Full Length Article

Estimating the future burden of hip fractures in Norway. A NOREPOS study

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ABSTRACT

Background: The incidence rate of hip fractures seems to be declining in many western countries. However, due to the ageing of the population, the number of fractures may still be on the rise. No papers so far have quantified the future burden of hip fractures in terms of both health loss (as measured in disability adjusted life years DALY) and costs. The purpose of this paper is to assess the future health and economic burden of hip fractures.
Methods: We collected population projections from Statistics Norway up until the year 2040. The medium projection was used for the base case analysis. Fracture rates for 2008 were estimated based on information from the Norwegian Epidemiologic Osteoporosis Studies (NOREPOS) hip fracture database (NORHip), which includes information about all hip fractures in Norway. Future fracture rate was assumed to decline by 0.7% per year in the base case. We used the same assumptions as the global burden of disease project on years of remaining life and disability weights. Cost of hip fracture was based on the published literature.

In sensitivity analyses, we assessed the impact of changing underlying assumptions on demographic change, development in hip fracture rate, assumed life expectancy and choice of disability weights.
Results: Assuming a medium population growth and a continued decline in fracture rate, our estimates indicate that health lost to hip fractures will approximately double, from 32,850 DALYs in 2020 to 60,555 in 2040. Over the same period, costs are estimated to increase by 65%.

Sensitivity analyses indicate that estimates are highly sensitive to assumptions on both population growth, fracture rate development, disability weights and assumed life expectancy.
Conclusion: The burden of hip fractures in terms of DALYs lost and cost incurred is likely to increase even if the fracture rate continues to decline.

1. Introduction

Recent research indicates that the age specific incidence of hip fractures may be declining in many Western countries [1,2] including Norway [3,4]. However, given an ageing population, the absolute number of hip fractures may still be on the rise [5]. Estimates indicate that by 2050, 20% of the Norwegian population will be 70 years old or older, compared to 12% today [6]. This population growth will greatly increase the population at risk of hip fractures and potentially the health and economic burden of hip fractures.

The burden of hip fractures is twofold, as fractures affect both the health of individuals and societal cost. The health burden of hip fractures manifests as both disability [7] and mortality [8]. One summary measure of the health burden is the Disability Adjusted Life Year (DALY), consisting of years of life with disability and years of life lost due to premature mortality [9]. The DALY is the measure of health

burden used by the WHO in the Global Burden of Disease Project (GBD) [10]. The cost of hip fractures results from the cost of acute care, but also from rehabilitation efforts and changes in living arrangements following functional decline.

To our knowledge, only two studies have attempted to estimate the burden of hip fractures in terms of DALYs. One is a study from Iran [11]; the other is a study pooling information from 14 European and US cohort studies (CHANGES consortium) [12]. No published studies have projected the future health burden in terms of DALYs.

A number of cost projections already exist for different countries [13–21]. Early papers [20,21] tended to assume that age specific incidence would continue to increase, whereas more recent work has generally assumed a constant future rate of fractures [19]. Cost projections have largely neglected to account for the combined effect of changes in fracture rates and population ageing. Accurate projections not only depend on demographic changes, but also on assumptions

about future fracture risk, thus new projections on future burden of hip fractures are warranted [22].

On this background, the aim of the current paper is threefold: (1) to estimate the current burden of hip fractures in Norway in terms of DALYs and health care costs, (2) to project the future health and economic burden, and (3) to assess the impact of the estimated projections by changing underlying assumptions about population growth, changes in incidence rates, choice of disability weights and assumed life expectancy.

This paper adds to the current literature by projecting both health and cost consequences of hip fractures. We also quantify how sensitive estimates of health burden of disease are to assumptions about life expectancy and choice of disability weights.

2. Methods

Current burden was calculated by multiplying the number of fractures by estimates of health care unit costs and current health burden in DALYs. For future projections, the number of fractures in each year was calculated by multiplying the number of eligible individuals in the different population projections by the assumed future age and gender specific fracture rates. Different scenarios based on different assumptions about input parameters supplement our best guess analysis.

2.1. Number of current hip fractures

Fracture rates for 2008 were estimated based on information from the Norwegian Epidemiologic Osteoporosis Studies (NOREPOS) hip fracture database (NORHip), which includes information about all hip fractures in Norway [3,23]. The NORHip database was created using information on hip fractures gathered from the patient administrative system of all Norwegian hospitals treating hip fractures through a procedure developed by the Norwegian Knowledge Centre for the Health Services. In total 139,913 new hip fractures were identified from 1 January 1994 to 31 December 2008. Age and gender specific number of fractures in 2008 were combined with population information from Statistics Norway on population at risk, defined as the mid-year population 50 years or older, in order to estimate incidence rates.

2.2. Health lost due to a hip fracture

We measured health lost due to hip fractures in Disability Adjusted Life Years (DALYs). The DALY combines the effects of mortality and disability following a fracture into one summary measure. The DALY consists of two components, years of life lost (YLL) and years lived with disability (YLD) [24].

$$DALY = YLL + YLD \qquad (1)$$

YLL was calculated using mortality rates from Statistics Norway, adjusted to reflect the increased mortality following an incident hip fracture using a hazard ratio of 2.0, based on an estimate from a Norwegian study [25]. Since the applied hazard ratio of dying was based on an analysis that adjusted for a number of covariates, we assumed that the remaining effect was causally related to a hip fracture and made no further adjustments. This post fracture mortality rate was multiplied by expected length of remaining life as used in the GBD project estimated by Coale and Guo [26]. We applied uniform age weighting.

$$YLL = N * L, \qquad (2)$$

where N is number of deaths and L is life expectancy at age of death.

A discount rate of 3% was applied in order to make estimates comparable to other studies [27].

In order to calculate YLD, we multiplied the age and gender specific hip fracture rate by the expected duration of impairment and a disability weight.

$$YLD = Incidence * duration\ of\ disease * disability\ weight \qquad (3)$$

Because hip fractures have been found to have an effect on both short and long-term quality of life, we estimated both a short and long-term loss. Based on findings by Bertram and co-workers [7], we assumed the duration of short-term disability to be six months. We applied disability weights of 0.228 for short-term disability and 0.057 for long-term disability, taken from a European update of the Global burden of Disease project by Haagsma and colleagues [28]. Because the long-term disability weight could be viewed as too low given that many patients suffer serious impairments [7,29], we assumed that this long-term weight represents the average impairment among all patients and not a weight to be assigned only to those with moderate or severe hip sequela.

2.3. Cost of a hip fracture

The cost of a hip fracture depends on the patient care pathway. Almost all patients sustaining a hip fracture will need surgery. Different types of surgery are available depending on the nature of the fracture (dislocated or un-dislocated fractures) and the surgeon's advice. Based on information from the Norwegian hip fracture registry (https://www.kvalitetsregistre.no/registers/nasjonalt-hoftebruddregister), we assumed that 40% of the fractures would need prosthesis, while 60% would rely on surgery using other, less expensive techniques, such as parallel screws. Based on national tariffs, the cost of prosthesis is €14,702, while cost of parallel screws is €8036, resulting in a weighted average of €10,703.

For other costs related to hip fracture, we based our estimate on a published randomized controlled trial of orthogeriatric care in Norway [30]. One limitation with this study was that patients already residing in a nursing home at the time of the fracture were excluded from the trial. Patients living at home at the time of the fracture have been shown to suffer the more expensive fractures [31,32], as the marginal impact of a fracture on living conditions are less dramatic for patients already residing in a nursing home. We assumed that patients residing in nursing homes would only incur operation costs causally related to the fracture event. Approximately 25% of all fractures occur among long-term care patients [33]. To further adjust for the fact that some of the costs in the year following the fracture event would have been incurred independent of the fracture [34], we used an adjustment factor based on a Canadian study [35] that estimated that 70% of the costs are causally related to the hip fracture.

2.4. Future number of hip fractures

Demographic projections were obtained from Statistics Norway for the period 2014 to 2040. The medium projection alternative was used in our base case analysis. For the fracture rate, we assumed a continued, but somewhat reduced decline in fracture rate (half of the decline observed in the period 1994 to 2008).

2.5. Sensitivity analyses

We explored the uncertainty in the number of future fractures arising from choice of demographic projection and uncertainty in fracture rate development. In addition, we changed the underlying assumption in the DALY calculations with regard to number of expected life years and disability weights, in order to assess the impact of the estimated future health burden.

2.5.1. Demographic change and incidence rate of hip fractures

Statistics Norway has three main projections that are based on different assumptions about fertility, mortality and immigration. While the medium projection was used in the base case, we explored the impact of using the low and high population projections in sensitivity

analysis.

For the incidence rate, we explored the impact of assuming a constant future fracture rate. The assumption being that the fracture rate had reached a minimum and would remain constant over time. Given that the future rate development is uncertain, we also explored a scenario assuming a continued decline in the fracture rate of the same magnitude as that observed in the period 1999–2008, i.e. a decline of 1.4% per year [5].

Together with the base case, these changing assumptions constitute five different scenarios for future number of fractures and, thus, alternative health loss and cost projections. The five scenarios are: [1] medium population growth and a half decline in fracture rates (i.e. 0.7% per annum), [2] low population growth combined with continued decline in fracture rates, [3] high population growth with constant fracture rates, [4] medium population growth with constant fracture rates and [5] medium population growth with continued decline in fracture rates.

2.5.2. Disability weights and choice of life expectancy

The health burden of hip fractures as measured in DALYs is naturally sensitive to choice of disability weights. We explored this uncertainty in a sensitivity analysis by replacing the GBD Haagsma weights [28] with the weights proposed by the International Osteoporosis Foundation (IOF) [36]. The IOF weights are 0.468 for the first year after fracture and 0.17 for subsequent years. We also applied Norwegian estimates of remaining life-years produced by Statistics Norway instead of the GBD estimates [26].

3. Results

3.1. Current health and economic burden of hip fractures

Current burden of hip fractures in terms of number of fractures, deaths, years of life lost, years of life with disability, DALYs, costs of surgery and total health and social care costs are displayed in Table 1. Based on 9978 hip fractures, the current health burden in terms of DALYs is 16,791 and 16,058 in women and men, respectively. In terms of cost, hip fractures pose a burden on the health system of €107 million for surgery, and of €348 million when the effect of rehabilitation and changes in living situation are also included. In the current situation,

most of the health lost and costs incurred result from fractures in women.

In terms of the different components of DALYs, we see that for men, disability is the greatest contributor to the DALYs until they reach their mid-60s, after which the mortality component is the main driver. For women, the disability factor is the largest contributor until they reach their 80s.

3.2. Future health and economic burden of hip fractures

Women lose more health to disability resulting from fractures than men, while men lose more life years. In terms of health burden, women currently lose more health to hip fractures than men, but this is expected to change around 2022, c.f. Fig. 1, left panel. Our estimates indicate that in the period from 2020 to 2040 health lost to hip fractures will approximately double, from approximately 32,850 DALYs in 2020 to approximately 60,555 in 2040. This is assuming the base case projection with a medium population growth and a continued, but reduced, decline in fracture incidence.

Given the base case projection, costs are expected to increase by 65% by 2040 compared to the current situation. As with health loss, the relative increase for men is expected to be much larger than for women (100% vs 42% increase respectively, c.f. Fig. 1, right panel).

When we split the estimated health burden on different age groups, we see that the increased health burden is clearly most pronounced in the oldest age groups, i.e. age 80–84 years old (71% increase), 85–89 years old (109% increase) and 90–94 (121% increase), c.f. Fig. 2.

3.3. Sensitivity analyses

3.3.1. Assumptions about demographic changes and incidence rates of fractures

The magnitude of the increase in the number of fractures is highly dependent on the assumptions about both demographic and fracture rate development. The increase in number of fractures varies from a 17% increase in the most conservative estimate (low population growth, continued decline in fracture rate) to a 131% increase in a more pessimistic scenario, assuming high population growth combined with a constant future fracture rate.

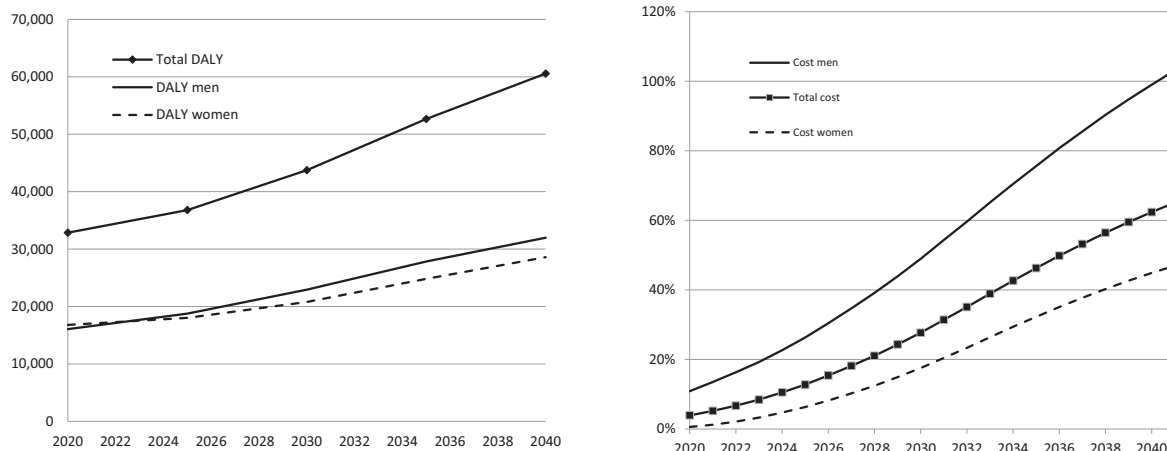In Fig. 3, we have calculated the health and economic burden of hip

Table 1
Current health and economic burden of hip fractures (2020).

Age group	Individuals	Fractures	Deaths caused by hip fracture	Remaining life years	YLL*	YLD	DALYs*	OP cost (€)	Total cost (€)
Women									
50–54	181,197	74	1	38	17	164	181	788,355	2,574,747
55–59	161,842	143	2	33	36	280	317	1,530,630	4,998,997
60–64	151,569	245	4	28	85	416	501	2,622,270	8,564,265
65–69	137,708	411	11	24	184	592	776	4,393,945	14,350,512
70–74	132,239	660	29	19	424	786	1210	7,060,708	23,060,090
75–79	93,388	996	61	15	749	954	1703	10,658,755	34,811,219
80–84	64,397	1198	159	12	1543	888	2431	12,826,257	41,890,223
85–89	43,473	1498	398	8	2895	828	3723	16,033,364	52,364,552
90–94	23,038	1197	1079	6	5472	478	5949	12,809,278	41,834,771
Sum women	988,851	6421	1744		11,405	5386	16,791	68,723,563	224,449,376
Men									
50–54	194,505	97	2	38	47	216	263	1,037,084	3,387,089
55–59	171,061	121	4	33	91	237	327	1,291,779	4,218,917
60–64	154,838	162	12	28	227	276	503	1,738,789	5,678,840
65–69	136,591	274	25	24	432	396	828	2,935,251	9,586,454
70–74	126,709	471	62	19	915	561	1476	5,036,704	16,449,743
75–79	82,469	518	131	15	1613	496	2109	5,543,843	18,106,048
80–84	48,416	652	277	12	2696	483	3179	6,974,472	22,778,445
85–89	26,625	760	462	8	3358	420	3778	8,134,283	26,566,357
90–94	10,441	502	669	6	3394	200	3594	5,375,472	17,556,152
Sum men	951,655	3557	1646		12,774	3284	16,058	38,067,677	124,328,045
Total	1,940,506	9978	3390		24,179	8671	32,850	106,791,240	348,777,421

* Discounted by 3%.

Fig. 1. Absolute future health loss (DALY) and % cost increase.

fractures under different assumptions of population ageing and fracture rate development. The total burden in terms of both health loss and costs are likely to increase under all assumptions analyzed. The magnitude of the burden varies from an estimated 44,500 DALYs and 18% cost increase by 2040 in the "best case scenario" to 78,000 DALYs and 97% cost increase in the "worst case scenario". Note that we have not included a scenario with an increasing fracture rate, which would have generated an even greater burden.

3.3.2. Choice of disability weights and life expectancy

If instead of the GBD disease weights, we use those proposed by the IOF, the estimated health loss increases by approximately 50% (varies somewhat between years). An additional effect of changing the disease weights is that disability in women becomes the largest component of the health loss until the year 2028, after which it is overtaken by life loss in men, c.f. Fig. 4, top right panel. This is contrary to the findings using the GBD disease weights, where years of life lost in men is the largest contributor.

If we, instead of the GBD remaining life years, use Norwegian gender specific estimates, the estimated total health lost to hip fractures is 60% lower, from 83,126 DALYs to 34,367 DALYs in the year 2040. Internal ranking of contributors to the DALYs are not affected by changing life expectancy reference, but curves shift downwards.

4. Discussion

Our study adds to the existing body of literature by providing a projection of both the health and economic burden of hip fractures, while also accounting for recent fracture rate developments. It illustrates that the burden of hip fractures is likely to increase, even if the incidence rates continue to decline. Health loss to hip fractures is likely to double by 2040 and cost may exhibit a 65% increase.

We find that, currently, 32,850 DALYs are lost to hip fractures. The GBD study [37,38] does not report on hip fractures as a separate injury or disease, but estimates DALYs lost to fall injuries. To our knowledge, included in fall injuries are all fractures, both low- and high-energy fractures, as well as all fracture types. Compared to their estimates of health loss to fall injuries, our estimate indicates a larger loss in lifetime (24,179 vs. 8535) and a lesser loss in disability (8671 vs. 17,596). One problem with this comparison is that fall injuries encompass several types of injuries and a broader age range than our estimate.

Compared to the two published studies on fracture burden in terms of DALYs, our calculations are based on an estimated 9978 fractures as compared to 10,119 in Iran [11] and 7724 in a mixed European and US cohort, CHANCES [12]. If we compare the findings based on no age weighting, we find a burden of 32,850 DALYs as compared to 26,600 in Iran and 11,145 in the mixed European and US cohort [12]. Contrary to the overall findings based on the CHANCES cohort [12], we find that mortality constitutes to be the largest contributor to health loss after fracture. Included in the 14 cohorts making up the CHANGES
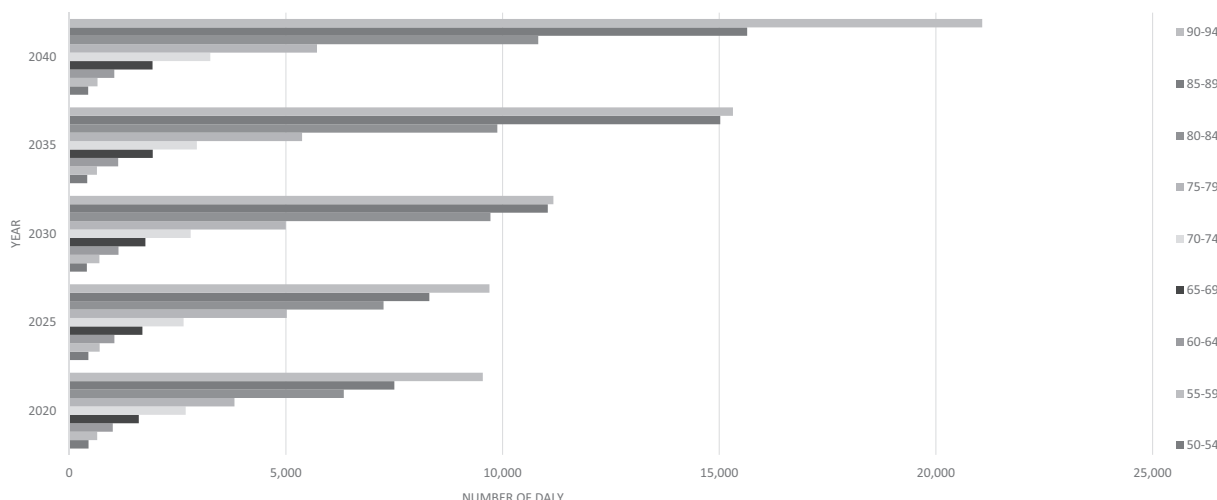

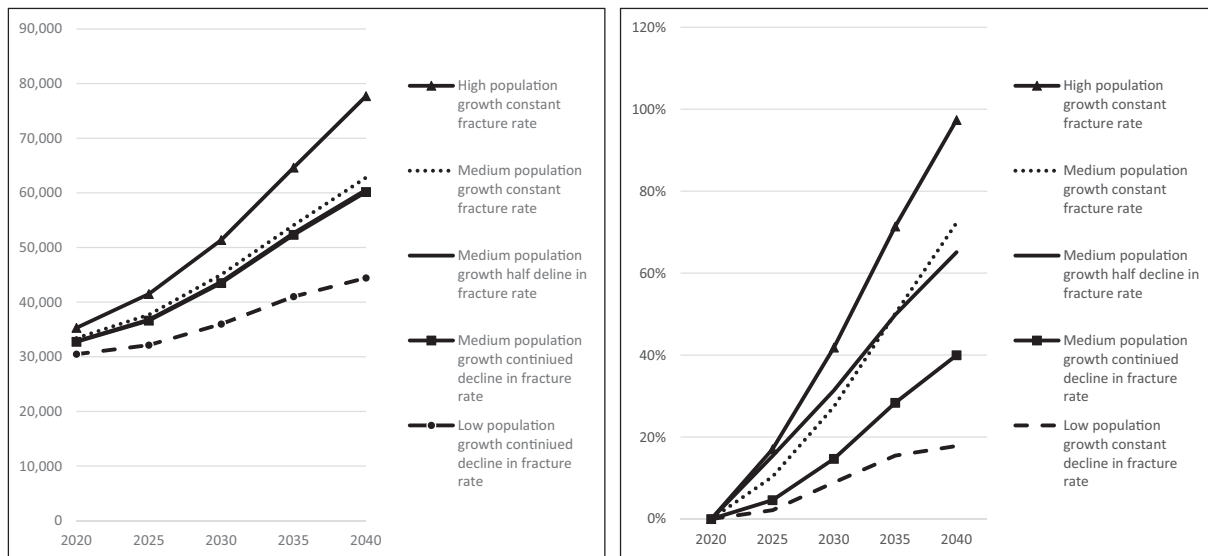**Fig. 2.** Future health loss (DALY) by age group.

Fig. 3. Future loss of health (DALYs) and costs projected based on different demographic and fracture rate assumptions.

consortium was both the Norwegian Tromsø study and the Swedish mammography cohort. Since life expectancy and rate of fractures vary geographically [20], we also compared our results to these sub populations. If we compare estimated years of life lost to disability as percentage of the total health loss to hip fractures for women only, we find it to constitute 56% as compared to 57% in the Tromso study and 58% in the Swedish mammography study.

For comparability, we have used the GBD methodology and calculated years of life lost based on the years of remaining life from the

Coale study as our base case [26]. The Coale life expectancy of 82.5 years is generated from Japanese women and is higher than the average life expectancy in most countries, including Norway. The GBD group argues for using the Coale estimates because these estimates are viewed as a maximum achievable goal [38]. Standardisation of life expectancy also makes comparisons across studies from different countries easier. As the life expectancy in these Japanese women is higher than the average life expectancy in Norway, choosing the Norwegian life expectancy rather than the Coale estimates decreases the
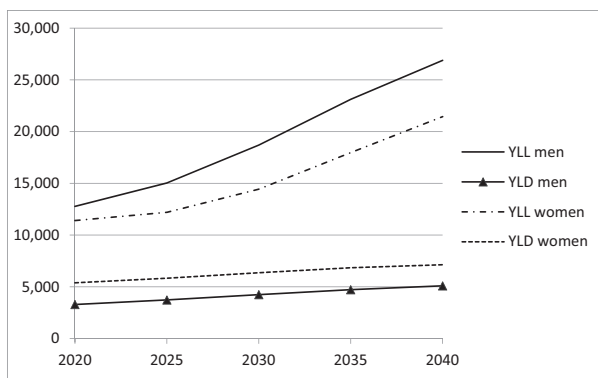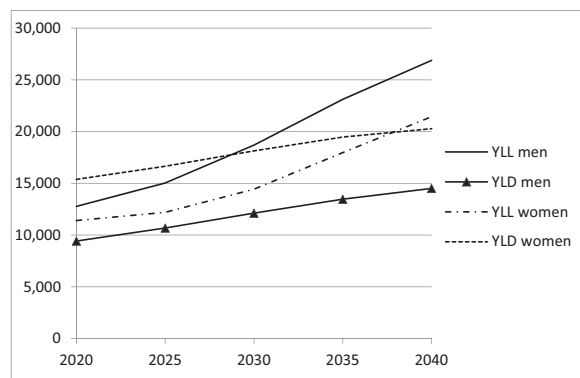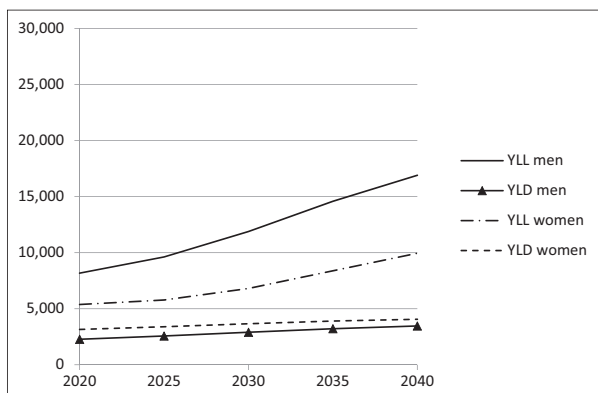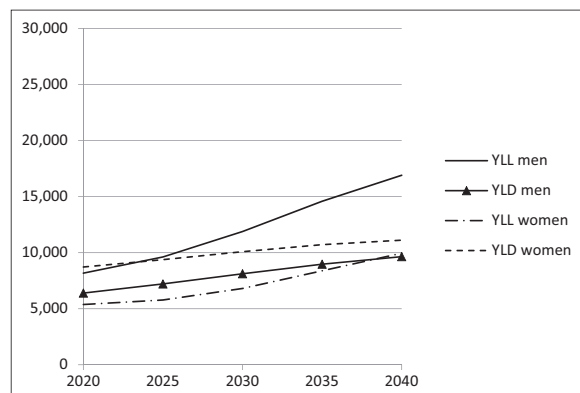

Fig. 4. Effect of choice of disability weights and life expectancy on future burden.

estimated health loss by 60%, on average. The choice of the Coale life expectancy as a standard has been criticized by Williams [39], among others, for generating unrealistically high, "fictional" estimates of burden. According to Williams, actual local estimates would be preferable. For estimations of potential health gained by specific interventions, estimates based on the Norwegian mortality tables are recommended [39,40].

Our estimates of future burden are country specific, countries with a different fracture rate or a different demographic development will have different results. Scandinavia and Oslo in particular has had a very high incidence rate of hip fractures, this will limit the external validity of our projections. However, contributing to the increased burden is the ageing of the population. To the degree that other countries are experiencing population ageing, it is reasonable to assume that this will lead to an increased burden, even in countries with a lower fracture rate.

A strength of this study is the very robust data on fracture rate and demographic change found in the Norwegian registries. Similarly, we also have robust data on the cost of a hip fracture event, although some assumptions were required.

A potential limitation is that we have used an overall estimate of cost after hip fracture rather than an age specific estimate. Although costs vary with age and may be observed to increase with increasing age, this variation seems to disappear when controlling for the cost incurred by age and sex matched controls [35]; if this holds true, our approach is appropriate. However, if the observed decline in hip fracture rates reflects a healthier group of older people, it is possible that these potentially fitter individuals will experience less functional decline following the fracture event and consequently require fewer (or shorter) stays in institutions. If this is the case, we may be overestimating the future cost. Another option would be that the fractures occur later in life on average, but because life expectancy also increases, it could still result in an increased burden of hip fractures [41].

The future is unknown and any projection can only reflect best available evidence at the time it is made. The cause of the decline in the fracture rate observed in the previous period is unknown, complicating a best guess of what will happen in the future. A Study from Denmark found that increased uptake of anti-osteoporosis medication was unlikely to explain the observed decline [42]. Some have speculated that the decrease is due to increasing body mass, as body fat acts as a cushion for the hip in the event of a fall. Should the fracture rate again start to increase due to unfavourable lifestyle factors, e.g., poor diet or an increasingly sedentary lifestyle (in a similar manner to obesity and diabetes), our projections will underestimate future burden.

Despite the availability of effective preventative measures, uptake of medications remains moderate to poor [43–45], possibly due to increased focus on rare side effects from bisphosphonates such as atypical fractures and osteonecrosis of the jaw. Preventive measures may further reduce the fracture rate or they may improve health outcomes, so that mortality or disability after fracture is reduced. Any reduction in disability is also likely to reduce cost, as loss of function contributes greatly to cost after fracture [46].

Despite declining hip fracture rates, the health and economic burden of hip fractures are very likely to increase by 2040. This increasing burden of hip fractures may warrant an increased focus on preventative and rehabilitation efforts.

Funding

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