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Cost-effectiveness of telephone-based weight loss support for patients with knee osteoarthritis: a pragmatic randomised controlled trial

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Abstract

Background: Telephone-based support offers a promising option to provide widely accessible and cost-effective weight loss care to the people with knee osteoarthritis who are overweight. While telephone-based interventions targeting weight loss are used routinely in the general populations, the cost-effectiveness of referring patients with knee osteoarthritis to these is unknown. The aim of this study was to assess the cost-effectiveness of referral to a telephone-based weight management and healthy lifestyle service for patients with knee osteoarthritis, who are overweight or obese, compared to usual care.

Methods: We randomised 120 patients with knee osteoarthritis to an intervention or usual care control group in a 1:1 ratio. Participants in the intervention group received a referral to an existing non-disease specific 6-month telephone-based weight management and healthy lifestyle service. The primary outcome of the study was quality-adjusted life years (QALYs). Secondary outcomes included pain intensity, disability, weight, and body mass index (BMI). Costs included intervention costs, healthcare utilisation costs (healthcare services and medication use) and absenteeism costs due to knee pain. The primary cost-effectiveness analysis was performed from the societal perspective.

Results: Mean cost differences between groups (intervention minus control) were, $454 (95%CI: -2735 to 4206) for healthcare costs, $-36, (95%CI: -73 to 2) for medication costs, and $-13 (95%CI: -225 to 235) for absenteeism costs. The total mean difference in societal costs was $1022 (95%CI: -2201 to 4771). For all outcomes, the probability of the intervention being cost-effective compared with usual care was less than 0.33 at all willingness-to-pay values.

Conclusion: From a societal perspective, telephone-based weight loss support, provided using an existing non-disease specific 6-month weight management and healthy lifestyle service was not cost-effective in comparison with usual care for overweight and obese patients with knee osteoarthritis for QALYs, pain intensity, disability, weight, and BMI.

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Background

Osteoarthritis is one of the fastest growing chronic health problems worldwide.[1,2] According to the 2015 Global Burden of Disease Study, osteoarthritis accounted for 3.9% of years lived with disability worldwide in 2015, up from 2.5% in 2010, and was the 13th highest contributor to global disability.[1,2] Knee osteoarthritis consistently accounts for approximately 85% of the burden attributable to osteoarthritis.[1,2] Osteoarthritis also imposes a significant economic burden, with the total annual costs estimated to be $A8.6 billion in Australia,[3] £20.9 billion in the UK,[4] and $US142.1 billion in the US.[5] The majority of these costs are attributable to ambulatory and inpatient care, including surgery and lost work productivity.[3,4]

Excess weight is an important modifiable risk factor for the onset and progression of knee osteoarthritis,[6] and there is strong evidence that weight loss interventions reduce pain and disability in overweight patients with knee osteoarthritis.[7,8] Consequently, international clinical practice guidelines recommend all patients with knee osteoarthritis who are overweight receive support to lose weight.[9–11] Typically, these treatments are delivered using clinical face-to-face models of care.[12] While such clinical models produce moderate effects on weight loss, pain, and physical function,[7,8] only 22% of patients with knee osteoarthritis report receiving weight loss care,[13] possibly due to limitations in service delivery and patient access to care. Arguably more scalable delivery options, using remotely delivered approaches, such as telephone-based support, can maximise the reach of weight loss care and are more cost-effective to support weight loss in this patient group. While telephone-based behavioural interventions targeting weight loss are used routinely in the general populations, the cost-effectiveness of referring patients with knee osteoarthritis to these is unknown.

Given the scarce resources in healthcare, policy-makers are increasingly requiring evidence of economic value for healthcare interventions to make informed decisions about how to allocate resources.[14] Therefore, undertaking economic evaluations of knee osteoarthritis management approaches is important. Recently, we conducted a randomised controlled trial (RCT) using an existing non-disease specific telephone-based weight management and healthy lifestyle service, which aimed to reduce weight in patients with knee osteoarthritis who are overweight or obese.[15] The purpose of the current study is to evaluate the cost-effectiveness of the aforementioned service, compared to usual care. For this study, the primary analysis was conducted from a societal perspective and a secondary analysis was conducted from a healthcare system perspective.

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Methods

Study participants and design

We performed a pre-planned economic evaluation alongside a two-arm pragmatic parallel group RCT, as part of a cohort multiple RCT.[16] The study design is described in detail elsewhere and was published in advance of data analysis.[17] The trial was prospectively registered (ACTRN1261500049057). Ethical approval was obtained from The Hunter New England Health Human Research Ethics Committee (13/12/11/5.18) and the University of Newcastle Human Research Ethics Committee (H-2015-0043).

Patients with knee osteoarthritis who were on a waiting list for an outpatient orthopaedic consultation at the John Hunter Hospital in NSW, Australia, were invited to participate. Patients were assessed for eligibility during a telephone assessment. Eligible patients were randomised to study conditions: i) offered the intervention (intervention group), or ii) usual care control group.

Inclusion criteria were: primary complaint of pain due to knee osteoarthritis lasting longer than 3 months; 18 years or older; overweight or obese (body mass index (BMI) ≥27kg/m^2 and <40kg/m^2); average knee pain intensity ≥3 out of 10 on a 0-10 numeric rating scale (NRS) over the past week, or moderate level of interference in activities of daily living (adaptation of item 8 of SF36); and access to a telephone. Exclusion criteria were: known or suspected serious pathology as the underlying cause of their knee pain (e.g. fracture; cancer, inflammatory arthritis; gout; or infection); previous obesity surgery; currently participating in any prescribed or commercial weight loss program; knee surgery in the last 6 months or planned surgery in the next 6 months; unable to comply with the study protocol that requires them to adapt meals or exercise due to non-independent living arrangements; medical or physical impairment precluding safe participation in exercise such as uncontrolled hypertension; and unable to speak or read English sufficiently to complete study procedures.

Intervention

The intervention included two components. First, brief advice and education about the benefits of weight loss and physical activity for knee osteoarthritis were provided over the telephone immediately after randomisation. Second, intervention participants were informed

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about the NSW Get Healthy Information and Coaching Service (GHS) (www.gethealthynsw.com.au),[18] and referred to the service for weight loss support. The GHS is an existing non-disease specific telephone-based health coaching service funded by the NSW Government to support adults to make sustained healthy lifestyle improvements. Targets include diet, physical activity and achieving a healthy weight, and where appropriate, referral to smoking cessation services.[18] The GHS involves 10 individually tailored coaching calls, based on national dietary and physical activity guidelines,[19,20] delivered over a 6-month period by university qualified health professionals.[18] Participants in the intervention group remained on the waiting list for orthopaedic consultation.

Control

Participants in the control group remained on the 'usual care pathway' (i.e. on the waiting list to have an orthopaedic consultation and could progress to consultation if scheduled or surgery if recommended by the orthopaedic department) and took part in data collection during the study period. No other active intervention was provided as part of the study, however; no restrictions were placed upon the use of other health services during the study period. Control participants were informed that a face-to-face clinical appointment was available in 6 months.

Measures

For this economic evaluation, the primary outcome was quality-adjusted life years (QALYs). Secondary outcomes included pain intensity, disability, weight, and BMI. We measured cost in terms of intervention costs, healthcare utilisation costs (healthcare services and medication use) and work absenteeism costs due to knee pain. The primary analysis was conducted from the societal perspective, which includes all these cost categories. The secondary analysis was conducted from the healthcare perspective, which excluded absenteeism costs.

Outcomes

All outcomes were assessed at baseline, six weeks and 26 weeks. Health-related quality of life was assessed using the 12-item Short Form Health Survey version 2 (SF-12.v2).[21] The participants' SF-6D[22] health states were translated into utility scores using the British tariff.[23] QALYs were calculated by multiplying the participants' utility scores by their time spent in a health state using linear interpolation between measurement points. Knee pain intensity was assessed using a 0-10 point NRS. Participants were asked to rate their "average knee pain

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intensity over the past week", where 0 represents 'no pain' and 10 represents 'the worst possible pain'.[24] Disability was assessed using the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC).[25] The WOMAC score ranges from 0 to 96, with higher scores indicating greater disability. Weight (kg) was assessed via participant self-report and BMI was calculated as weight/height squared (kg/m^2)[26] using self-reported weight and height.

Cost measures

All costs were converted to Australian dollars in 2016 using consumer price indices.[27] Discounting of costs was not necessary due to the 26-week follow-up.[28]

Intervention costs were micro-costed and included the cost to provide the brief advice as well as GHS coaching calls. The cost to provide the brief advice was estimated from the development and operational costs of the call and the interviewer wages for the estimated average time (5 minutes) taken to provide the brief advice. The cost to provide the GHS coaching calls was provided by the GHS[29] and multiplied by the number of calls each participant received. The number of health coaching calls received was reported directly by the GHS.

Healthcare utilisation costs included any healthcare services or medications used for knee pain (independent of the intervention costs) and were calculated from a patient reported healthcare utilisation inventory. Participants were asked to recall any healthcare services (the type of services and number of sessions) and medications used for their knee pain during the past six weeks, at the six and 26 weeks follow-up. Healthcare services were valued using Australian standard costs and, if unavailable, prices were according to professional organisations.[30–32] Medications were valued using unit prices from the Australian pharmaceutical benefits scheme[33] and, if unavailable, prices were obtained from online Australian pharmacy websites.

Absenteeism was assessed by asking participants to recall the total number of sickness absence days due to knee pain during the past six weeks, at the six and 26 weeks follow-up. Absenteeism costs were estimated using the 'Human Capital Approach'[28] and were calculated per participant by multiplying their total number of sickness absence days off by the national average hourly income for their gender and age according to the Australian Bureau of Statistics.[27,34]

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To gain an estimate of the cost of healthcare utilisation and absenteeism over the entire 26-week period, the average of the week six and week 26 costs per patient was extrapolated, assuming linearity.

Statistical analyses

All outcomes and cost measures were analysed under the intention-to-treat principle (i.e. analyses were based on initial group assignment and missing data were imputed). Means and proportions of baseline characteristics were compared between the intervention and control group participants to assess comparability of the groups. Missing data for all outcomes and cost measures were imputed using Multiple Imputation by Chained Equations (MICE), stratified by treatment group.[34] Data were assumed missing at random. Thirty different data sets were created in order for the loss-of-efficiency to be below the recommended 5%.[34] These separate datasets were analysed as indicated below, after which pooled estimates from all imputed datasets were calculated using Rubin's rules.[35]

Mean cost differences between study groups were calculated for total and disaggregated costs. The cost measures were adjusted for the confounders of baseline knee pain intensity, baseline duration of knee pain, baseline BMI and number of days on the waiting list for orthopaedic consultation because the addition of these confounders to the regression model changed the cost differences by more than 10%. Seemingly unrelated regression analyses were performed to estimate total cost differences (i.e. ΔC) and effect differences for all outcomes (i.e. ΔE), adjusted for baseline values as well as other potential baseline prognostic factors (knee pain intensity, duration of knee pain, BMI and number of days on the waiting list for orthopaedic consultation, obtained from hospital records). An advantage of seemingly unrelated regression is that two regression equations (i.e., one for ΔC and one ΔE) are modelled simultaneously so that their possible correlation can be accounted for.[36]

Incremental cost-effectiveness ratios (ICERs) were calculated by dividing the adjusted difference in total costs between both groups by the adjusted difference in outcomes (i.e. ΔC/ΔE). Uncertainty surrounding the ICERs and 95% confidence intervals (95%CIs) around cost differences was estimated using bias-corrected and accelerated bootstrapping (5000 replications). Uncertainty surrounding the ICERs was graphically illustrated by plotting bootstrapped incremental cost-effect pairs (CE-pairs) on cost-effectiveness planes (CE-planes).[28] A summary measure of the joint uncertainty of costs and outcomes was provided

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using cost-effectiveness acceptability curves, which provide an indication of the intervention's probability of being cost-effective in comparison with usual care at different values of willingness-to-pay (i.e., the maximum amount of money decision-makers are willing to pay per unit of effect).[28] Data were analysed in STATA (V13, Stata Corp).

Sensitivity analysis

To assess the robustness of results, we performed a per-protocol sensitivity analysis from the societal perspective that included only participants that completed at least six telephone GHS coaching calls in the intervention group.[29]

Secondary analysis: healthcare perspective

A secondary analysis was performed from the healthcare perspective (i.e. excluding absenteeism costs).

Results

Participants

A total of 120 patients were randomised into the study (Figure 1). Baseline participant characteristics are reported in Table 1. At 26 weeks complete data were available for between 70% and 82% of participants (QALYs 70%, pain intensity 82%, disability 79%, weight 81%, BMI 81%). For cost data, 48% of participants had complete data at 26 weeks. As a consequence, 18%-30% of outcome data and 52% of cost data were imputed.

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Figure 1. Flow diagram of trial participants

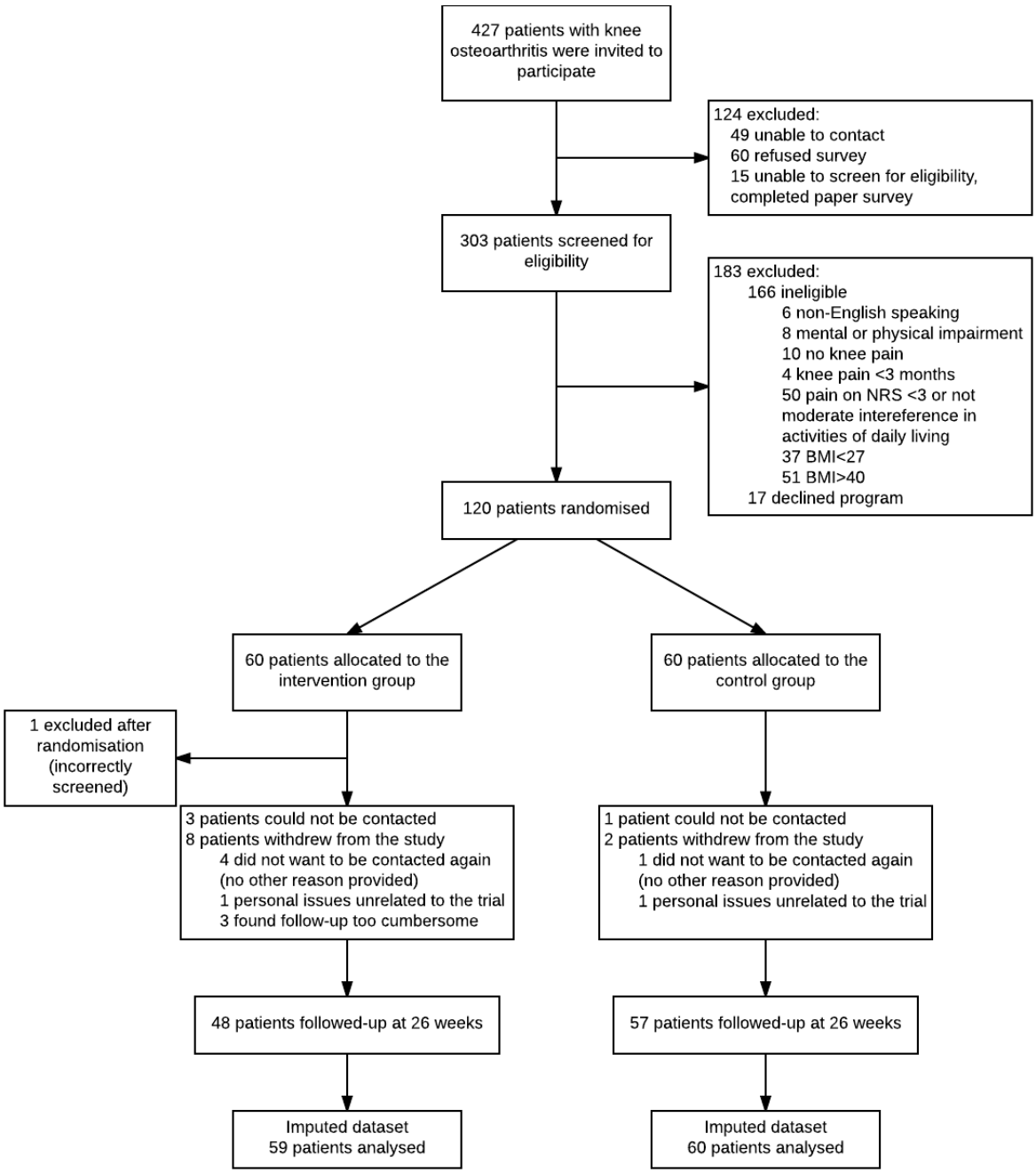

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Table 1. Baseline characteristics of the study population*

Characteristics	Intervention group *n*=59	Control group *n*=60
Age (years)	63.0 (11.1)	60.2 (13.9)
Gender (male), n (%)	20 (34)	25 (42)
Australian and/or Torres Strait Islander, n (%)	5 (9)	2 (3)
Employment status, n (%)		
Employed	12 (20)	14 (23)
Unemployed	7 (12)	8 (13)
Retired	31 (53)	28 (47)
Can't work (health reasons)	9 (15)	10 (17)
Country of origin (Australia), n (%)	54 (92)	51 (85)
Highest level of education (>High school), n (%)	11 (19)	17 (28)
Private health insurance, n (%)	1 (2)	5 (8)
Pain intensity (NRS, range: 0-10)	6.9 (1.8)	6.8 (2.0)
Pain duration (years)	9.6 (10.6)	6.7 (8.5)
Disability (WOMAC, range: 0-96)	47.9 (17.4)	48.6 (16.5)
Weight (kg)	93.3 (12.9)	89.5 (13.5)
BMI (kg/m^2)	33.4 (3.4)	32.1 (3.1)
Number of days waiting for orthopaedic consultation, median (IQR)	379.0 (279.0-507.0)	390.0 (313.0-532.0)
Utility score	0.6 (0.1)	0.7 (0.1)

NRS=numeric rating scale, WOMAC=Western Ontario and McMaster Universities Osteoarthritis Index, BMI=Body Mass Index, IQR=interquartile range
*Data presented as mean (SD) unless otherwise indicated.

Outcomes

No differences were found between the intervention and control group for QALYs (MD 0.00, 95%CI: -0.02 to 0.03), pain intensity (MD 0.58, 95%CI: -0.57 to 1.74), disability (MD -0.01, 95%CI: -8.00 to 7.99), weight (MD 0.36, 95%CI: -2.87 to 3.59), and BMI (MD 0.27, 95%CI: -0.93 to 1.46) (Table 2).

Table 2: Differences in pooled mean costs and effects (95% Confidence intervals), incremental cost-effectiveness ratios, and the distribution of incremental cost-effect pairs around the quadrants of the cost-effectiveness planes

Analysis		Sample size		Outcomes	ΔC (95% CI)	ΔE (95% CI)	ICER	Distribution CE-plane (%)			
		Int	Cont		AUD	Points	AUD/point	NE[a]	SE[b]	SW[c]	NW[d]
Primary analysis	Societal perspective	59	60	QALYs	1022 (-2217 to 4745)	0.00 (-0.02 to 0.03)	483453	37.6	18.7	14.2	29.4
		59	60	Pain intensity	1022 (-2227 to 4760)	0.58 (-0.57 to 1.74)	1759	9.5	5.3	27.7	57.5
		59	60	Disability	1022 (-2205 to 4725)	-0.01 (-8.00 to 7.99)	-178860	33.3	16.1	16.9	33.7
		59	60	Weight	1022 (-2218 to 4717)	0.36 (-2.87 to 3.59)	2851	28.5	13.4	19.3	38.7
		59	60	BMI	1022 (-2225 to 4750)	0.27 (-0.93 to 1.46)	3850	23.7	10.9	22.0	43.4
Sensitivity analysis	Per protocol	59	60	QALYs	192 (-3692 to 4303)	0.01 (-0.03 to 0.04)	22985	37.0	31.6	14.1	17.3
		59	60	Pain intensity	192 (-3710 to 4303)	0.56 (-0.98 to 2.10)	340	12.6	10.7	35.0	41.7
		59	60	Disability	192 (-3684 to 4316)	-0.04 (-11.40 to 11.48)	-5347	27.9	21.6	24.1	26.4
		59	60	Weight	192 (-3678 to 4287)	1.32 (-4.12 to 6.76)	146	17.2	14.8	30.9	37.1
		59	60	BMI	192 (-3658 to 4317)	0.74 (-1.27 to 2.74)	261	13.3	11.1	34.5	41.1
Secondary analysis	Healthcare perspective	59	60	QALYs	758 (-2439 to 4439)	0.00 (-0.02 to 0.03)	358615	34.9	21.3	16.4	27.4
		59	60	Pain intensity	758 (-2448 to 4456)	0.58 (-0.58 to 1.74)	1305	8.9	6.1	31.8	53.2
		59	60	Disability	758 (-2460 to 4409)	-0.00 (-8.00 to 8.00)	-164545	30.5	18.8	19.1	31.6
		59	60	Weight	758 (-2434 to 4466)	0.36 (-2.88 to 3.60)	2115	26.3	15.7	22.2	35.8
		59	60	BMI	758 (-2431 to 4442)	0.27 (-0.93 to 1.46)	2856	21.8	12.4	25.3	40.5

Int=Intervention, Cont=Control, CI=confidence interval, C=costs, E=effects, ICER=incremental cost-effectiveness ratio, CE-plane=cost-effectiveness plane, BMI=Body mass index, QALYs=quality-adjusted life years

Note: costs are expressed in 2016 Australian Dollars

[a] The northeast (NE) quadrant of the CE plane, indicating that the intervention is more effective and more costly than control

[b] The southeast (SE) quadrant of the CE plane, indicating that the intervention is more effective and less costly than control

[c] The southwest (SW) quadrant of the CE plane, indicating that the intervention is less effective and less costly than control

[d] The northwest (NW) quadrant of the CE plane, indicating that the intervention is less effective and more costly than control

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Costs

Of the intervention group participants, the average number of GHS coaching calls to intervention participants was 4.7 (SD 4.6). The mean intervention costs were $622 (SE 80) per participant.

From the societal perspective, mean cost differences between groups (intervention minus control) were, $454 (95%CI: -2735 to 4206) for healthcare costs, $-36, (95%CI: -73 to 2) for medication costs, and $-13 (95%CI: -225 to 235) for absenteeism costs. The total mean difference in societal costs was $1022 (95%CI: -2201 to 4771) (Table 3).

For all outcomes, the probability of the intervention being cost-effective compared with usual care was less than 0.33 at all willingness-to-pay values.

From the healthcare perspective, total mean difference between groups (intervention minus control) was $876 (95%CI: -2419 to 4575).

Table 3. Mean costs per participant in the intervention and control groups, and unadjusted and adjusted mean cost differences between study groups during the 6-month follow-up period (based on the imputed dataset)

Cost category	Intervention group *n*=59 mean (SE)	Control group *n*=60 mean (SE)	Unadjusted mean cost difference CI (95%)	Adjusted mean cost difference* CI (95%)
Intervention costs	622 (80)	0 (0)	622 (480 to 792)	618 (464 to 807)
Healthcare costs	2728 (1747)	2605 (1463)	312 (-2728 to 3533)	454 (-2735 to 4206)
Medication costs	108 (24)	139 (22)	-35 (-71 to 1)	-36 (-73 to 2)
Absenteeism costs	174 (124)	160 (72)	17 (-170 to 236)	-13 (-225 to 235)
Total	**3632 (1781)**	**2904 (1478)**	**916 (-2163 to 4135)**	**1022 (-2201 to 4771)**

SE=standard error, CI=confidence interval
Note: costs are expressed in 2016 Australian Dollars
Negative difference values indicate control group costs greater than intervention
*****Mean cost difference (intervention minus control) adjusted for the baseline variables: knee pain intensity, duration of knee pain (years), BMI, number of days on the waiting list for orthopaedic consultation.

Cost-effectiveness

The majority of the incremental CE-pairs were located in the northeast quadrant, indicating the intervention was on average more costly and more effective than usual care (Figure 2

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[1a]). The ICER for QALYs was 483,453, indicating that one QALY gained in the intervention group was associated with a societal cost of $483,453 as compared with the control group (Table 2). This large ICER is due to the very small effect on QALYs (MD 0.00, 95%CI: -0.02 to 0.03). The cost-effectiveness acceptability curve for QALYs is presented in Figure 2 (2a).

For the secondary outcomes, the majority of incremental CE-pairs were located in the northwest quadrant (Table 2, Figure 2 [1b-1e]), indicating that the intervention on average achieved poorer outcomes at a higher cost compared to usual practice. As such these ICERs had to be interpreted as cost per unit of effect lost. For pain intensity, an ICER of 1,759 indicated that the intervention costs $1,759 per point increase in pain intensity in comparison to the control group (Table 2, Figure 2 [1b]). ICERs for weight (2,851) and BMI (3,850) in a similar direction were found, which indicated the intervention costs $2,851 per one kilogram gained and $3,850 per one unit BMI increase (Table 2, Figure 2 [1d and 1e]). In contrast, the ICER for disability was -178,860, which indicated for every 1-point decrease in disability (i.e. improvement), the intervention costs $178,860 compared with the control group (Table 2, Figure 2 [1c]). This large ICER was due to the very small effect on disability (MD -0.01, 95%CI: -8.00 to 7.99). Cost-effectiveness acceptability curves for pain intensity, disability, weight, and BMI are presented in Figure 2 (2b-2e).

For all outcomes, the probability of the intervention being cost-effective in comparison to usual care was 0.33 at a willingness-to-pay of $0/unit of effect gained. For QALYs, disability, weight, and BMI the probability remained about the same irrespective of the willingness-to-pay (Figure 2 [2a, 2c-2e]). For pain intensity, this probability decreased with increasing values of willingness-to-pay (Figure 2 [2b]).

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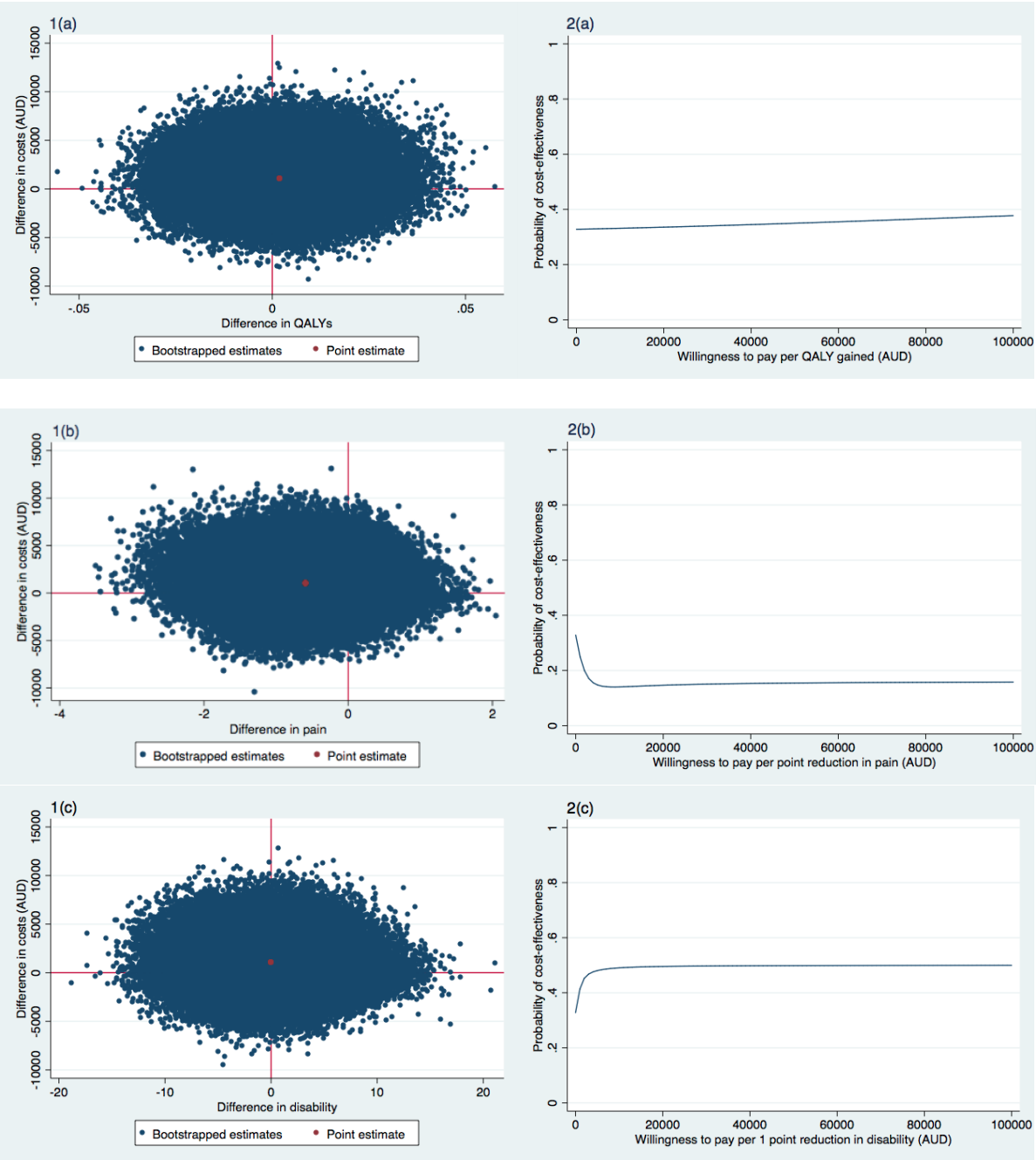
Figure 2. Cost-effectiveness planes indicating the uncertainty around the incremental cost-effectiveness ratios (1) and cost-effectiveness acceptability curves indicating the probability of cost-effectiveness for different values ($) of willingness-to-pay per unit of effect gained (2) for QALY (a), pain intensity (b), disability (c), Weight (d), and BMI (e) (based on the imputed dataset)



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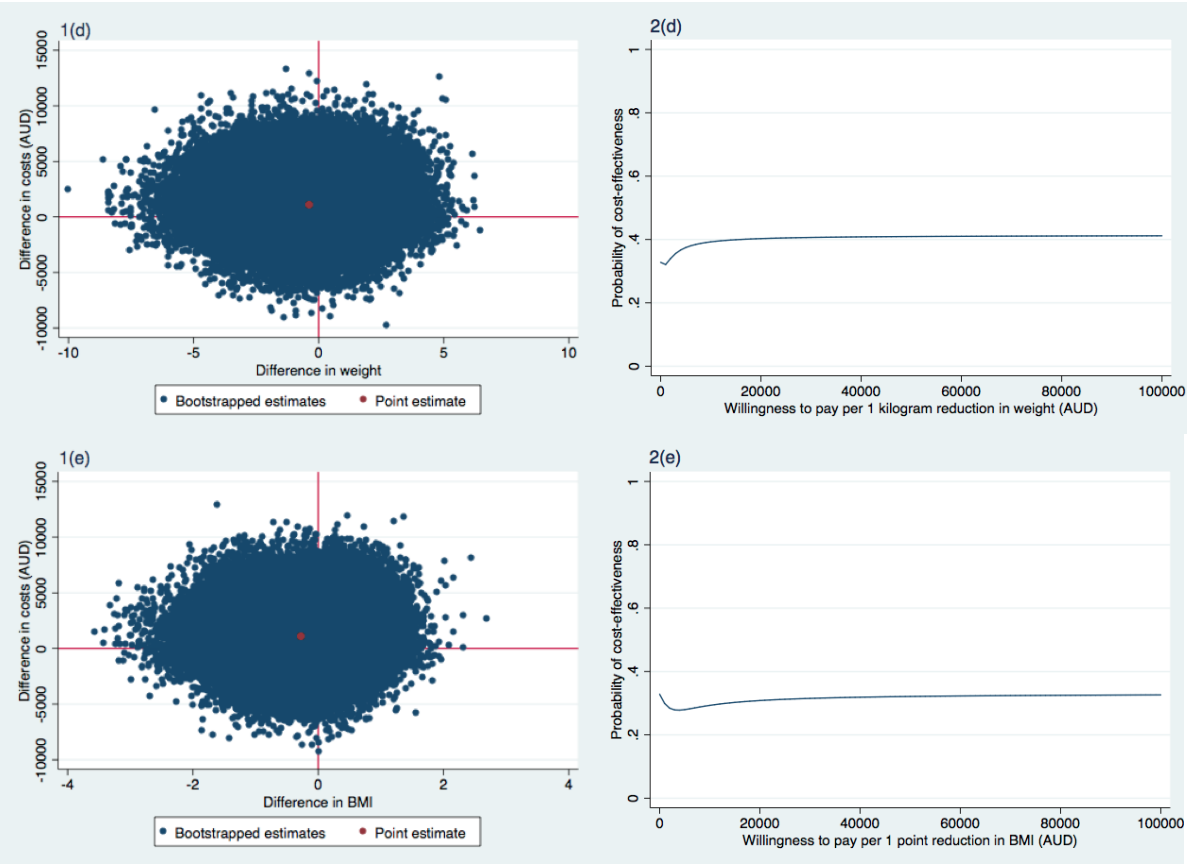

Sensitivity analysis

Results of the sensitivity analysis can be found in Table 2. In brief, for QALYs, the probability of cost-effectiveness was 0.47 at a willingness-to-pay of $0 per QALY gained. For QALYs and disability, the probability of cost-effectiveness remained about the same irrespective of the willingness-to-pay. For pain intensity, weight and BMI the probability decreased for increasing values of willingness-to-pay.

Secondary analysis: healthcare perspective

The ICER for QALY was 358,615 indicating that one QALY gained was associated with a cost of $358,615 compared with the control group (Table 2).

For pain intensity, the ICER was 1,305, indicating that a one-point increase in pain intensity was associated with a cost of $1,305, indicating that the intervention was on average more costly and less effective than usual practice (i.e. achieving poorer outcomes at a higher cost). ICERs in similar directions were found for weight ($2,115 per one kilogram gained) and BMI ($2,856 per one-point increase) (Table 2). For disability, an ICER of -164,545 was

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found. This indicates that for every 1-point decrease (i.e. improvement) in disability, the intervention costs $164,545 (Table 2).

For all outcomes, the probability of the intervention being cost-effective in comparison to usual care was 0.37 at a willingness-to-pay of $0/unit of effect gained. For QALYs, disability, and weight the probability remained about the same irrespective of the willingness-to-pay. For pain intensity and BMI, this probability decreased with increasing values of willingness-to-pay.

Discussion

Main findings

We found that referral to a telephone-based weight management and healthy lifestyle service was not cost-effective from a societal perspective compared with usual care, for patients with knee osteoarthritis who are overweight or obese. Sensitivity analyses confirmed these results. The maximum probability of the intervention being cost-effective was low for all outcomes and perspectives, irrespective of the willingness-to-pay.

Comparison with the literature

To our knowledge, there are no other economic evaluations of telephone-based interventions for patients with knee osteoarthritis, yet our study supports other studies showing limited evidence of cost-effectiveness for conservative treatments for osteoarthritis. A systematic review of nonpharmacological and non-surgical interventions found from 11 cost-effectiveness studies, exercise programs appear to offer the most cost saving but limited evidence of cost-effectiveness for any conservative treatment compared to usual or minimal care controls.[37] Of all four trials evaluating lifestyle programs, none were cost-effective.[37] Importantly, the review reported less than 50% of studies have acceptable methodological quality due to a combination of poor RCT quality, and poor quality economic analyses. Our study using a high-quality RCT and contemporary economic analytic methods shows that telephone support targeting weight loss behaviours, physical activity and diet was neither cost saving nor cost-effective.

A more recent high-quality study assessed the cost-effectiveness of a 6-week multidisciplinary face-to-face treatment program compared with a telephone-based program

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for patients with generalised osteoarthritis.[38] In this study, all patients received in-depth education with the overall goal to enhance self-management skills.[38] Patients in the face-to-face group received six therapeutic groups session (2-4 hours each), whereas the telephone group received only two face-to-face group sessions (2-2.5 hours each) and four individual telephone contacts (15-30 mins each). The study found that from a societal perspective the face-to-face treatment was more likely to be cost-effective at 1-year follow-up.[38] These results, together with the findings from our current study, suggest that telephone-based care for patients with osteoarthritis may not be a cost-effective management approach. Since many patients with osteoarthritis do not receive recommended treatments via clinical models of care,[13,39] understanding why telephone-based interventions are reported to be as effective as face-to-face interventions but not cost-effective, is an important consideration to inform how best to provide care to this patient group.

Strengths and limitations

An important strength of the present study is the pragmatic RCT design. The pragmatic design of the trial enabled us to evaluate the intervention under 'real world' circumstances. This facilitates the generalisability of the results and allows decision-makers to use these results to help guide future healthcare interventions. Another strength is the use of contemporary statistical methods. Multiple imputation was used to avoid problems of lost power and inefficiency associated with complete-case analyses. Seemingly unrelated regression analyses were used for analysing the cost and effect components of the cost-effectiveness analysis, allowing us to adjust for various potential confounders that may not be the same for costs and effects, while simultaneously accounting for the possible correlation between costs and effects. Bootstrapping techniques were used allowing for an estimation of uncertainty surrounding the cost-effectiveness estimates.

This study is not without limitations. Firstly, the rate of missing data at 26 weeks, between 18% and 30% for effect measures and 52% for cost data is high, however, not dissimilar to those in other economic evaluations.[40] We used multiple imputation to account for the missing data, which is recommended over complete case analyses, despite this, results from this study should be treated with caution. Another limitation is that costs were obtained through self-reported questionnaires, which may have introduced recall bias, although the recall period was short (6 weeks). Lastly, presenteeism costs were not included, (i.e. reduced productivity while at work) which is known to be an issue reported by patients with chronic disabling pain.[41]

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Implications and future directions

There is a need for more information about the cost-effectiveness of lifestyle interventions for osteoarthritis. Although this study indicates that the use of a generic non-disease specific telephone-based service is not cost-effective for overweight and obese patients with knee osteoarthritis, the current evidence suggests existing models of care delivery are unable to provide recommended care to the large number of patients with knee osteoarthritis.[13] More research into how to provide scalable models of care that are cost-effective are needed. A key feature of our study and that of other osteoarthritis telephone interventions is that they only provide support over a relatively short period (six weeks to six months). However, other general weight loss programs occur over a much longer time frame. Better understanding about how the key ingredients for telephone services like dose and relevant components (e.g. exercise, weight loss, education) affect cost-effectiveness may provide more insight about the true value of telephone-based approaches for osteoarthritis.

Conclusion

Our findings suggest that referral to a telephone-based weight management and healthy lifestyle service is not cost-effective compared with usual care for overweight and obese patients with knee osteoarthritis. These findings apply to QALYs, pain intensity, disability, weight, or BMI, from the societal and healthcare system perspectives.

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References

1. Vos T, Allen C, Arora M, Barber R. Global, regional, and national incidence, prevalence, and years lived with disability for 310 diseases and injuries, 1990-2015: a systematic analysis for the Global Burden of Disease Study 2015. The Lancet. 2016;388(10053):1545–602. doi: 10.1016/S0140-6736(16)31678-6

2. Vos T, Flaxman AD, Naghavi M, Lozano R, Michaud C, Ezzati M, et al. Years lived with disability (YLDs) for 1160 sequelae of 289 diseases and injuries 1990–2010: a systematic analysis for the Global Burden of Disease Study 2010. The Lancet. 2012;380(9859):2163–96. doi: 10.1016/S0140-6736(12)61729-2

3. Arthritis and Osteoporosis Victoria. A problem worth solving: the rising cost of musculoskeletal conditions in Australia. Elsternwick: Arthritis and Osteoporosis Victoria. 2013.

4. Oxford Economics. The economic costs of arthritis for the UK economy. 2010.

5. United States Bone and Joint Initiative. The Burden of Musculoskeletal Diseases in the United States (BMUS), Third Edition [Internet]. Rosemont, IL; 2014 [cited 2016 Jul 18]. Available from: Available at http://www.boneandjointburden.org

6. Silverwood V, Blagojevic-Bucknall M, Jinks C, Jordan JL, Protheroe J, Jordan KP. Current evidence on risk factors for knee osteoarthritis in older adults: a systematic review and meta-analysis. Osteoarthr Cartil OARS Osteoarthr Res Soc. 2015 Apr;23(4):507–15. doi: 10.1016/j.joca.2014.11.019

7. Christensen R, Bartels EM, Astrup A, Bliddal H. Effect of weight reduction in obese patients diagnosed with knee osteoarthritis: a systematic review and meta-analysis. Ann Rheum Dis. 2007 Apr;66(4):433–9. doi: 10.1136/ard.2006.065904

8. Messier SP, Mihalko SL, Legault C, Miller GD, Nicklas BJ, DeVita P, et al. Effects of intensive diet and exercise on knee joint loads, inflammation, and clinical outcomes among overweight and obese adults with knee osteoarthritis: the IDEA randomized clinical trial. JAMA. 2013 Sep 25;310(12):1263–73. doi: 10.1001/jama.2013.277669

9. NICE. Osteoarthritis: care and management in adults. Clinical Guideline CG177 [Internet]. National Clinical Guideline Centre. National Institute for Health and Clinical Excellence (NICE); 2014. Available from: http://www.nice.org.uk

10. McAlindon TE, Bannuru RR, Sullivan MC, Arden NK, Berenbaum F, Bierma-Zeinstra SM, et al. OARSI guidelines for the non-surgical management of knee osteoarthritis.

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Osteoarthr Cartil OARS Osteoarthr Res Soc. 2014;22(3):363–88. doi: 10.1016/j.joca.2014.01.003

11. RACGP. Guideline for the non-surgical management of hip and knee osteoarthritis. The Royal Australian College of General Practitioners (RACGP); 2009. Available from: https://www.racgp.org.au

12. Shaw K, O'Rourke P, Del Mar C, Kenardy J. Psychological interventions for overweight or obesity. Cochrane Database Syst Rev. 2005;(2). doi: 10.1002/14651858.CD003818.pub2

13. Haskins R, Henderson JM, Bogduk N. Health professional consultation and use of conservative management strategies in patients with knee or hip osteoarthritis awaiting orthopaedic consultation. Aust J Prim Health. 2014;20(3):305–10. doi: 10.1071/PY13064

14. Petrou S, Gray A. Economic evaluation alongside randomised controlled trials: design, conduct, analysis, and reporting. BMJ. 2011 Apr 7;342:d1548. doi: 10.1136/bmj.d1548.\

15. O'Brien KM, Wiggers J, Williams A, Campbell E, Hodder RK, Wolfenden L, et al. Telephone-based weight loss support for patients with knee osteoarthritis: a pragmatic randomized controlled trial. Osteoarthritis Cartilage. 2018. pii: S1063-4584(18)30010-4. doi: 10.1016/j.joca.2018.01.003. [Epub ahead of print]

16. Relton C, Torgerson D, O'Cathain A, Nicholl J. Rethinking pragmatic randomised controlled trials: introducing the "cohort multiple randomised controlled trial" design. BMJ. 2010 Mar 19;340:c1066. doi: 10.1136/bmj.c1066

17. O'Brien KM, Wiggers J, Williams A, Campbell E, Wolfenden L, Yoong S, et al. Randomised controlled trial of referral to a telephone-based weight management and healthy lifestyle programme for patients with knee osteoarthritis who are overweight or obese: a study protocol. BMJ Open. 2016 Mar 1;6(3):e010203. doi: 10.1136/bmjopen-2015-010203

18. O'Hara BJ, Phongsavan P, Venugopal K, Eakin EG, Eggins D, Caterson H, et al. Effectiveness of Australia's Get Healthy Information and Coaching Service®: Translational research with population wide impact. Prev Med. 2012;55(4):292–8. doi: 10.1016/j.ypmed.2012.07.022

19. National Health and Medical Research Council (NHMRC). Australian Dietary Guidelines. Canberra: NHMRC; 2013.

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20. Brown W, Bauman A, Bull F, Burton N. Development of Evidence-Based Physical Activity Recommendations for Adults (18-64 years). Report prepared for the Australian Government Department of Health; 2012.

21. Ware JE, Kosinski M, Turner-Bowker DM, Gandek B. User's Manual for the SF-12v2 Health Survey (with a Supplement Documenting SF-12 Health Survey). Boston, MA: Lincoln, RI: QualityMetric Incorporated; 2002.

22. Brazier J, Roberts J, Deverill M. The estimation of a preference-based measure of health from the SF-36. J Health Econ. 2002 Mar;21(2):271–92. PMID: 11939242

23. Trépel D, Crean M, Begley E. Executive summary: an economic analysis of home care services for people with dementia. 2015 Oct 1 [cited 2017 Jan 20]; Available from: http://www.lenus.ie/hse/handle/10147/580006

24. Hawker GA, Mian S, Kendzerska T, French M. Measures of adult pain: Visual Analog Scale for Pain (VAS Pain), Numeric Rating Scale for Pain (NRS Pain), McGill Pain Questionnaire (MPQ), Short-Form McGill Pain Questionnaire (SF-MPQ), Chronic Pain Grade Scale (CPGS), Short Form-36 Bodily Pain Scale (SF-36 BPS), and Measure of Intermittent and Constant Osteoarthritis Pain (ICOAP). Arthritis Care Res. 2011 Nov;63 Suppl 11:S240-252.

25. Bellamy N. WOMAC User Guide IX. Brisbane, QLD; 2009.

26. National Heart, Lung, and Blood Institute & North American Association for the Study of Obesity. The practical guide: identification, evaluation, and treatment for overweight and obesity in adults. Bethesda, MD: U.S. Dept. of Health and Human Services, Public Health Service, National Institutes of Health, National Heart, Lung, and Blood Institute; 2000.

27. Reserve Bank of Australia. Inflation Calculator [Internet]. 2015 [cited 2016 Oct 12]. Available from: http://www.rba.gov.au/calculator/annualDecimal.html

28. Drummond M, Sculpher M, Claxton K, Stoddart G, Torrance G. Methods for the Economic Evaluation of Health Care Programmes. New York: Oxford University Press; 2005.

29. Scandol J, Phongsavan P, Haas M. An economic appraisal of the NSW Get Healthy Information and Coaching Service. Sydney: Prevention Research Collaboration, Sydney School of Public Health; 2012.

30. AMA. List of Medical Services and Fees: 1 November 2016 [Internet]. Australia: Australian Medical Association (AMA); 2016. Available from: https://ama.com.au/

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31. Australian Government Department of Health. The July 2016 Medicare Benefits Schedule [Internet]. Australian Government Department of Health; [cited 2017 Jan 20]. Available from: http://www.mbsonline.gov.au/internet/mbsonline/publishing.nsf/Content/Downloads-201607

32. NSW Health. Guideline: Costs of Care Standards 2009/10 [Internet]. NSW Health; 2011. Report No.: GL2011_007. Available from: http://www0.health.nsw.gov.au/policies/gl/2011/pdf/GL2011_007.pdf

33. Australian Government Department of Health. Pharmaceutical Benefits Scheme (PBS) | Home [Internet]. Australian Government Department of Health; [cited 2016 Oct 12]. Available from: http://www.pbs.gov.au/pbs/home

34. White IR, Royston P, Wood AM. Multiple imputation using chained equations: Issues and guidance for practice. Stat Med. 2011 Feb 20;30(4):377–99. doi: 10.1002/sim.4067

35. Rubin DB. Multiple imputation using chained equations: Issues and guidance for practice. New York: John Wiley & Sons; 1987.

36. Willan AR, Briggs AH, Hoch JS. Regression methods for covariate adjustment and subgroup analysis for non-censored cost-effectiveness data. Health Econ. 2004 May;13(5):461–75.

37. Pinto D, Robertson MC, Hansen P, Abbott JH. Cost-effectiveness of nonpharmacologic, nonsurgical interventions for hip and/or knee osteoarthritis: systematic review. Value Health J Int Soc Pharmacoeconomics Outcomes Res. 2012 Jan;15(1):1–12. doi: 10.1016/j.jval.2011.09.003.

38. Cuperus N, van den Hout WB, Hoogeboom TJ, van den Hoogen FHJ, Vliet Vlieland TPM, van den Ende CHM. Cost-Utility and Cost-Effectiveness Analyses of Face-to-Face Versus Telephone-Based Nonpharmacologic Multidisciplinary Treatments for Patients With Generalized Osteoarthritis. Arthritis Care Res. 2016 Apr;68(4):502–10. doi: 10.1002/acr.22709

39. Hunter DJ, Neogi T, Hochberg MC. Quality of osteoarthritis management and the need for reform in the US. Arthritis Care Res. 2011 Jan;63(1):31–8. doi: 10.1002/acr.20278

40. Noble SM, Hollingworth W, Tilling K. Missing data in trial-based cost-effectiveness analysis: the current state of play. Health Econ. 2012 Feb;21(2):187–200. doi: 10.1002/hec.1693

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41. Agaliotis M, Mackey MG, Jan S, Fransen M. Burden of reduced work productivity among people with chronic knee pain: a systematic review. Occup Environ Med. 2014 Sep;71(9):651–9. doi: 10.1136/oemed-2013-101997