inactive (tpRegress). Individuals move
39 between states using monthly cycles, and spending a month as active or inactive has a cost and
40 health outcome associated with it (described below). An outline of the model is shown in figure 1.

41 Health effects

42 To estimate the value for money of *MobileMums*, health effects are expressed in terms of quality-
43 adjusted life-years (QALYs). Given the design of the model used, *MobileMums* can only affect health-
44 related quality-of life, with no mortality effects. The health-related quality-of-life associated with
45 being physically active or inactive was estimated from participants’ responses to SF-12
46 questionnaires at T1, T2 and T3. Mean imputation was used for missing questionnaire data at each

1 time period (1% of participants at T1, 13% at T2, and 32% at T3). Two errors were made in the
2 printing of the SF-12 questionnaires. First, at T1 one question from the SF-12 was omitted in error,
3 and so scores were randomly generated for this dimension. Second, one of the questions offered
4 one too many potential responses at all time periods, and so those who selected this superfluous
5 response were evenly split and moved into either the next best or next worst choice.

6 Questionnaire responses were transformed into the EQ-5D, a standardised measure of health
7 outcomes, using an algorithm provided by Gray et al.[17] which provides utility scores close to group
8 means, especially for individuals not in poor health. This approach generates health-related quality-
9 of-life scores associated with spending a year as physically active or inactive which could range
10 between 0 (equivalent to death) and 1 (equivalent to perfect health). Monthly scores were simply
11 one-twelfth of this. QALYs and costs in the second year were discounted at 5% following the relevant
12 guidelines.[18, 19]

13 **Costing perspective**

14 This study is intended to inform decision making regarding resource allocation across the health
15 system in Queensland. Consequently, a health system perspective is taken, with only the costs borne
16 by the health system included.[20] While costs falling outside of the health system, such as the cost
17 to participants of purchasing goods or services related to undertaking exercise, may be of interest,
18 they are not of direct relevance given the perspective taken here and so have been excluded.
19 All costs reported have been inflated to 2014 AUD and any costs accruing in the second year of the
20 model have been discounted at 5% in line with guidelines for submission to the Medical Services
21 Advisory Committee[18] and the Pharmaceutical Benefits Advisory Committee[19] in Australia.

22 The estimated cost of providing *MobileMums* across Queensland is based on the costs of delivering
23 the intervention in the randomised controlled trial.[16] To extrapolate these costs, assumptions
24 have been required concerning number of behavioural counsellors and programme coordinators
25 required for widespread dissemination. It is assumed that counsellors could be assigned to 30
26 participants per week, while coordinators could cover five counsellors and their participants per
27 week. Counsellors and coordinators are assumed to be health practitioners with, on average, 2 years
28 in their current role and, in terms of Queensland Health's salary scale,[21] paid at a HP3 (6,092 AUD
29 per month) and a HP4 (8,150 AUD per month) level, respectively. The costs of developing the
30 computer programme to send text-messages, sending the text- messages and providing other
31 programme materials are assumed to be the same as in the trial.

32 In addition to the costs of delivering the intervention, the costs relating to participants health care
33 use have also been incorporated. If the intervention reduces future health care use then the cost
34 saving associated will counterbalance the cost of providing *MobileMums*. Participants' reported their
35 use of health care services at T1, T2 and T3 and the average use of those who were physically active
36 and inactive were estimated. As with the SF-12, mean imputation was used for missing data (0% of
37 participants at T1, 12% at T2, and 31% at T3). The associated costs were estimated using the
38 Medicare Benefits Schedule for July 2011[22] and Australian hospital statistics.[23]

39 **Expected effects**

40 The purpose of this evaluation is to estimate the expected value for money of the *MobileMums*
41 intervention, which is indicated by the incremental cost effectiveness ratio (ICER) for *MobileMums*.
42 This ratio is given by the expected (mean) change in costs associated with the intervention divided
43 by the expected change in QALYs.[24] This ratio can then be compared against a cost-effectiveness
44 threshold. The threshold used here is 64,000 AUD which is based on the estimate by Shiroiwa et
45 al.[25] of the willingness-to-pay for an additional QALY in Australia. If the cost effectiveness ratio for
46 *MobileMums* falls below 64,000 AUD then the intervention can be expected to be 'cost-effective'.

1 Uncertainty

2 Parameter uncertainty was quantified using Monte Carlo simulations, with the model evaluated
3 10,000 times, with each simulation involving random draws from each parameter distribution. These
4 distributions are based on the trial data, with transition probabilities and QALYs given beta
5 distributions, while health care utilisation and its associated costs assigned gamma distributions and
6 uniform distributions respectively. This produces 10,000 pairs of incremental costs and effects, and
7 these are presented on a cost-effectiveness plane along with the expected costs and effects and the
8 cost-effectiveness threshold. The probability that *MobileMums* is cost-effective is given by the
9 proportion of pairs of incremental costs and benefits at which the intervention would be considered
10 cost-effective. The percentage of pairs where the change in QALYs is positive and the change in costs
11 is negative is equal to the probability that *MobileMums* is cost-saving. It is also possible to estimate
12 credible intervals around the expected change in costs and QALYs by taking percentiles of the costs
13 and QALYs produced in the Monte Carlo analysis.[26]

14 Uncertainty also exists surrounding the modelling assumptions. In particular, three areas stand out
15 for particularly onerous assumptions: transition probabilities after nine months (T3), the number of
16 programme counsellors and coordinators required, and the number of women who would be
17 eligible and willing to participate in the trial. The assumptions used for these areas are the subject of
18 scenario analyses. First, the model is reassessed under the assumption that after T3 all programme
19 activity effects are mitigated entirely, and then again under the assumption that the estimated
20 treatment effect observed at T3 is maintained for a further 15 months, at which point the treatment
21 effect is entirely mitigated. Second, the number of counsellors and coordinators required is
22 increased by 50% and reduced by 50%. And lastly, increasing the cohort size by 50% and reducing it
23 by 50% is considered.

24 RESULTS

25 Average effects

26 The input variables are detailed in Table 1. Around 70% of the women entering the model at T1 are
27 expected to be physically inactive. Under usual care there is a small and gradual expected positive
28 net movement from inactive to active over time, and after 24 months around 35 percent of the
29 initial cohort are expected to be in the active state. The expected effect of *MobileMums* is to cause a
30 substantial increase in physical activity over the duration of the 12-week intervention, with 50
31 percent of the participants expected to be in the active state at T2. Following the intervention
32 gradual reduction in the proportion of active participants each month is expected, until after 16
33 months whereby the effect of *MobileMums* has been mitigated entirely. These expected changes in
34 activity levels are presented in figure 2.

		Mean	Standard error	Distribution
Probability of being inactive at T1		0.71	0.03	Beta
	Usual Care (T1 to T2)	0.20	0.04	Beta
Probability of moving from inactive to active (tplmprove)	<i>MobileMums</i> (T1 to T2)	0.35	0.05	Beta
	Usual Care (T2 to T3)	0.14	0.04	Beta
	<i>MobileMums</i> (T2 to T3)	0.26	0.05	Beta

	Usual Care (T1 to T2)	0.43	0.08	Beta
	<i>MobileMums</i> (T1 to T2)	0.18	0.06	Beta
Probability of moving from active to inactive (tpRegress)	Usual Care (T2 to T3)	0.33	0.07	Beta
	<i>MobileMums</i> (T2 to T3)	0.45	0.06	Beta
Monthly health care utilisation costs (2014 AUD per participant)	Physically active	53.30	39.20	Uniform and Gamma*
	Physically inactive	75.40	32.62	Uniform and Gamma*
Cost of delivering <i>MobileMums</i> (2014 AUD per participant)		62.64	13.08	Uniform
EQ5D score	Inactive	0.78	0.01	Beta
	Active	0.81	0.01	Beta

* A uniform distribution for health care costs and a gamma distribution for health care utilisation

Table 1 Input variables for the Markov model

Time spent in the active state is expected to provide slightly higher utility than time spent in the inactive state, with a year spent as physically active associated with a health-related quality-of-life score of 0.81 compared with 0.78 for a year spent as physically inactive. As *MobileMums* is expected to increase the total number of months spent by the cohort in the active state, the intervention can therefore also be expected to improve health-related quality-of-life. Over 24 months, *MobileMums* is estimated to lead to an increase of 131 QALYs across the cohort of 36,364 women or, equivalently, 0.0036 QALYs per person.

The expected cost of delivering *MobileMums* to the cohort is 2,277,950 AUD, or 63 AUD per person. The breakdown for this cost is shown in Table 2. Almost half the cost is due to the behavioural counsellors. While there are significant costs associated with setting up the programme, such as the development of a computer programme to send personalised text-messages, these costs are of little consequence with a cohort of 36,364 women.

		Total cost (AUD)	Cost per participant (AUD)
Development of the computer program for sending automated text-messages		14,204	0.39
Sending text-messages		620,999	17.08
Providing additional programme materials		621,388	17.08
Behavioural counsellors (24 required)	Salaries	438,628	12.06
	Equipment	36,231	0.99
	Travel costs	388,368	10.68
Programme coordinators (5 required)	Salaries	122,248	3.36
	Office costs	35,885	0.98
Total		2,277,950	62.64

Table 2 Estimated costs of delivering *MobileMums* in Queensland, Australia, in 2014 AUD

1 Based on data from the trial it is estimated that active individuals cost the health system 53 AUD a
 2 month on average, while inactive individuals cost 75 AUD per month. As *MobileMums* reduces the
 3 average number of months spent in the inactive state, the cost of delivering the intervention is
 4 partly offset by an expected reduction in these health care costs. As a result, the total expected
 5 incremental cost to the health system from introducing *MobileMums* is 1,124,209 million AUD, or 31
 6 AUD per person.

7 With an expected (mean) incremental cost of 1,124,209 million AUD and an incremental
 8 improvement in health outcomes of 130 QALYs, the cost-effectiveness ratio for *MobileMums* is
 9 approximately 8,608 AUD per QALY. At a cost-effectiveness threshold of 64,000 AUD, the
 10 intervention can therefore be expected to be cost-effective.

11 Uncertainty

12 The pairs of incremental costs and consequences produced by the Monte Carlo simulation are
 13 shown in figure 3. *MobileMums* has a 98% probability of being cost-effective at a threshold of 64,000
 14 AUD (98% of simulations are below the sloped threshold line). The intervention has around a 19%
 15 probability of being cost-saving and health-improving (19% of simulations are in the south-east
 16 quadrant).

17 The results from the scenario analyses are presented in Table 3. None of the changes in assumptions
 18 had any substantial effect on the probability that *MobileMums* is cost-effective at a threshold of
 19 64,000 AUD, which remained over 95% under all scenarios. Changes in the assumption surrounding
 20 the maintenance of changes in activity levels into the future did, however, have a substantial effect
 21 on the probability that *MobileMums* is cost-saving. If changes were entirely mitigated after 9 months
 22 (T3) then the intervention would only have a 1% chance of being cost-saving, while if the observed
 23 difference in activity levels at T3 was maintained for up to 24 months *MobileMums* would have a
 24 39% probability of being cost-saving.

Scenario	Mean change (95% credible interval) caused by <i>MobileMums</i>		Expected (mean) ICER	Probability <i>MobileMums</i> is	
	Total costs (AUD)	QALYs		Cost- effective*	Cost- saving
Base case	1,124,209 (1,102,044 to 1,146,374)	131 (126 to 135)	8,608	98%	19%
Changes in activity levels entirely mitigated at 9 months (T3)	1,363,736 (1,363,736 to 1,372,716)	103 (102 to 105)	13,186	97%	1%
Changes in activity levels maintained from 9 months to 24 months	240,173 (217,066 to 263,281)	232 (227 to 236)	1,037	97%	39%
Number of counsellors and coordinators required increased by 50%	1,456,518 (1,434,365 to 1,478,670)	131 (126 to 135)	11,152	98%	15%
Number of counsellors and coordinators required reduced by 50%	823,527 (802,374 to 844,680)	130 (127 to 134)	6,306	98%	24%
Cohort size increased by 50% to 54,546 women	1,643,613 (1,610,282 to 1,676,943)	196 (190 to 202)	8,390	98%	20%
Cohort size reduced by 50% to 18,182	585,020 (574,005 to 596,035)	65 (63 to 67)	8,959	98%	17%

25 ICER: incremental cost-effectiveness ratio

1 * at a threshold of 64,000 AUD

2 **Table 3 Results from the scenario analyses which examine whether the intervention remains cost-**
3 **effective for a range of assumptions.**

4 DISCUSSION

5 Principal findings

6 The results from this study suggest the *MobileMums* intervention would be a cost-effective use of
7 health resources in Queensland, Australia. While the expected health benefits of the intervention
8 are modest, with an average health improvement of only 0.0036 additional QALYs, the cost of the
9 intervention, after taking into account reduced health care utilisation, is low at just 31 AUD per
10 person. Consequently, the expected cost-effectiveness ratio is 8,608 AUD per QALY, which is far
11 below the estimated willingness to pay for an additional QALY in Australia of 64,000 AUD.[5] Neither
12 parameter nor modelling uncertainty have a substantial effect on this conclusion.

13 Study strengths and limitations

14 This study has been largely informed by the results of a recent 9-month randomised controlled trial.
15 By using a decision-analytic model, it was possible to extrapolate these findings to consider the costs
16 and consequences of *MobileMums* if it were offered in practice to a large cohort of women and to
17 account for expected costs and consequences beyond the trial's time horizon. Although several
18 assumptions underpin this approach, they were subjected to sensitivity analyses which have shown
19 them to have little effect on the overall conclusion that the intervention is likely cost-effective.

20 With the effect of *MobileMums* on activity levels expected to last for less than two years, and under
21 the conservative assumption that only longer-term changes in activity will affect the risk of an
22 individual developing future chronic health conditions, the model used here is only required to have
23 a short-time horizon. However, if *MobileMums* does prompt some long-term improvements in
24 physical activity then the benefits of the intervention will be understated. In addition, while the
25 simplicity of the model used has advantages, particularly for ease of exposition, there are
26 limitations. In particular, only those changes in activity enough to move participants between the
27 two states of the model are captured, with any changes of activity levels within a state overlooked.

28 Comparison with other studies

29 While a number of economic evaluations of physical activity interventions have been undertaken,
30 there is significant methodological heterogeneity making direct comparisons difficult in many cases.
31 Of those studies which use a similar methodology, i.e. using a decision-analytic model as a
32 framework for analysis with the cost per quality-adjusted (or disability-adjusted) life-year estimated,
33 many of the interventions are found to be cost-effective. For example, the 'green prescription'
34 programme in New Zealand is found to have an incremental cost of 3,000 AUD per QALY,[27] while
35 Cobiac et al.[28] found a pedometer intervention in Australia to be cost-saving and an internet-
36 based intervention to have an incremental cost of 4,000 AUD per QALY. However, the cost-
37 effectiveness of such physical activity intervention is by no means guaranteed. Cobiac et al.[28] find
38 that a referral to exercise scheme has an incremental cost of 100,000 AUD per QALY, while a 8-week
39 social support programme was found by Roux et al.[29] to have an incremental cost of 95,000 AUD
40 per QALY.

41 Interestingly, while these other studies typically assumed that the benefit from physical activity
42 interventions was only through reducing the incidence of future chronic diseases, this study
43 demonstrates that they are also likely to produce an immediate improvement in health-related
44 quality-of-life. Active participants in the trial of *MobileMums* reported higher health-related quality-

1 of-life than those who were physically inactive, so that *MobileMums* is expected to be cost-effective even without any long-term changes in activity levels. With this immediate improvement in quality-of-life missed in most analyses of physical activity interventions, these studies may well have underestimated the full benefits from effective physical activity interventions.

5 Policy implications

6 Health prevention programmes in Queensland, and across Australia, have recently been going through a period of disinvestment. However, if the goal of the health system is to maximise health outcomes then there seems little reason for prevention health interventions to be treated any differently to a curative intervention. While the *MobileMums* intervention can only be expected to provide a modest improvement in health-related quality of life for the average participant, it does provide a meaningful improvement in terms of population health. Health care resources should be directed to those uses which provide best value for money, i.e., the greatest improvement in health outcomes for a given level of cost. Given the relatively low cost of delivering *MobileMums*, the intervention can be expected to provide good value for money and is likely a cost-effective use of health care resources given the estimated willingness-to-pay for an additional QALY in Australia.

16 Providing the intervention across Australia can be expected to provide a similar level of value for money. Levels of physical inactivity are similar across Australia[3] and costs, such as those associated with the counsellors and coordinators, should also be comparable. While differences in costs make it more difficult to generalise our results to other countries, the results of this study are still likely to be of relevance in many high-income countries with similarly high levels of physical inactivity. It would seem likely that a programme such as *MobileMums* would provide good value for money if provided in such countries. However, this is an area where further research is required.

23 CONCLUSION

24 *MobileMums* can be expected to be a cost-effective use of health resources in Queensland, Australia. If the objective of Queensland Health is to maximise population health outcomes given a finite budget, then *MobileMums* should be freely provided.

28 Figure 1 Outline of the Markov model used to estimate the costs and effects of *MobileMums* and usual care

30 Figure 2 The expected (mean) effect of *MobileMums* on activity levels

31 Figure 3 Cost-effectiveness plane for *MobileMums* versus usual care with 1,000 sets of incremental costs and effects randomly drawn from the 10,000 Monte Carlo simulations along with the expected (mean) incremental costs and effects and a cost-effectiveness threshold of 64,000 AUD

37 ACKNOWLEDGEMENTS

38 Computational resources and services used in this work were provided by the High Performance Computer and Research Support Unit, Queensland, University of Technology, Brisbane, Australia.

40 AUTHOR CONTRIBUTIONS

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1 Conceived and designed the experiments: AM, YM, BF, AB, NG

2 Performed the experiments: AM, YM, AB, BF, NG

3 Analysed the data: EB, AB, NG

4 Wrote the paper: EB, AM, YM, AB, NG

5 **FUNDING INTERESTS**

6 This study was supported by a National Health and Medical Research Council project grant number
7 614244.

8 **COMPETING INTERESTS**

9 None

10 **ETHICS APPROVAL**

11 The trial used to inform this analysis was registered retrospectively with the Australian Clinical Trials
12 Registry (ACTRN12611000481976). Ethical clearance was obtained through the Queensland
13 University of Technology Human Research Ethics Committee (Application number 0900001407).

14 **PROVENANCE AND PEER REVIEW**

15 Not commissioned; externally peer reviewed

16 **DATA SHARING STATEMENT**

17 The full data set is available by emailing the first author of the study.

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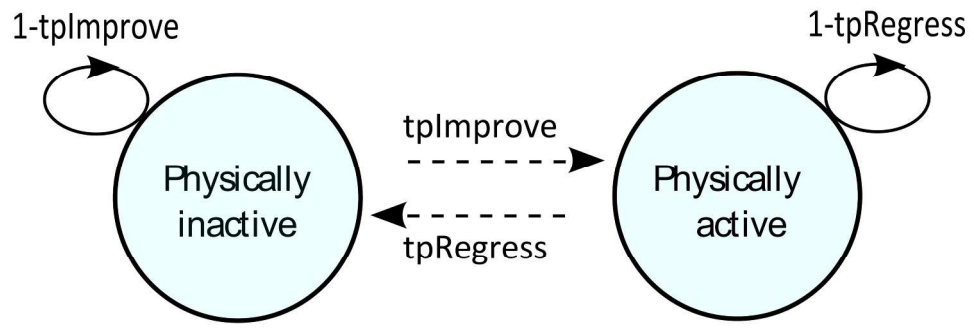


Figure 1 Outline of the Markov model used to estimate the costs and effects of MobileMums and usual care
115x41mm (600 x 600 DPI)

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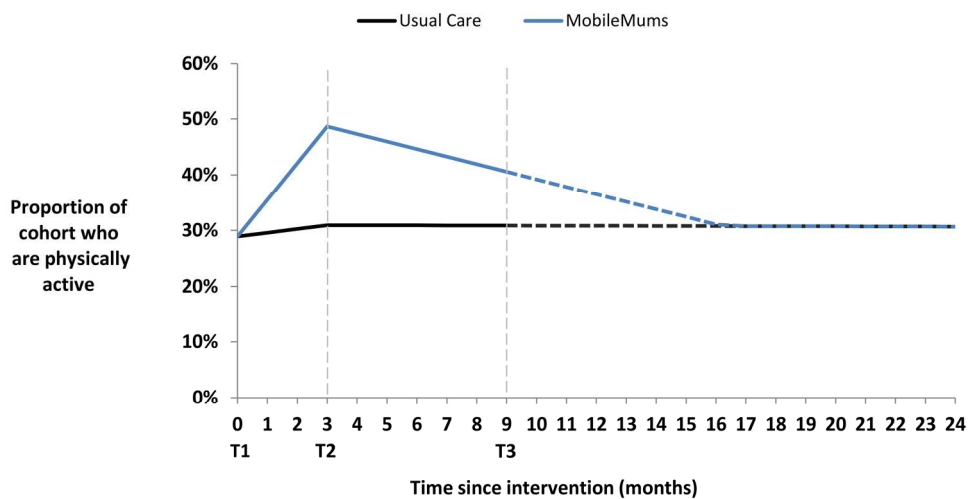


Figure 2 The expected (mean) effect of MobileMums on activity levels
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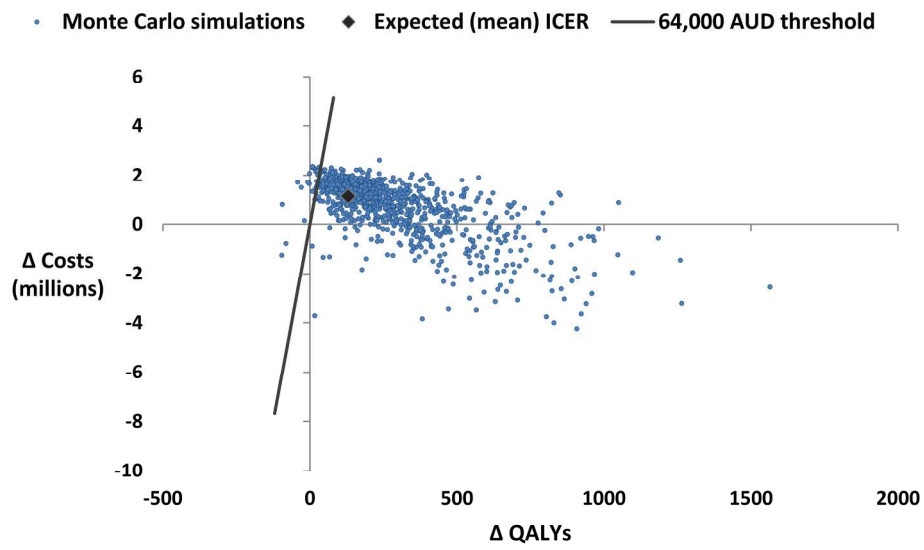


Figure 3 Cost-effectiveness plane for MobileMums versus usual care with 1,000 sets of incremental costs and effects randomly drawn from the 10,000 Monte Carlo simulations along with the expected (mean) incremental costs and effects and a cost-effectiveness threshold of 64,000 AUD
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The CHEERS Checklist is part of the CHEERS Statement. The CHEERS Statement has been endorsed and co-published by the following journals:

- BJOG: An International Journal of Obstetrics and Gynaecology
- [BMC Medicine 2013; 11:80](#)
- [BMJ 2013;346:f1049](#)
- [Clinical Therapeutics 27 March 2013 \(Article in Press DOI: 10.1016/j.clinthera.2013.03.003\)](#)
- [Cost Effectiveness and Resource Allocation 2013 11:6.](#)
- [The European Journal of Health Economics 2013 Mar 26. \[Epub ahead of print\]](#)
- International Journal of Technology Assessment in Health Care
- [Journal of Medical Economics 2013 Mar 25. \[Epub ahead of print\]](#)
- [Pharmacoeconomics 2013 Mar 26. \[Epub ahead of print\]](#)
- [Value in Health 2013 March - April;16\(2\):e1-e5](#)

CHEERS Checklist

Items to include when reporting economic evaluations of health interventions

Section/item	Item No	Recommendation	Reported on page No/ line No
Title and abstract			
Title	1	Identify the study as an economic evaluation or use more specific terms such as “cost-effectiveness analysis”, and describe the interventions compared.	Page 1 Lines 1,2
Abstract	2	Provide a structured summary of objectives, perspective, setting, methods (including study design and inputs), results (including base case and uncertainty analyses), and conclusions.	Page 2-3 Lines 16-42
Introduction			
Background and objectives	3	Provide an explicit statement of the broader context for the study. Present the study question and its relevance for health policy or practice decisions.	Pages 4-5 Lines 61-109
Methods			
Target population and subgroups	4	Describe characteristics of the base case population and subgroups analysed, including why they were chosen.	Page 6 Lines 111-121
Setting and location	5	State relevant aspects of the system(s) in which the decision(s) need(s) to be made.	Page 3 Lines 96-109
Study perspective	6	Describe the perspective of the study and relate this to the costs being evaluated.	Page 8 Lines 164-189
Comparators	7	Describe the interventions or strategies being compared and state why they were chosen.	Page 5 Lines 96-98
Time horizon	8	State the time horizon(s) over which costs and consequences are being evaluated and say why appropriate.	Pages 6-7 Lines 134-137
Discount rate	9	Report the choice of discount rate(s) used for costs and	Pages 8, Lines 162-163, 171-172



1			outcomes and say why appropriate.	
2				
3	Choice of health	10	Describe what outcomes were used as the measure(s) of	Page 9
4	outcomes		benefit in the evaluation and their relevance for the type of	Lines 194-200
5			analysis performed.	
6	Measurement of	11a	<i>Single study-based estimates</i> : Describe fully the design	Pages 6,7
7	effectiveness		features of the single effectiveness study and why the single	Lines 123-144
8			study was a sufficient source of clinical effectiveness data.	
9				
10		11b	<i>Synthesis-based estimates</i> : Describe fully the methods used for	
11			identification of included studies and synthesis of clinical	
12			effectiveness data.	
13	Measurement and	12	If applicable, describe the population and methods used to	Pages 7,8
14	valuation of preference		elicit preferences for outcomes.	Lines 150-163
15	based outcomes			
16	Estimating resources	13a	<i>Single study-based economic evaluation</i> : Describe approaches	
17	and costs		used to estimate resource use associated with the alternative	
18			interventions. Describe primary or secondary research methods	
19			for valuing each resource item in terms of its unit cost.	
20			Describe any adjustments made to approximate to opportunity	
21			costs.	
22		13b	<i>Model-based economic evaluation</i> : Describe approaches and	
23			data sources used to estimate resource use associated with	
24			model health states. Describe primary or secondary research	
25			methods for valuing each resource item in terms of its unit	Pages 8,9
26			cost. Describe any adjustments made to approximate to	Lines 173-189
27			opportunity costs.	
28	Currency, price date,	14	Report the dates of the estimated resource quantities and unit	
29	and conversion		costs. Describe methods for adjusting estimated unit costs to	Page 8
30			the year of reported costs if necessary. Describe methods for	Lines 170-172
31			converting costs into a common currency base and the	
32			exchange rate.	
33	Choice of model	15	Describe and give reasons for the specific type of decision-	Page 9
34			analytical model used. Providing a figure to show model	Lines 122-144
35			structure is strongly recommended.	
36	Assumptions	16	Describe all structural or other assumptions underpinning the	Pages 6,8
37			decision-analytical model.	Lines 135-136,
38				174-176
39	Analytical methods	17	Describe all analytical methods supporting the evaluation. This	
40			could include methods for dealing with skewed, missing, or	Page 7,9
41			censored data; extrapolation methods; methods for pooling	Lines 148-163,
42			data; approaches to validate or make adjustments (such as half	187-189
43			cycle corrections) to a model; and methods for handling	
44			population heterogeneity and uncertainty.	
45	Results			
46	Study parameters	18	Report the values, ranges, references, and, if used, probability	
47			distributions for all parameters. Report reasons or sources for	Page 11
48			distributions used to represent uncertainty where appropriate.	Line 236
49			Providing a table to show the input values is strongly	
50			recommended.	
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1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41	Incremental costs and outcomes Characterising uncertainty Characterising heterogeneity Discussion Study findings, limitations, generalisability, and current knowledge Other Source of funding Conflicts of interest	19 20a 20b 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41	For each intervention, report mean values for the main categories of estimated costs and outcomes of interest, as well as mean differences between the comparator groups. If applicable, report incremental cost-effectiveness ratios. <i>Single study-based economic evaluation:</i> Describe the effects of sampling uncertainty for the estimated incremental cost and incremental effectiveness parameters, together with the impact of methodological assumptions (such as discount rate, study perspective). <i>Model-based economic evaluation:</i> Describe the effects on the results of uncertainty for all input parameters, and uncertainty related to the structure of the model and assumptions. If applicable, report differences in costs, outcomes, or cost-effectiveness that can be explained by variations between subgroups of patients with different baseline characteristics or other observed variability in effects that are not reducible by more information. Summarise key study findings and describe how they support the conclusions reached. Discuss limitations and the generalisability of the findings and how the findings fit with current knowledge. Describe how the study was funded and the role of the funder in the identification, design, conduct, and reporting of the analysis. Describe other non-monetary sources of support. Describe any potential for conflict of interest of study contributors in accordance with journal policy. In the absence of a journal policy, we recommend authors comply with International Committee of Medical Journal Editors recommendations.	Page 12 Lines 256-259 Pages 12,13 Lines 260-276 N/A Page 13-16 Lines 277-344 Page 17 Lines 367-369 Page 17 Lines 370-371
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For consistency, the CHEERS Statement checklist format is based on the format of the CONSORT statement checklist

The CHEERS Statement may be accessed by the publication links above.

The **ISPOR CHEERS Task Force Report** provides examples and further discussion of the 24-item CHEERS Checklist and the CHEERS Statement. It may be accessed via the *Value in Health* link or via the ISPOR Health Economic Evaluation Publication Guidelines – CHEERS: Good Reporting Practices webpage: <http://www.ispor.org/TaskForces/EconomicPubGuidelines.asp>

The citation for the CHEERS Task Force Report is:

Husereau D, Drummond M, Petrou S, et al. Consolidated health economic evaluation reporting standards (CHEERS)—Explanation and elaboration: A report of the ISPOR health economic evaluations publication guidelines good reporting practices task force. *Value Health* 2013;16:231-50.

