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COST AND EFFECTIVENESS OF HIP PROTECTORS AMONG THE ELDERLY

Maria Segui-Gomez
Eric Keuffel
Kevin D. Frick
Johns Hopkins School of Hygiene and Public Health

Abstract

Objective: To characterize the net cost and quality of life effects associated with hip protector use among the elderly relative to no intervention.
Methods: We developed two deterministic hypothetical cohorts of 500,000 65-year-old women or men and followed them over the remainder of their lifetimes. Data inputs were collected from secondary sources. Net costs are expressed in 1999 U.S. dollars, whereas net effectiveness is expressed in lives saved and in quality-adjusted life-years (QALYs) gained.
Results: Hip protector use results in net cost savings for both elderly women and men. Women over age 65 and men over age 85 also gain QALYs through hip protector use.
Conclusion: Using the estimates available in the literature, our analysis indicates that use of hip protectors among women is associated with large cost savings and QALY gains even when accounting for the inconvenience of using the protectors. Among men, hip protectors are also associated with cost savings (although of smaller magnitude), but there are net losses of QALYs because of the inconveniences associated with the protectors.

Keywords: Hip protectors, Hip fractures, Aged, Cost-effectiveness, Quality of life

The burden of hip fractures among the elderly, which include high mortality rates, impairment, functional limitations, disability, and costs, have been sufficiently proven (1;3;4;6;20;30;38;40;41). The epidemiology, risk factors, and potential interventions to prevent hip fractures have also been studied extensively (10;11;12;13;15;21;24;26;27;32;33;35;37). Hip protectors are one of the most promising strategies evaluated to date, with hip fracture reduction rates of more than 50% (5;14;15;19). However, hip protectors must be purchased and used in order to be protective (29). As with any preventive measure, not all those purchasing and using hip protectors would suffer a hip fracture without them. Our objective was to compare all benefits and inconveniences (including costs) associated with using protectors. For this purpose, we used a cost-effectiveness framework (8).

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METHODS

We developed a deterministic state transitional model to track two hypothetical cohorts of 500,000 65-year-old men or women with and without hip protectors through death. Separate gender cohorts allowed for different hip fracture incidence rates, hip fracture–related and non-hip fracture–related mortality rates, life expectancy, and perceived quality-of-life decrement due to wearing the hip protectors.

In developing the model, we followed the recommendations of the reference case issued by the U.S. Department of Health and Human Services Panel of Cost-Effectiveness in Health and Medicine (8). We adopted a societal perspective, and analyses were conducted to compute the net costs associated with the intervention (in 1999 U.S. dollars) and the net quality-adjusted-life-years (QALYs) saved. We also calculated the cost per hip fracture prevented and the cost per life saved, but for the sake of brevity these results are not presented here.

Depending on the net cost and effectiveness, the intervention could result in: a) cost savings and QALY gains; b) cost savings and QALY losses; c) positive cost and QALY gains; and d) positive cost and QALY losses. These combinations and their implications for the implementation of the intervention are summarized in Figure 1 (34).

For each year in our model, any given individual could experience one of the five following scenarios: a) fracture a hip and live; b) fracture a hip and die due to the hip fracture (excess deaths due to hip fracture); c) fracture a hip but die of a non-hip-related cause; d) not fracture a hip and live; and e) not fracture a hip but die. Net costs and effects were calculated for each year of the intervention as well as cumulatively. The cohorts were run until either all its individuals had died or until the survivors turned 100 years old, whichever came first. Future costs and health benefits were discounted at 3%. Inflation

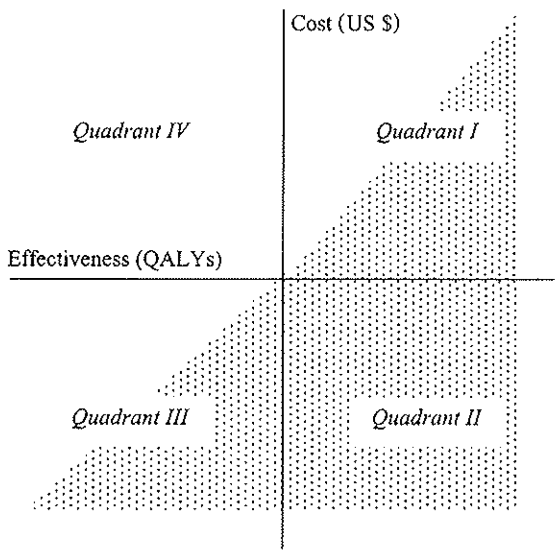

Figure 1. Cost and effectiveness quadrants and implications for recommendation. Shared areas indicate situations in which the intervention could be recommended based on the following rationale: cost savings and QALY gains (quadrant II); cost savings and QALY losses (quadrant III) but ratios above some cost-effectiveness ratio threshold; positive cost and QALY gains (quadrant I) and ratios below some cost-effectiveness ratio threshold. Adapted from Stinnett & Mullahy (34).

adjustments were based on the Consumer Price Index (2). Calculations were performed using Microsoft® Excel software (22).

Sensitivity analyses allowed for variation in key input parameters. We evaluated alternative input values reported in the literature and changes by 30% in the base case values. We also searched for values that transformed the impact of hip protectors from net savings to net positive costs, from net QALY gains to QALY losses, or from cost-effectiveness ratios below $100,000 per QALY gained to ratios above that level. We chose this arbitrary cut-off point of $100,000 per QALY because this ratio has been reported as an upper bound in other evaluations of medical and injury-related interventions (9).

The data used for the base case and sensitivity analyses calculations are summarized in Table 1.

Mortality and Morbidity Incidence

Hip fracture incidence rates by gender were derived from the most recent U.S. National Hospital Discharge Survey data available (32). These rates are available only in 10-year age intervals starting at age 65. Hip fracture rates are statistically significantly higher for women than men across all ages.

Excess mortality due to hip fracture (by gender and age category) was derived by multiplying the marginal risk of death associated with hip fracture by the number of individuals who fractured their hip (6;39). As seen in Table 1, the relative risk of mortality is higher for men in each age category (although not always statistically significantly higher).

No evidence was found in the literature that hip fractures affect life expectancy beyond the first year after the event. Hence, we applied the same life expectancy to 1-year survivors of hip fracture as that of individuals of the same age and sex who did not sustain a hip fracture.

Effectiveness of Hip Protectors and Quality of Life Impact

The relative risk of hip fracture when hip protectors are used was assumed to be 0.44 based on one of the two largest randomized studies available (18). Assuming 100% compliance, this relative risk translates into an efficacy of 56%. This estimate is consistent with the 54% efficacy recently reported (15). Although the populations in these trials had higher fracture rates than in healthier populations, we found no evidence to suggest that the efficacy of the hip protectors varies across age or gender. However, the varying hip fracture rates among different age and gender groups leads to different effectiveness rates (which accounts for both efficacy and hip fracture incidence) and efficiencies. Sensitivity analyses were conducted on both the relative risk and the compliance rate. Relative risk was varied by 30%, and the compliance rate was reduced in 10% decrements.

The net impact on Quality of Life (QoL) due to the use of hip protectors was evaluated by subtracting the QALYs lost due to the generalized and continued use of hip protectors by the population (our measure of "inconvenience") from the QALYs gained from averted fatal and nonfatal hip fractures.

Individuals for whom the hip protectors prevented a fatal hip fracture were assumed to retain their prefracture (or baseline) QoL for their remaining life expectancy. The baseline QoL and life expectancy estimates were sex- and age-specific values derived from the general U.S. population (7;39).

Individuals who survived the hip fracture were assumed to suffer a reduction in their baseline QoL that would last for their remaining life expectancy. The amount of QoL lost was derived from the Functional Capacity Index, an injury preference–based measure that represents the predicted long-term functional limitations associated with a health condition (19). In a scale ranging from 0 (death) to 1 (perfect health), hip fractures are

Table 1. Reference Case Values and Ranges Used in Sensitivity Analysis

Variables	Base case value	Sensitivity analysis range	Reference no.
Initial population size			
Women	500,000	—	
Men	500,000	—	
Discount rate	3%	0–7%	8
Mortality and morbidity incidence, Women			
Incidence of hip fracture per 100,000			
Age 65–74	501.10	411.0–591.2[a]	32
Age 75–84	1620.30	1440.4–1800.2[a]	32
Age 85+	3958.30	3,471.6–4,445.0[a]	32
Relative risk of mortality for hip fracture			
Age 65–74	3.3	2.1–5.2[a]	6
Age 75–84	2.5	2.0–3.1[a]	6
Age 85+	1.6	1.2–2.0[a]	6
Mortality and morbidity incidence, Men			
Incidence of hip fracture per 100,000			
Age 65–74	168.0	112.2–225.2[a]	32
Age 75–84	682.1	560.4–803.7[a]	32
Age 85+	2,256.2	1,611.3–2,901.0[a]	32
Relative risk of mortality for hip fracture			
Age 65–74	4.2	2.8–6.4[a]	6
Age 75–84	2.9	2.2–3.9[a]	6
Age 85+	3.1	2.2–4.2[a]	6
Efficacy and QoL			
Hip protector efficacy	56%	43%–69%	5;15
Hip protector use (compliance)			
Age 65–74	1.00	0.1–0.9	
Age 75–84	1.00	0.1–0.9	
Age 85+	1.00	0.1–0.9	
QoL loss due to hip fracture (morbidity)	0.14	0.33, 0.69, 0.95[b]	18;31;37
Women:			
Prefracture (baseline) QoL			
Age 65–74	0.83	0.35–1[a]	7
Age 75–84	0.79	0.24–1[a]	7
Age 85+	0.80	0.1–1[a]	7
QoL due to hip protector use			
Age 65–74	0.005	0.0, 0.001, 0.01, 0.05[b]	
Age 75–84	0.005	0.0, 0.001, 0.01, 0.05[b]	
Age 85+	0.005	0.0, 0.001, 0.01, 0.05[b]	
Remaining life expectancy			
Age 65–74	15.5[c]	—	39
Age 75–84	9.1[c]	—	39
Age 85+	3.8[c]	—	39
Men:			
Prefracture (baseline) QoL			
Age 65–74	0.84	0.39–1[a]	7
Age 75–84	0.84	0.31–1[a]	7
Age 85+	0.82	0.21–1[a]	7
QoL loss due to hip protector use			
Age 65–74	0.01	0.0, 0.001, 0.005, 0.05[c]	
Age 75–84	0.01	0.0, 0.001, 0.005, 0.05[c]	
Age 85+	0.01	0.0, 0.001, 0.005, 0.05[c]	

(Continued)

Table 1. (*Continued*)

Variables	Base case value	Sensitivity analysis range	Reference no.
Remaining life expectancy			
Age 65–74	12.7[c]	—	39
Age 75–84	7.5[c]	—	39
Age 85+	3.1[c]	—	39
Cost			
Hip protector (initial and replacement)	$50	$35–65[d]	[f]
Frequency of replacement (years)	1	2, 3[c]	
Cost of nonfatal fracture	$37,019	$18,818–48,125[b,e]	1;23
Cost of fatal fracture			
Women	$8,237	$5,766–10,708[d]	25
Men	$8,197	$5,738–10,656[d]	25

[a] Range reflects 95% confidence intervals.
[b] Range extends beyond ±30% and incorporates alternate values from literature.
[c] Life expectancy is age-specific (in 1-year increments). For simplicity, values shown in table are mid-range values (remaining life expectancy at ages 70, 80, and 93, respectively).
[d] Range reflects ±30%.
[e] 80% of costs incurred in year of injury, remaining 20% spread through remaining lifetime.
[f] Personal communication, 2000; DJ Orthopaedics, Tracy, CA; The Hipsaver Company, Inc., Canton, MA; and Prevent Products, St. Paul, MN.

reported to result in a loss of 0.14. In sensitivity analyses we also evaluated alternative losses derived using general heath-related QoL instruments (31).

In the absence of any formal work to quantify the inconvenience associated with using hip protectors, we elicited QoL estimates from a convenience sample of gerontologists and elderly individuals using visual analog scales (36). Subjects reported no losses in QoL (0.0), moderate losses (0.01). In light of these findings and inconvenience values used in a previous study, we arbitrarily chose an 0.005 and 0.01 loss for women and men, respectively, for the base case analysis and conducted extensive sensitivity analyses on these values (13). We placed particular emphasis in identifying how net QALYs vary with different values of decrements for hip protector use.

Net Costs

Cost savings associated with averted mortality and morbidity (e.g., hospitalization, emergency visits, rehabilitation) were subtracted from the costs associated with hip protector use. Productivity losses were excluded from our cost calculation since they are assumed to be a part of the QoL estimates (8).

Direct costs for hip fracture–related mortality ($8,237 for women and $8,197 for men) were derived from the costs for fatal falls (25). Total savings due to averted hip fracture–related mortality were calculated by multiplying the costs per fatal fracture by the number of individuals in the cohort whom the hip protectors protected from sustaining such a fracture.

Direct costs for nonfatal hip fractures were reported to be $37,019 (23). We assumed that 80% of this morbidity cost occurred during the first year postfracture and that the remaining 20% cost was evenly distributed over the remaining life expectancy of the individual (25). In the sensitivity analysis, we also evaluated a lower reported cost of $18,818 (1). Total nonfatal fracture costs saved were computed by multiplying the costs of a nonfatal hip fracture by the number of nonfatal cases prevented by the hip protectors.

The use of hip protectors does not require a major resource investment at the beginning of the intervention. However, the protectors and the girdle where the protectors are fitted need to be replaced regularly. We assumed annual replacement. The annual cost of hip protectors equaled the costs of a girdle and protectors multiplied by the number of people purchasing

Table 2. Base Case Results: Cost and Effectiveness per 500,000 Population and Implications

	Total net cost in millions (1999 US $)	Total net effectiveness		Implications for hip protector use[a]
		In lives	In QALYs	
Women (all)	(1,215)[b]	5,906	32,000	Recommend
Age 65–74	(182)	579	4,000	Recommend
Age 75–84	(553)	2,239	18,000	Recommend
Age 85+	(480)	3,089	10,000	Recommend
Men (all)	(135)	5,962	(26,000)[c]	Do not recommend ($6,400 saved per QALY lost)
Age 65–74	78	123	(25,000)	Do not recommend
Age 75–84	(117)	1,429	(5,000)	Do not recommend ($39,000 saved per QALY lost)
Age 85+	(96)	1,109	4,500	Recommend ($16,000 spent per QALY gained)

[a] Recommendation based on the following rationale: if cost savings and QALY gains ->, recommend; if costs savings and QALY losses ->, decide based on cost-effectiveness ratio threshold of $100,000 saved per QALY lost; if positive cost and QALYgains ->, decide based on cost-effectiveness ratio threshold of $100,000 spent per QALY gained; if positive costs and QALY losses, do not recommend.
[b] Total net costs are negative because savings due to mortality and morbidity prevented exceed hip protector cost.
[c] Total net QALYS are negative because inconvenience of consistently wearing hip protectors exceeds benefits in mortality and morbidity.

them at the beginning of each year. We estimated a constant $50 per year using figures provided by medical supply vendors (personal communications, 2000; DJ Orthopaedics, Tracy, CA; The Hipsaver Company, Inc, Canton, MA; Prevent Products, St. Paul, MN). In the base case, we assumed a 100% compliance rate (i.e., all living individuals buy the equipment and use it), but we modified this compliance rate in the sensitivity analysis. In particular, we evaluated both lowering compliance rates without changing purchases (i.e., all individuals buy protectors, but some do not use them) and with changes in purchases (i.e., whoever does not use the hip protector does not buy it either).

RESULTS

Base Case

As seen in Table 2, use of hip protectors among women in our hypothetical cohort led to cost savings exceeding $1.215 billion, 5,906 fewer hip fracture–related deaths, and 32,000 QALYs gained. The cost savings reflects the high incidence rate of hip fracture among this population and the low cost of the intervention. These cost savings and QALY gains are particularly large during the decade from 75 to 84 years old due to the large number of women still alive in that age group (409,000 at age 75 vs. 243,000 at age 85) and the much higher incidence rate of hip fracture in this age group. In fact, about half of the costs saved and the QALYs gained due to hip protectors in our hypothetical cohort of women occurred during this age period (45% and 56%, respectively).

Use of hip protectors among men led to an overall net cost savings of over $135 million, 5,962 hip fracture–related deaths averted, and a net loss of 25,000 QALYs. However, these findings differ as the cohort ages; hip protectors are cost saving only for men over 75, and there is a net QALY gain only beyond age 85.

Sensitivity Analyses

The above results were robust to extensive sensitivity analyses (i.e., although the numbers change, the policy implications remain the same). Only the variables which change substantively are discussed below.

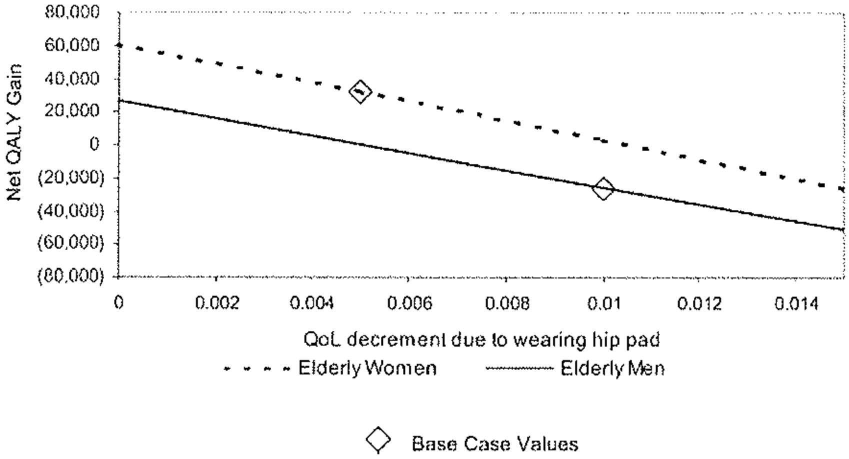

Figure 2. Hip protector net QALY gain versus QoL loss associated with wearing hip protectors. Note: Numbers in parentheses indicate net losses.

Figure 2 presents the impact of alternative QoL estimates related to the inconvenience of using hip protectors on the total net QALYs associated with the intervention by gender. Even if using hip protectors did not constitute an inconvenience (i.e., QoL decrement or loss = 0.0), men would gain only about half as many QALYs as women (34,500 vs. 61,000) due to the higher hip fracture and survival rates in women. If women are assumed to have the same decrement in QoL as men did in the base case (0.01), hip protectors are still associated with a positive net gain in QALYs (2,650). This inconvenience must reach an 0.0105 loss in QoL per woman before the losses outweigh the QALYs gained due to the averted hip fractures. Among men, net QALYs become zero when the hip protector inconvenience is reduced to just over 0.005 per user. If this discomfort is further reduced below this amount, hip protectors result in a net QALY gain (32).

Figure 3 summarizes the impact of changes in the QoL associated with nonfatal hip fractures on the net QALYs resulting from the intervention. QoL gains due to averted

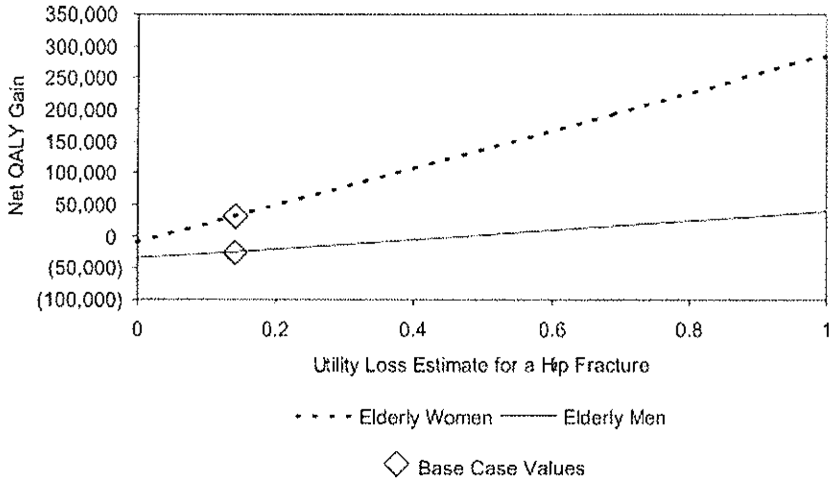

Figure 3. Hip protector net QALY gain versus QoL loss estimate for a hip fracture. Note: Numbers in parentheses indicate net losses.

morbidity only have to be 0.03 for net QALY gains to occur among women, whereas this "breakeven" QoL value is 0.49 for men. Use of larger QoL loss values increases net QALY gains among women to 87,984 (when QoL loss = 0.33) or 270,874 (if QoL loss = 0.95). Among men, the net QALYs changed to −11,758, 15,106, or 34,507 when 0.33, 0.69, or 0.95 were used, respectively.

Net costs were sensitive to changes beyond 30% of both the base case value in nonfatal hip fracture costs and in hip protector costs. Net costs increase as nonfatal hip fracture costs decrease, since less is saved for each fracture prevented. This cost had to be lowered to $25,104 for hip protectors to result in a net (positive) cost among men and to $7,918 for a net positive cost among women, as demonstrated in Table 3.

Table 3. Selected Sensitivity Analyses Values Affecting the Base Case Results

Variable	Values at which: Net costs = 0	Net QALYs = 0	Cost-effectiveness ratio reaches $100,000 per QALY
QoL loss due to wearing hip protector			
Women	N/I[a]	0.0105	0.0125[b]
Men	N/I	0.005	0.0053[b]
QoL loss due to Nonfatal hip fracture			
Women	N/I	0.03	None[c]
Men	N/I	0.49	0.47[d]
Cost of nonfatal hip fracture			
Women	$7,918	N/I	None[e]
Men	$25,104	N/I	None[f]
Hip protector cost			
Women	$219	N/I	$665[g]
Men	$72	N/I	None[h]
Hip protector efficacy			
Women	13%	27%	24%[i]
Men	39%	None[j]	None[k]
Hip fracture incidence (% baseline)			
Women	23%	48%	43%
Men	70%	201%	181%[l]
Compliance (all individuals still purchase protector)			
Women	23%	0%	7.5%[m]
Men	70%	0%	None[n]

[a] N/I indicates that changes in the variable value had no impact on this parameter.
[b] Value above which hip protectors are not recommended since the CE ratio is less than $100,000 saved per QALY lost (not shaded area of quadrant III in Figure 1).
[c] As QoL loss due to nonfatal hip fracture diminishes from 0.03 to 0.0, the intervention is still recommended since at least $100,000 are always saved per QALY lost (shaded area of quadrant III).
[d] Value below which hip protectors are not recommended, same as in footnote b.
[e] As cost of nonfatal hip fracture diminishes from $7,918 to $0, hip protectors are still recommended since no more than $100,000 are spent per each QALY gained (shaded area of quadrant I).
[f] As cost of nonfatal hip fracture diminishes from $25,104 to $0, hip protectors are no longer recommended since there are negative QALYs and positive costs (quadrant IV).
[g] Above $665 per hip protector, they are no longer recommended since the cost-effectiveness ratio exceeds $100,000 per QALY (unshaded area in quadrant I).
[h] Above $72 per hip protector, same as in footnote f.
[i] Between 24% and 27%, hip protectors are recommended, same as in footnote c.
[j] QALYs are always negative for men at all compliance levels.
[k] QALYs are always negative and savings are never enough to reach the $100,000 saved per QALY lost threshold.
[l] At this level both costs and QALYs are negative, but there is $100,000 in cost savings per QALY lost.
[m] Between 7.5% and 23%, same as in footnote c.
[n] Between 0% and 70% compliance, there are negative QALYs and positive costs; there is never a point above 70% compliance in which the cost savings are greater than $100,000 per QALY lost.

Hip protector cost must increase to $72 for the intervention to result in positive net costs for men, or to $219 for women. Even if net costs are positive, the cost-effectiveness ratio of hip protectors among women remains lower than $100,000 per QALY gained as long as the cost of hip protectors does not exceed $665.

Net costs and net QALYs remained robust to changes in hip fracture incidence rates and hip protector effectiveness.[1] Among women, hip protector efficacy must be less than 27% for net QALY losses to occur, and it must be less than 13% to result in net (positive) costs. In contrast, hip protectors in men do not result in net QALY gains even if efficacy is 100%, and they result in net (positive) costs when efficacy is less than 39%.

Regarding hip fracture incidence, only when the base case incidence rates for women are applied to the male cohort do hip protectors gain QALYs for men (even with a much higher QoL lost due to wearing the protector).

Compliance rates can affect the effectiveness of the intervention and its costs. When compliance was lowered and purchase of the hip protectors was eliminated for those who were noncompliant, hip protectors remained cost saving among women and men but to a lesser degree. For example, if compliance was 50%, cost savings would be reduced from $1.2 billion to $600 million and from $134 million to $67 million among women and men, respectively. The impact on QALYs would also change: women would gain 16,000 QALYs rather than 32,000 QALYs, and men would lose 13,000 QALYs instead of 26,000. Men actually have a smaller loss in QALYs lost since only half as many men would experience the loss in QoL due to wearing the hip protector.

Hip protectors only result in cost savings when compliance is 70% or higher in men and 23% or higher in women (assuming that all men and women continue to purchase hip protectors). Lower compliance rates never result in net QALYs gains for men. Women show net QALY gains at all levels of compliance, but the magnitude of the gain depends on the extent of compliance. Among women, hip protectors are either cost saving or result in a cost-effectiveness ratio less than $100,000 per QALY gained when compliance is above 7.5%.

Multivariate analyses confirmed our findings. Minimizing hip fracture–related QoL decrements and simultaneously maximizing the QoL decrement for hip protector use led to a similar net QALY loss in women and men (233,000 QALYs lost). Maximizing fracture-related QoL losses while minimizing the hip protector inconvenience led to substantially larger QALY gains in women (300,000) than men (86,000). Even if cost variables are set so that costs are maximized and savings minimized, women still have a net cost savings while men show a net cost of $91 million. When these variables are again reversed, both sexes show a large cost savings, although the savings for women far exceed those of men ($1.79 billion vs. $360 million). If all variables except compliance are simultaneously shifted from best case values (values that favor adoption of hip protectors) to worst case values, hip protectors are always cost saving for women and range from being cost saving ($1.42 billion in savings) to cost incurring ($282 million in costs) among men. Among women, net effectiveness ranges from 411,000 QALYs lost to a gain of 883,000 QALYs. Men share a similar lower bound (379,000 QALYs lost) but have a substantially smaller upper bound (264,000 QALYs).

DISCUSSION

Using the estimates available in the literature, our analysis indicates that use of hip protectors among women is associated with large cost savings and QALY gains even when accounting for the inconvenience of using the protectors. Among men, hip protectors are also associated with cost savings (although of smaller magnitude), but there are net losses of QALYs. The more favorable findings among women are due primarily to their higher incidence of hip fractures but also reflect the lower inconvenience assumed on women who use hip protectors. These findings are robust to the use of alternative values found in the literature for the costs of hip fractures, the impact on quality of life of nonfatal fractures, and effectiveness values (1;15;31). The findings are also robust to assumptions that we made during the analysis, such as compliance rate and inconvenience of using hip protectors. But even when no inconvenience is accounted for and every member of the cohort uses the protectors regularly, the gender gap in QALYs gained persists.

It is important to note the relationship between compliance rates and the QoL associated with the inconvenience of wearing the protector. In our analysis, using a scale from 0 (no loss of QoL) to 1 (total loss), every woman must, on average, rate this inconvenience as 0.0105 or higher for the hip protectors to have a net QALY loss impact after accounting for all the hip fractures prevented in this population. This value is 0.005 or higher among men. Arguably, those who perceive the largest inconvenience are the ones less likely to comply with use. Improvements to reduce the inconvenience could improve compliance. However, we chose to separate these two concepts in our analysis for two reasons: 1) many other issues beyond inconvenience affect compliance (e.g., availability, affordability, cognition, peer pressure); and 2) even if one agrees to use hip protectors (i.e., the perceived benefits exceed the perceived inconveniences), the inconveniences persist, and it would be too simplistic to dismiss those in the net QALY effects.

Our analysis is not without limitations. Some of these, as indicated above, relate to the uncertainty around some parameters. Others relate to the way some data were available in the literature. For example, hip fracture rates are only available in 10- or 15-year intervals, thus limiting our calculations of benefits and cost to the same age intervals (32). Another example is the assumption that life expectancy after a nonfatal hip fracture equals life expectancy for an age and gender-matched individual who has not suffered a hip fracture. This means that benefits of a prevented hip fracture may be carried over too long a period; therefore, our findings may be overly optimistic. However, the discount of future benefits minimizes the actual impact of this potential bias.

The choice of cost-effectiveness analysis as our analytical framework is not without limitations (16). However, we believe that its implied systematic and comprehensive evaluation of the interventions' advantages and disadvantages is helpful in the process in resource allocation. First, it allows the intervention to be positioning in relation to some boundaries. When the intervention results in cost savings and QALY gains or when it results in positive cost and QALY losses, the decision regarding its implementation is easy. When the intervention results in cost savings and QALY losses or positive cost and QALY gains, another parameter must be defined: the monetary threshold that we are willing to save or spend for each QALY lost or gained, respectively. Based on previously reported thresholds, we choose a $100,000 per QALY limit, but the readers are encouraged to choose their own. Second, robust findings, even in the presence of uncertain parameters, reduce the need for additional research to better define those parameters before a decision can be made.

POLICY IMPLICATIONS

This is, to our knowledge, the first attempt to estimate cost and effectiveness of hip protectors to prevent hip fractures. Our analyses produced robust findings. Hip protectors among women 65 years or older lead to QALY gains and, predominantly, cost savings. Even when they result in net positive costs, their cost-effectiveness ratio is lower than those reported for other interventions (9;13;35;37). Hip protectors among men are a cost-saving intervention but do not lead to QALY gains until men reach age 85. Before then, hip protectors result in QALY losses sufficiently large so that the intervention does not reach our $100,000 saved per QALY lost threshold. The inconvenience associated with hip protector use would have to be substantially reduced (if not completely eliminated) for the protectors to result in net positive effects among men aged 65–84.

Our results highlight the importance of comparing the costs and effects imposed by the proposed preventive measure on the entire population who would have to adopt it to the benefits reaped by the subset of those individuals who would suffer the injurious event.

NOTE

[1] Interestingly, when incidence rates from frail populations, such as those in the hip protector efficacy trials, are used, hip protectors result in even more favorable cost-effectiveness ratios. For example, in women, cost savings grows to $5.1 billion from $1.2 billion and QALYs saved increases to 208,000 from 32,000 when imputed baseline rates from the Lauritzen trial population are used (17). Among men the cost savings increases from $134 million to $4.5 billion and a QALY loss of 25,000 QALYs becomes a QALY gain of 225,000 QALYs. This underscores the fact that hip protectors are particularly efficient in frail, at-risk populations.

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