An Outreach Rehabilitation Program for Nursing Home Residents after Hip Fracture may be Cost-Saving

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Abstract

Background: We compared the cost-effectiveness of 10 weeks of outreach rehabilitation (intervention) versus usual care (control) for ambulatory nursing home residents after hip fracture.

Methods: Enrollment occurred February 2011 through June 2015 in a Canadian metropolitan region. 77 participants were allocated in a 2:1 ratio to receive a 10-week rehabilitation program (intervention) or usual care (control) (46 intervention; 31 control). Using a payer perspective, we performed main and sensitivity analyses. Health outcome was measured by quality-adjusted life years(QALYs), using the EQ5D, completed at study entry, 3-, 6-, and 12-months. We obtained patient-specific data for outpatient visits, physician claims, and inpatient re-admissions; the trial provided rehabilitation utilization/cost data. We estimated incremental cost and incremental effectiveness.

Results: Groups were similar at study entry; the mean age was 87.9±6.6 years, 54(71%) were female and 58(75%) had severe cognitive impairment. EQ5D QALYs scores were non-significantly higher for intervention participants. Inpatient re-admissions were two times higher among controls, with a cost difference of -$3350/patient for intervention participants, offsetting the cost/intervention participant of $2300 for the outreach rehabilitation. The adjusted incremental QALYs/patient difference was 0.024 favouring the intervention, with an incremental cost/patient of -$621 for intervention participants; these values were not statistically significant. A sensitivity analysis reinforced these findings, suggesting that the intervention was likely dominant.

Conclusion: A 10-week outreach rehabilitation intervention for nursing home residents who sustain a hip fracture may be cost-saving, through reduced post-fracture hospital re-admissions. These results support further work to evaluate post-fracture rehabilitation for nursing home residents.

Key words – Hip Fracture, Nursing Home, Rehabilitation, Cost-Effectiveness, Functional Recovery,

INTRODUCTION

Hip fractures are devastating injuries for older adults. Despite 20-25% of these injuries occurring in residential care facilities,(1) nursing home residents are infrequently included in research studies.(2) Many of these residents have underlying cognitive impairment,(3) a condition that also affects their eligibility for post-fracture rehabilitation. The current evidence, although limited, suggests that these individuals experience poorer recovery from hip fractures and have a higher mortality rate.(4-6) Evaluations of the cost of post-fracture care in residential settings are limited.(7;8) Heinrich et al. (2011) described high healthcare costs in the first post-fracture year, with additional costs related to re-admissions and increased care needs for this vulnerable patient population.(9) A recent randomized trial demonstrated short-term benefits of a four-week rehabilitation program for similar patients, although these benefits were not sustained over 12-months.(10) This randomized trial also reported the program was not deemed cost-effective. In contrast, we recently reported a controlled feasibility trial that demonstrated modest benefits in mobility that were sustained to 12-months post-fracture following a 10-week rehabilitation program.(11) Our program was designed specifically for nursing home residents who were ambulatory prior to their fracture; there were no cognitive criteria for inclusion in the program. The intent of the current analysis was to perform a cost-effectiveness analysis on this rehabilitation program for nursing home residents.

METHODS

Description of the Feasibility Trial

As outlined in a previous publication,(11) eligible participants were ambulatory nursing home residents who sustained a hip fracture between February 2011 and June 2015 in a Canadian metropolitan health zone that provides universal healthcare coverage for 1.5 million residents. Non-English speaking residents and those who only ambulated from bed to wheelchair pre-fracture were excluded, and no cognitive criteria were applied for participation. Participants were assigned without knowledge of participants' functional or cognitive status to the outreach intervention (intervention) or usual care (control) groups, at a 2:1 ratio as the outreach team could accommodate. We used proxy respondents to determine outcomes as 58 (75%) participants had severe cognitive impairment (i.e., Mini Mental Status Exam Scores of <12 when assessed post-operatively before hospital discharge by a trained research associate). The outreach group received 10 weeks of rehabilitation following hospital discharge while the control group received usual care. The regional health ethics board provided research ethics approval (Pro00010006).

Economic Evaluation

This evaluation includes two cost-effectiveness analyses that were conducted from a public payer perspective (i.e., the direct cost of health services incurred by the provincial ministry of health, Alberta Health (AH), and the single provincial health authority, Alberta Health Services (AHS)). The costs of all hospital inpatient, hospital outpatient and physician services utilized during the one year follow-up period (excluding the surgical hospital stay) were included. The cost of rehabilitation services comprising the outreach (intervention) program and usual care (control) was also included. Indirect costs such as personal expenditures and productivity loss, of participants and care-givers, were excluded. The primary analyses imputed values that were missing; a second sensitivity analysis based on available cases was also performed.

Since the analytic horizon was 1 year, there was no need to discount costs and QALYs.(12) The analyses were conducted according to the intention-to-treat principle with the main analysis including 46 participants in the intervention and 30 participants in the control group. One control patient, with total healthcare costs 18 times the mean of other control participants, was deemed to be an outlier and was excluded from the analysis.

Health Outcomes

As recommended for cost-effectiveness analyses, the health outcome was measured by quality-adjusted life years (QALYs),(13) using the EQ5D-3L instrument. The EQ5D, used to measure general patient quality of life, is a validated non-disease-specific instrument based on econometric modelling.(12) It has 5 dimensions representing attributes of personal health and activities of daily living. Proxy respondents were asked to complete the EQ5D questionnaire at baseline (pre-fracture), and at 3, 6, and 12 months. Although validated for use with older populations, including hip fracture, its use with proxy respondents is more limited;(30;31) however, it appears that family members provide reasonable responses to less-observable domains.(32) A single index score, with limiting values of 0 (dead) or 1 (no health problems), was derived from the results of each questionnaire by applying population-based utility weights.(12) The index scores of the four observations were combined using the area under the curve method to derive patient-specific QALYs.(14)

Cost Estimates

With recruitment occurring over 4 years (2011-2015), the direct costs of physician and hospital services were adjusted to a single reference year (2015) in Canadian dollars (CAD). We obtained patient-specific utilization data for hospital outpatient clinics (including the emergency department) and hospital inpatient admissions from AHS, as well as physician claims records from AH. Data related to the utilization of rehabilitation services and payments to service providers were obtained from the feasibility trial.

We estimated hospital and physician costs at the service event level. Relative cost weights, based on patient characteristics and treatment variables, were assigned to hospital inpatient and outpatient service events that had been grouped to clinically relevant and statistically homogeneous categories.(15) The cost estimates of hospital services were estimated as the product of the relative cost weight of each service and the Alberta cost per weighted case.(16) These relative cost weights were based on grouping methodologies specific to inpatient and outpatient modes of care. Outpatient weights were scaled so that the inpatient cost per weighted case could be applied to outpatient services.(17) The cost of operational overhead for each service was included in the estimates. AH uses a fee-for-service system to pay for physician services, based on a standard schedule. For all physician services, provided in hospital and in the long-term-care facilities, fees were adjusted to the 2015 schedule.(18)

Outreach Intervention

Outreach participants received 30 sessions of rehabilitation over 10 weeks in their nursing home after hospital discharge. Outreach rehabilitation teams consisted of a licensed physical therapist (PT) and two physical therapy assistants (PTAs) who were hired and trained by the investigators to provide the rehabilitation program. Usual rehabilitation services that would normally be provided by the long-term-care facility were discontinued for the intervention participants during the 10-week intervention period. The cost of the intervention was estimated as the product of the number of weeks each patient received the intervention and the cost per week. In order to estimate the weekly unit cost, provider-specific payments records were accessed reflecting salary, benefits, and operational overhead. Since the intervention services were delivered by non-facility providers, travel cost between the research office and the long-term-care facilities was also included.

Control (Usual Care): Control participants received usual post-fracture care in their nursing home after hospital discharge. Nursing home personnel logged their hours of rehabilitation care for control participants, but received no directions for post-fracture rehabilitation care. Complete rehabilitation care data were available for only 9 of 30 controls, with the remaining participants providing incomplete or no rehabilitation information. Two control participants who survived less than a week were assumed to have no rehabilitation cost. In keeping with the outreach intervention providers, control rehabilitation costs included salary, benefits and overhead.

All other services provided by the long-term-care facilities to both intervention and control participants were not included patient-specific costs in long-term-care facilities not reported in Alberta. Nevertheless, we expected that services provided to all participants by the facilities would be virtually identical after the intervention period between the two groups.

Missing Data and Imputation

About 9% of the data cells required to estimate incremental cost and QALYs were missing from the study data set. Missing data occurred in only quality of life (EQ5D) variables and the rehabilitation cost for the control group. The proportion of missing quality of life data was similar between groups: 8% and 11% for the intervention and control groups, respectively. The missing values were distributed over 44 participants, so the complete case analysis was based on 32 (42%) participants. A smaller complete case number lowers the statistical power of the analysis, increasing the risk of biased estimates.(19)

Since data were collected from proxy respondents, we assumed that missing data were not related to adverse outcomes and were generally ‘missing at random’.(19) A multiple imputation procedure was undertaken at the patient level to estimate missing values. Twenty data sets were generated to incorporate the uncertainty involved in the imputation process.(20) We used the Amelia II v1.7.3 package for R to conduct multiple imputation analysis, using the observed data and the empirical relationships between variables to estimate the missing values.(21)

Cost-effectiveness Analysis

We assessed cost-effectiveness by estimating incremental cost (the difference in mean cost per patient between the study arms) and incremental effectiveness (the difference in mean QALYs per patient). An intervention is considered cost-effective, in relation to an alternative, in the following situations: (a) it costs less (incremental cost is negative) and is more effective (the incremental health effect is positive); (b) the intervention costs more and is more effective than the alternative, but society is willing to pay for the additional cost per QALY; and, (c) theoretically at least, the intervention costs less and is less effective, but society is unwilling to pay for the additional cost per QALY of the alternative.(12;22;23) Interventions that cost less and are more effective are considered dominant or 'cost-savings'.

We used regression analysis to estimate incremental cost effect, adjusting for the length-of-stay (LOS) on the index hospital event and survival time during the follow-up period. The baseline EQ5D score was the only variable used to adjust the incremental health effect. The Rcmdr package v2.1-5 for R was used to conduct the analyses(24) and Filemaker Pro Advanced v16.05 (Filemaker Inc., Santa Clara, USA) was used for general database management.

Uncertainty

To account for the uncertainty due to sampling variation, and to overcome the inherent skewness in sampling distributions of economic variables, we used a non-parametric bootstrap analysis to generate the joint distribution of incremental cost and health effect.(12;23;25) We used the boot package v1.3-20 for R to generate 10000 replications for each of the 20 imputed data sets.(26) The bootstrap replicates were used to derive a cost-effectiveness acceptability curve (CEAC), indicating the probability of the intervention being cost-effective at various levels of society's willingness to pay per unit of health effect gained.(27;28) Confidence intervals, for incremental cost and health effect estimates, were based on estimates of standard errors obtained by the application of Rubin's method to the bootstrap replicates of the imputed data sets.(29)

Sensitivity Analysis

To further assess the influence of missing data, we conducted a cost-effectiveness analysis based on available cases: 57 participants had complete cost data and 44 complete EQ5D data. Regression analyses were used to estimate the incremental cost and health effect. Since the number of complete cases for cost and health outcome data were different, we were not able to bootstrap both the cost and QALY regressions simultaneously. In order to estimate the CEAC, we employed an alternative approach based on the application of the central limit theorem (i.e., the sampling distribution of an estimator will tend to normality as the sample size increases).(30) In order to estimate confidence intervals for incremental cost and QALYs, we used a separate bootstrap analysis (10000 replications) for each regression.

RESULTS

As previously reported, 77 participants were enrolled in the trial, with 46 allocated to the intervention group and 31 to control (with one outlier removed for a total of 30 for this evaluation).(11) After removing the patient deemed to be an outlier, there were no significant group differences at study entry, aside from a slight delay in hospital rehabilitation starts postoperatively for the intervention group (Table 1). The mean age of the cohort was 87.9±6.6 years, 54 (71%) were female and 58 (75%) had severe cognitive impairment as measured by the Mini-Mental Status Examination (i.e., scores <13).(31) Both groups reported high levels of dependence pre-fracture based on Functional Independence Measure Motor domain (FIM_{motor}) scores, but 42% of participants were independently walking (i.e., FIM ambulation scores >5; p=0.91 for group differences). The EQ5D baseline scores based on the imputed data set (data missing for 7 participants) were not significantly different (95% CI, Table 2), although the mean score for intervention participants was 0.08 higher than control participants.

Health Outcomes

At all observation points after baseline, the EQ5D scores were higher for intervention participants than controls, but these differences were not significant (Table 2). Intervention participants experienced a non-significant difference of 0.051 QALYs per participant in relation to controls based on imputed data that was unadjusted for baseline differences between participants.

Health Service Utilization and Costs

Hospital outpatient visits and physician services per participant were virtually equal between study arms (Table 3). However, the control group had a higher proportion of inpatient re-admissions in the 12-month follow-up period relative to the intervention group; this finding was not statistically significant. Overall, there were 14 re-admissions in 13 patients (8 re-admissions in 7 (23%) of 30 patients in the control group vs 6 (13%) of 46 patients in the intervention group). Re-admissions appeared related to the hip fracture event with 5 re-admissions associated with infectious events (septicemia [n=3 control] or urinary tract infections [n=2 intervention]), 5 related to issues with fracture fixation / mobility issues [4 control; 1 intervention], and 2 related to new fracture events [2 intervention]. The remaining 2 re-admissions were associated with renal failure [1 control] and mental health [1 intervention].

The cost difference for inpatient re-admissions was $3350 CAD less/participant for the intervention than the control group. This re-admission cost more than offset the estimated excess cost per participant of $2300 CAD for the outreach group relative to the control group. Consequently, the unadjusted total cost per participant was $1312 CAD less for the intervention group; again this finding was not statistically significant.

Cost-effectiveness Analysis

After adjusting for baseline differences among participants, the incremental QALYs per participant declined to a difference of 0.024 (Table 4) in favour of the intervention. The adjusted incremental total cost per participant was $621 CAD less for the intervention group. Although both incremental values were not statistically significant, the point estimates of this main analysis, based on multiple imputation, did indicate dominance (less costly and more effective) of the intervention versus control (usual care). The CEAC shown by the solid line in Figure 1, embodying the uncertainty of the estimation process, shows that the intervention was more likely to be cost-effective than the control. The CEAC rises from a 55% probability of the intervention being cost-effective at the origin, where society will not pay any premium for additional costs per QALY to 70% at the final point on the curve where society's willingness-to-pay is $100,000 per QALY gained per participant.

Sensitivity Analysis

The results of the available case analysis reinforce the results of the main analysis, indicating that the intervention was likely to be dominant. The non-significant incremental cost and health effect point estimates were higher than the main analysis. However, the width of CIs was greater for corresponding incremental values in the available case analysis compared to those of the main analysis, indicating greater uncertainty. Nevertheless, the CEAC shown by the dotted line is higher than the curve for the main analysis, reinforcing the conclusion that the rehabilitation intervention may be cost-effective compared to usual care (Figure 1).

DISCUSSION

Evidence regarding care and outcome of nursing home residents who sustain a hip fracture is limited, with little known about the costs of providing post-fracture care for these individuals. We recently demonstrated that participation in a standardized rehabilitation program was feasible, and provided modest benefits in mobility that were maintained to 12-months post-fracture.(11) The current analysis suggests that a prolonged rehabilitation program (10 weeks) may also be cost-saving from a healthcare payer perspective, primarily due to a reduction in post-fracture hospital re-admissions. The group that received the rehabilitation program had post-fracture healthcare costs that were $621 CAD less than those who received usual care over the first 12 post-fracture months despite the $2300 CAD costs per participant associated with providing the rehabilitation program. The cost-effectiveness findings, although promising, were not statistically significant as they were obtained from a feasibility trial that was not powered for a full effectiveness or cost-effectiveness analysis.

However, the findings are encouraging, as re-hospitalizations are common after hip fracture for people living in nursing homes. Mitchell et al. (2019) reported that aged care residents in Australia had fewer rehabilitation episodes than those who were community-dwelling after their hip fracture and were more likely to have a hospital re-admission.(32) Heinrich et al. (2010) reported increased post-fracture costs associated with both rehabilitation and re-admissions after hip fracture for nursing home residents in Germany, but did not perform a cost-effectiveness analysis to examine the impact of post-fracture care and determine the relative benefit of rehabilitation in preventing or avoiding future complications requiring hospital re-admission.(9)

While our feasibility trial indicates a modest, but sustained mobility benefit after a 10-week post hip fracture rehabilitation program for nursing home residents, another well-powered randomized trial did not find sustained benefits after a 4-week rehabilitation program for a similar group of residents.(10) In contrast to our current cost-effectiveness findings, the 4-week program in that randomized trial was not cost-effective. That trial and ours represent the most rigorous evaluations of post-fracture rehabilitation and its associated costs for nursing home residents.(7;8) Despite contradictory findings, the difference in the interventions evaluated in these trials, predominantly the duration of the rehabilitation program, would suggest that further research is warranted for this vulnerable patient group. It is possible that post-fracture rehabilitation needs to be extended for a longer time period to allow these frail individuals to achieve modest but sustained benefits. Although extended rehabilitation adds cost, sustained benefits of the program may offset the costs associated with rehabilitation by avoiding future hospital re-admissions. Avoiding hospital re-admissions has both payer and patient benefits.

The cost-effectiveness analysis performed herein used accepted methodology to determine the cost and impact associated with the intervention. However, there are some notable limitations. Although we had complete cost data on the intervention program, the usual care (control) group yielded very limited data, despite repeated and sustained efforts by the investigators to obtain usual practice data from the participating nursing homes. Only 9 of 30 health care providers for the usual care group returned a fully completed rehabilitation log, so we had to use imputation to build our comparison model. In our previous qualitative evaluation, caregivers in these settings acknowledged that it was difficult to provide rehabilitation and care after hip fracture due to a lack of resources (both personnel and time).(33;34) It was not possible, based on our data to know why rehabilitation services were so limited in the control group and whether rehabilitation treatment decisions were based on resource limitations or patient capacity to participate.

Finally, despite applying accepted analytic approaches, our evaluation was under-powered as it was performed with data obtained in a feasibility trial, which did not use a power calculation, so our results must be considered preliminary. Despite these limitations, this evaluation provides valuable information for others considering rehabilitation for nursing home residents after a hip fracture.

In summary, a 10-week outreach rehabilitation intervention for ambulatory nursing home who sustain a hip fracture, not only provides modest gains in mobility that were sustained to 12-months post fracture, but may also be cost-effective (i.e. costs less, but is more effective). The cost-saving appears to arise from a reduction in post-fracture hospital re-admissions. These results should be considered preliminary, but they support further work evaluating the impact and value of post-fracture rehabilitation for this most vulnerable group of patients sustaining hip fracture.

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Table 1. Clinical Data of REGAIN II Participants at Study Entry by Group Allocation

	Mean ± SD or n (%)		
	Intervention (n=46)	Control (n=30)	p-value
Participant Characteristics			
Age in years			0.78
< 85	10 (22)	8 (27)	
85+	36 (78)	22 (73)	
Gender, Female	31 (71)	23 (77)	0.45
Comorbidities			0.38
≤ 2	11 (24)	4 (13)	
3 or more	35 (76)	25 (86)	
Walker Type			1.0
Outdoor walker	13 (30)	8 (28)	
Indoor walker	31 (70)	20 (72)	
Assistance			0.31
No/Minimum	37 (88)	20 (77)	
Moderate to Maximum	5 (12)	6 (23)	
Proxy			1.0
Family member (Spouse/Offspring)	39 (89)	25 (89)	
Other	5 (11)	3 (11)	
Functional Independence Measure (FIM)			
FIM_{motor} Domain	43.8 ± 18.4	39.9 ± 15.6	0.35
Locomotion Domain	6.1 ± 2.7	5.6 ± 2.3	0.39
Mobility Domain	11.2 ± 4.7	10.9 ± 4.5	0.75
Surgical and Hospital Data			
Fracture type			0.33
Femoral neck	15 (33)	14 (47)	
Trochanteric	30 (67)	16 (53)	
Hospital complications			1.0
Yes (*1or 2 complications*)	7 (15)	5 (17)	
Hospital days			0.65
Median (IQR)	7 (5-10)	8 (6-11)	
[range]	[3-18]	[3-18]	
Surgery days			0.73
Median (IQR)	1 (0-1)	1 (0.75-1.25)	
[range]	[0-4]	[0-3]	
Postoperative rehabilitation start days			0.006
Median (IQR)	1.5 (1-2)	1 (1-1.5)	
[range]	[1-3]	[1-4]	

Legend: SD: Standard Deviation; FIM: Functional Independence Measure; IQR: Interquartile Range

Table 2. Health Outcome by Group Allocation *

Variable / Observation	Intervention n=46	Control n=30	Mean Difference [95% CI]**
EQ5D baseline	0.558	0.477	0.081 [-0.037, 0.199]
EQ5D 3 month	0.283	0.235	0.048 [-0.045, 0.141]
EQ5D 6 month	0.259	0.214	0.045 [-0.061, 0.151]
EQ5D 12 month	0.235	0.180	0.055 [-0.055, 0.165]
QALY l2 month	0.297	0.244	0.053 [-0.038, 0.148]

Legend: EQ-5D = Euro Quality of Life 5 Dimension; QALYs = Quality Adjusted Life Years; CI = Confidence Intervals

* Based on multiple imputation: 20 imputed data sets.

** Unadjusted for baseline variables.

Table 3. Cost and Utilization per Patient by Group Allocation*

Cost Component	Intervention n=46	Control n=30	Difference [95% CI]***
Intervention / Rehabilitation**	2741	441	2300 [1688, 2912]
Inpatient			
Cost per patient	1598	4947	-3350 [-7649, 949]
Admissions per patient	0.13	0.27	-0.14 [-1.38, 0.17]
Hospital Outpatient			
Cost per patient	628	814	-185 [-668, 297]
Visits per patient	1.6	1.7	-1.0 [-0.9, 0.6]
Physicians			
Cost per patient	2080	2156	-76 [-849,698]
Services per patient	61	59	2 [-16, 21]
Total Cost per Patient*	7047	8359	-1312 [-6187, 3563]

Legend: CI = Confidence Intervals

* Costs are based on 2015 Canadian Dollars

**Based on multiple imputation: 20 imputed data sets.

*** Unadjusted for baseline variables.

Table 4. **Final CEA Results* by Group Allocation ****

Analyses	Intervention	n	Control	n	Unadjusted Mean Difference	Adjusted Difference*** [95% CI]****
Main Analysis*						
Cost per Patient	7047	46	8359	30	-1312	-621 [-6546, 5165]
QALYs per Patient	0.297	46	0.244	30	0.053	0.024 [-0.058, 0.108]
Sensitivity Analysis						
Cost per Patient	7047	46	10590	11	-3543	-1407 [-12122, 4944]
QALYs per Patient	0.328	24	0.210	20	0.118	0.068 [-0.033, 0.192]

Legend: CEA = Cost Effectiveness Analysis; QALYs = Quality Adjusted Life Years; CI = Confidence Intervals

* Costs are based on 2015 Canadian Dollars

** Based on multiple imputation: 20 imputed data sets.

*** Adjusted for baseline variables.

**** Based on 10000 bootstrap replicates of each imputed data set for the main analysis and 10000 replicates of each incremental cost and QALYs gained.

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Figure 1 Legend. Cost-effectiveness Acceptability Curves*

* Costs are expressed in constant 2015 Canadian dollars

Figure 1

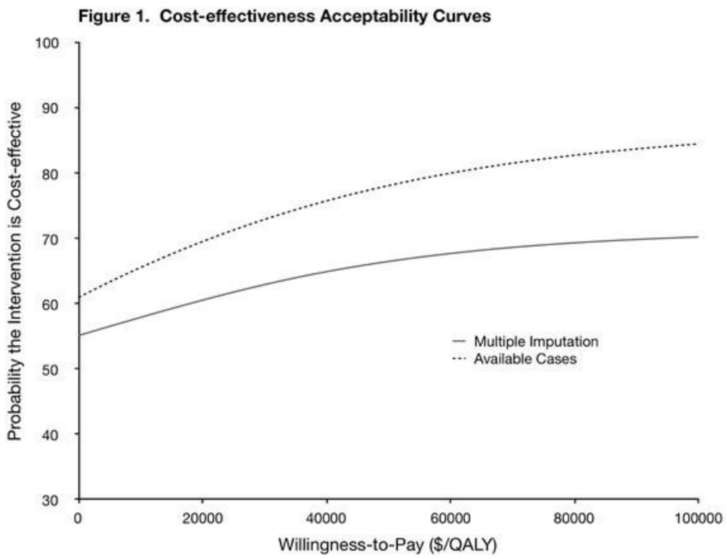

Figure 1. Cost-effectiveness Acceptability Curves
Probability the Intervention is Cost-effective
100
90
80
70
60
50
40
30
0
20000
40000
60000
80000
100000
Willingness-to-Pay ($/QALY)
Multiple Imputation
Available Cases