Trends in incidence rate, health care consumption, and costs for patients admitted with a humeral fracture in The Netherlands between 1986 and 2012

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ABSTRACT

Introduction: This study aimed to examine long-term population-based trends in the incidence of patients with a humeral fracture admitted to a hospital in the Netherlands from 1986 to 2012 and to give a detailed overview of the health care consumption and productivity loss with associated costs.

Materials and Methods: Age and gender-standardized incidence rates of hospital admissions for patients with a proximal, shaft, or distal humeral fracture were calculated for each year (1986-2012). Injury cases, length of hospital stay (LOS), trauma mechanism, and operation rate were extracted from the National Medical Registration. An incidence-based cost model was applied to calculate costs for direct health care and lost productivity in 2012.

Results: Between 1986 and 2012 112,910 patients were admitted for a humeral fracture. The incidence rate increased from 17.8 in 1986 to 40.0 per 100,000 person years in 2012. Incidence rates of proximal fractures increased the most, especially in elderly women. Operation rates decreased in patients aged 70 years or older. The mean LOS decreased from nine days in 1997 to five days in 2012. The cumulative LOS of all patients in 2012 was 28,880 days of which 73% were caused by women and 81% were 50 years or older. Cumulative medical costs in 2012 were M€55.4, of which M€43.4 was spent on women. Costs increased with age. Costs for hospital care contributed most to the overall costs per case until 70 years of age. From 70 years onwards, the main cost determinants were hospital care, rehabilitation/nursing care, and home care. Cumulative costs due to lost productivity were M€23.5 in 2012. Costs per case increased with age in all anatomic regions.

Conclusions: The crude number of patients admitted for a humeral fracture increased 124% in 27 years, and was associated with age and gender. Proximal fractures in elderly women accounted most significantly for this increase and most of the costs. The main cost determinants were hospital care and productivity loss.

INTRODUCTION

Between 1986 and 2008, over 3.7 million persons presented to an Emergency Department (ED) of a Dutch hospital with an upper extremity injury; this comprised 42% of all ED visits in The Netherlands[1]. The incidence of upper extremity injuries overall increased by 13%, from 970 in 1986 to 1,098 per 100,000 person years in 2008, showing these injuries put an increasing pressure to resources. Incidence rates and health care use were related both to age and gender. In 2007, the total health care costs of upper extremity injuries in The Netherlands amounted €290 million. Fractures were the most expensive injuries to treat among upper extremity injuries, as 76% of the overall costs of the treatment were spent on the treatment of fracture patients[1].

Given the sometimes permanent, disabling effect of humeral fractures, the societal burden associated with these injuries can be high[2-4]. Trauma affects persons of all ages and fractures in employed patients cause high costs for health care and lost productivity [5, 6]. In current economic distress, insight into trends in incidence and costs of individual patient groups is highly relevant. Population-based knowledge of trends in incidence gives directions for the allocation of health care services and for preventive measures. Age and gender dependency of humeral fractures at the proximal end versus the shaft versus the distal end have not been described in detail yet. Likewise, detailed evaluations of costs, gaining insight in the parameters that contribute most to the overall costs, such as cost for hospital stay, physical therapy and rehabilitation, nursing care and costs due to productivity loss are not available. Due to budgetary restraints and increasing health care costs, such economic analyses are gaining importance.

Therefore, this study aimed to examine long-term population-based trends in the incidence of patients with a humeral fracture admitted to a hospital in the Netherlands from 1986

to 2012 and to give a detailed overview of the associated costs for health care and lost

productivity.

METHODS

Data source

For this retrospective, epidemiological study data were collected for patients admitted to a hospital in The Netherlands with a humeral fracture in the period 1986-2012. In 2012 the Netherlands had 16.7 million inhabitants[7]. Injury cases were extracted from the National Medical Registration (LMR) of the Dutch Hospital Database (DHD), Utrecht, the Netherlands. The DHD collects hospital data of all hospitals in the Netherlands with a uniform classification system and has an almost complete national coverage (missing values <5%, except in 2007 12%). These figures were extrapolated by the Consumer and Safety Institute to full national coverage for each year. An extrapolation factor was estimated by comparing the adherence population of the participating hospitals with the total Dutch population in each year using the population data obtained from Statistics Netherlands[7, 8]. Patients are included in the LMR for their main diagnosis at discharge, defined by the International Classification of Diseases (ICD) 9th and (since 2010) 10th revision[9]. Codes for humeral fractures are presented in Table 1. Injuries include both traumatic and pathologic fractures.

The study was exempted by the local Medical Research Ethics Committee Erasmus MC (No. MEC-2014-120).

Calculation of incidence rates

Age- and gender-specific incidence rates were calculated in 5-year age groups for each year of the study. In order to adjust for differences in the demographic composition over time, incidence rates were standardized for age (in 5-year age groups) and gender using a direct standardization

method, as previously described[1]. In short, the age- and sex-specific incidence rates per 100,000 person years were calculated based upon the Dutch mid-year standard population (calculated using the formula $((N_{1986} + N_{2012})/2)$.

Hospital length of stay, trauma mechanism, and surgical intervention

Data regarding hospital length of stay (LOS), trauma mechanism, and operation rate were extracted from the LMR database for 10-year age categories. In order to assess trends in LOS and trauma mechanism over time, mean LOS and percentage of trauma mechanisms were averaged over 5-year intervals from 1993-2012. For operation rates, data were averaged over a 5-year interval 2008-2012, as earlier data were not available.

Direct and indirect health care costs

The incidence-based Dutch Burden of Injury Model was used in order to measure and describe direct and indirect health care costs[1, 10-12]. Patient numbers, health care consumption and related costs and costs for lost productivity were calculated using the LMR database and a patient follow-up survey on health care use[13]. Costs were measured from societal perspective and patients and patients were followed until two years after trauma. Medical costs included ambulance care, in-hospital care, general practitioner (G.P.) care, home care, physical therapy, and rehabilitation/nursing care. Health care costs were calculated by multiplying incidence and health care volumes with unit costs (*e.g.*, costs per day in hospital). Unit costs were estimated according to national guidelines for health care costing[14].

Costs for lost productivity were determined as described before[12]. Productivity costs were defined as the costs associated with production loss and replacement due to illness, disability,

and premature death[15]. The absenteeism model was used in order to estimate costs for

productivity loss for all patients aged 15-64 years. The friction cost method was used because

health care needs are most substantial in the first year after injury for the majority of injuries[16].

Age-specific costs are presented in 10-year (medical costs) or 5-year (lost productivity)

age groups for men and women separately. Data were averaged over 5-year intervals; 2002-2007

2008-2012, as earlier data were not available. Inflation has been taken into account.

RESULTS

Incidence rates

During the study period 112,910 patients were admitted for a humeral fracture. The crude number of patients per year increased by 124% ; from 2,790 in 1986 to 6,250 in 2012. The overall incidence rate increased from 17.8 per 100,000 person years (py) in 1986 to 40.0 per 100,000 py in 2012. The increase in incidence rate was largest for proximal fractures (20.0/100,000 py in 2012; +277%), but was also noted for shaft fractures (7.2/100,000 py in 2012; + 132%) and distal fractures (12.8/100,000 py in 2012; +36%; Figure 1A). The largest increase was seen for proximal fractures in women since the year 2002.

The incidence rates showed a bimodal distribution, with a clear peak at 5-9 years of age for both genders and a gradual increase from 50 years onwards in women and from 65 years onwards in men (Figures 1B-C). Whereas the peak at 5-9 years has remained fairly stable during the study period (83.0/100,000 py for boys and 97.8/100,000 py for girls in 2012), the increase in the elderly has become more pronounced after the year 2002.

Figures 1D and E show incidence rates for the different age groups and anatomical regions in 2012 for men and women separately. Until 15 years of age, humeral fractures were mainly located at the distal end both in boys (40.3/100,000 py or 83% of total) and girls (47.2/100,000 py or 86% of total). From 50 years onwards, incidence rates of proximal, shaft, and distal fractures increased, especially in women. From 65 years, proximal fractures (33.1/100,00 py in men versus 119.1/100,000 py in women) clearly outnumbered fractures at the shaft (9.7 versus 37.6/100,000 py), and distal end (6.5 versus 23.0/100,000 py).

Trauma mechanism

Throughout the study period, falling was the dominant trauma mechanism at all ages. In 2012, falling caused 71% of proximal, 69% of shaft, and 79% of distal fractures in men. In women, these percentages were 82%, 81%, and 80%. The second most common mechanism was a traffic accident (22%, 20%, and 14% in men, and 15%, 13%, and 17% in women, respectively).

Operative treatment

In 2012, operation rates for men and women of all ages combined were 62% for proximal, 67% for shaft, and 80% for distal fractures (Figure 2). For both genders, operation rates were fairly stable until 70 years, and decreased at older age. Overall, 73% of proximal fractures were operated in patients aged <70 years. At older age, operation rates decreased to 22% (24% in men, 22% in women) in the 90+ age group. Of the shaft fractures, 72% were operated in patients aged <70 years, and decreased to 47% (50% in men, 46% in women) in the oldest old. Distal fractures were operated most frequently; 81% in patients aged <70 years, decreasing to 48% (25% in men, 52% in women) in the oldest old.

Length of hospital stay

The cumulative hospital LOS decreased from 34,050 days in 1997 to 28,880 days in 2012. In four consecutive 5-year periods, the mean LOS per case increased with age, most significantly after 70 years (Figures 3A-B). Over time the mean LOS per case decreased in all age groups from nine days in 1997 to five days in 2012. The mean LOS per case in men and women admitted with a proximal fracture in 2012 was five days (4 days in patients <70 years and 7 days in patients aged 70 or older; Figures 3C-D). For patients with a shaft fracture mean LOS per case

was five days (4 days at < 70 years and 8 days at 70+). For patients with a distal fractures, mean LOS per case was three days (2 and 8 days, respectively). LOS per case seemed unrelated to gender. The cumulative LOS in 2012 for men and women combined was 28,880 days, of which 73% were caused by women (Figures 3E-F). Of these hospital days 81% were caused by patients aged 50 years or older. Proximal fractures account for the largest part of the total LOS; 16,810 days versus 6,150 days for shaft and 5,920 days for distal fractures.

Cost for health care consumption

The cumulative medical costs for admitted patients increased from 47.8 million euro (M€) in 2007 to M€ 55.4 in 2012, of which approximately 75% were caused by women (Table 2). The proximal humeral fractures accounted for the major part of the total costs (M€35.0 in 2012), while shaft and distal fractures were less expensive (M€10.6 and M€9.7, respectively). Costs per case were €11,224 for proximal, €9,430 for shaft, and €4,858 for distal fractures. In addition to costs per case being higher in women than in men (€10,383 versus €5,796 in 2012 for all fractures and age groups combined, see Table 2), costs consistently increased with age (Figure 4).

For each anatomic region, costs for hospital care contributed most to the overall cost per case until 70 years of age. From 70 years onwards, the main cost determinants were hospital care, rehabilitation/nursing care, and (most significantly in women) home care. For proximal fractures, overall costs per case until 70 years were €6,111 (€5,207 for men versus €6,620 for women), of which 60% (68% versus 56%) were spent on hospital care. At ages >70 years, mean costs per case were €17,119 (€15,144 versus €17,483), of which 39% (47% versus 38%) were spent on hospital care, 30% (30% versus 30%) on rehabilitation/nursing care, and 25% (16%

versus 26%) on home care. For shaft fractures, overall costs per case until 70 years were €5,260 (€4,556 versus €5,870 for women), of which 66% (74% in men versus 61% in women) were spent on hospital care. At ages >70 years, mean costs per case were €15,163 (€12,039 versus €15,750), of which 33% (40% versus 32%) were spent on hospital care, 35% (36% versus 35%) on rehabilitation/nursing care, and 26% (17% versus 27%) on home care. For distal fractures, overall costs per case until 70 years were €3,393 (€3,233 for men versus €3,540 for women), of which 83% (87% in men versus 79% in women) were spent on hospital care. At ages >70 years, mean costs per case were €13,7719 (€11,908 versus €14,092), of which 35% (41% versus 34%) were spent on hospital care, 35% (37% versus 35%) on rehabilitation/nursing care, and 26% (17% versus 27%) on home care.

Costs for lost productivity

For all anatomic regions, >90% of patients had to take time off from work due to their humeral fracture, with no clear difference between men and women or across age groups. The cumulative number of days off work were 70,900 days in 2012 and were higher for proximal fractures (39,000 days) than for shaft (16,950 days) or distal (14,950 days) fractures. The associated cumulative costs for lost productivity were M€23.5 (€13.5, M€5.4, and M€4.6, respectively), with consistently higher total costs as well as costs per case for men (Table 3). The costs per case gradually increased with age in all anatomic regions to more than €25,000 in men and more than €19,000 in women aged 60 years or older (Figures 5A and B). Due to differences in incidence rates, cumulative costs were highest for patients with a proximal fracture, with a peak for men aged 50-54 years (M€1.5) and women aged 55-59 years (M€2.1).

DISCUSSION

In the 27 year study period, the crude number of patients increased by 124% to 112,910 patients in 2012. Incidence rates, health care consumption, and direct and indirect costs were all associated with anatomic region, age, and gender.

The increase in humeral fractures over time in general may be attributable to population ageing, with increasing numbers of elderly (women) being at risk for fractures due to osteoporosis[17]. The incidence rate of proximal humeral fractures of 20.0/100,000 person years in 2012 is somewhat lower than published[18], although that study included patients from the age of 15 years. The incidence rate of proximal fractures increased mostly in women, similar to studies from Finland and Austria[19-21]. The even faster increase in clinical admissions since 2002 may also be attributable to introduction of new and development of existing locking plates resulting in new technologies and techniques. Increased operation rates since 2002 has been described before in a single-center study from the US[22] and, especially for women, also in a Finnish population study[23].

Similarly, development of new plating options may explain the increase in admissions of patients with shaft fractures, which was also reported for the Finnish population[24]. These new options may have resulted in operative treatment of patients that would previously have been treated nonoperatively, not requiring hospitalization. Both in their and our study, this effect was most noticeable in women and the older age groups. The incidence rate for humeral shaft fractures of seven per 100,000 person years is in line with published data[18]. The current data also confirm the known bimodal age distribution, with a peak in the age group 20-24 and a gradual

increase from 50 years onwards[25, 26]. In the current study, however, the peak in young adult women was less pronounced.

Distal humeral fractures account for the biggest share of humeral fractures in children, with a peak in the age groups 5-9. This is in line with the reported average age of 6.8 years[27]. The incidence rate (13/100,000 person years) in the current study was slightly higher than the 9/100,000 person years published for patients aged 15 years or older[18].

As reported before, falling was the dominant trauma mechanism for all three types of humeral fractures[25, 26, 28, 29]. This supports the relevance of fall prevention strategies as a measure to reduce the number of fractures[30].

Since 1993 LOS decreased from nine to five days per case. Previous data (13.8 days in 1989 and 9.3 days in 2013) seem to support this trend[31, 32]. The 9.3 days was reported for patients admitted to a regional trauma center only, which may explain their seemingly longer hospital stay[31]. Although this decrease is most likely due to changing hospital protocols and care pathways (aimed at earlier transfer to nursing or rehabilitation facilities), current data are not suitable to confirm this. Despite increasing incidence rates, the decrease in LOS per case was paralleled by a decrease in the cumulative LOS over time. Elderly women with a proximal humeral fracture contributed most significantly to the cumulative LOS. As costs for hospital stay are only a part of the total medical costs, reduced LOS did not cause a reduction in medical costs.

Current data showed that medical costs increased with age. This has not been reported before. Main cost determinants were hospital care, and rehabilitation/nursing care and home care. The finding that especially elderly women need more home care might reflect that women tend to outlive their partners and elderly are more prone to losing their independence after sustaining an injury. Polinder *et al.* reported lower costs per case for upper arm fractures in 2007

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(€4,440) than the current study in 2012 (€8,644)[1]. However, that study also included non-admitted patients. Previous studies reported total costs without providing the cost components as done in the current study[1, 10].

A strength of our study is that it is population-based, offering long-term trends. National registry data are more reliable in representing true health care problems than extrapolating data from a single study or hospital. In addition, as the rate of missing data was fairly stable over time, trends noted are unlikely due to changes in coding and documentation. Data are reported for humeral fractures as a whole, but also for specific anatomical regions. Moreover, age and gender-dependent trends were evaluated. This study presented detailed information on health care and lost productivity costs in patients admitted for a humeral fracture. To the best of our knowledge, this has not been previously described.

We acknowledge limitations, the most obvious being that this study only included admitted patients. The LMR database only contains information about admitted patients. A national database that records all Emergency Department attendances exists, but there is no unique code for extracting the data for humeral fractures as a whole, nor per anatomical region. In that database humeral fractures are pooled together with fractures of the clavicle and scapula. In addition, the ICD coding system is the same for traumatic and pathological fractures, making it impossible to exclude the pathological fractures. Also, as patients are recorded based on the main injury at discharge underreporting might occurred in patients with multiple injuries.

CONCLUSION

This study showed an increase of 124% in absolute numbers of patients admitted for humeral fractures in the last 27 years. This increase was associated with age and gender. Proximal fractures in elderly women accounted most significantly for this increase and most of the costs. This insight in direct and indirect medical costs and costs for lost productivity offer tools for cost reduction and give direction to future demands.

SOURCE OF FUNDING

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TABLES AND FIGURES

Table 1. Humeral fractures classified in ICD-9 and ICD-10

Fracture region	Fracture closed or open	ICD-9	ICD-10
Proximal	Fracture of upper end of humerus closed	812.0	S42.2
	Fracture of upper end of humerus open	812.1	S42.2
Shaft	Closed fracture of shaft or unspecified part of humerus	812.2	S42.3
	Fracture of shaft or unspecified part of humerus open	812.3	S42.3
Distal	Fracture of lower end of humerus closed	812.4	S42.4
	Fracture of lower end of humerus open	812.5	S42.4

Table 2: Medical costs per case and cumulative costs by anatomical region and gender in

2012

	Proximal	Shaft	Distal	Total
Men				
N	828	378	861	2,067
Cost/case (€)	7,913	6,043	3,650	5,796
Total cost (M€)	6.6	2.3	3.1	12.0
Women				
N	2,293	749	1,136	4,179
Cost/case (€)	12,420	11,140	5,773	10,383
Total cost (M€)	28.5	8.3	6.6	43.4
Overall (men + women)				
N	3,121	1,128	1,997	6,246
Cost/case (€)	11,224	9,430	4,858	8,864
Total cost (M€)	35.0	10.6	9.7	55.4

Table 3: Absenteeism and associated costs for lost productivity by anatomical region and gender in 2012

	Proximal	Shaft	Distal	Total
Men				
Employed[A]	343 (78)	174 (75)	159 (75)	676 (76)
Cost/case (€)	22,383	19,256	19,464	20,890
Total cost (M€)	7.1	3.1	2.9	13.1
Women				
Employed[A]	369 (54)	139 (61)	109 (59)	317 (56)
Cost/case (€)	18,506	17,681	17,339	18,114
Total cost (M€)	6.3	2.3	1.8	10.4
Overall (men + women)				
Employed[A]	712 (63)	313 (68)	269 (68)	1,293 (65)
Cost/case (€)	20,374	18,558	18,598	19,566
Total cost (M€)	13.5	5.4	4.640	23.5

[A] Data are shown as number (%).

Figure 1. Age-related incidence rates (per 100,000 person years) of humeral fractures overall (A), in males (B, D), and in females (C, E)

Data are shown by anatomical region (A, D, E) and year (B, C). Figures 1D and E show data for 2012.
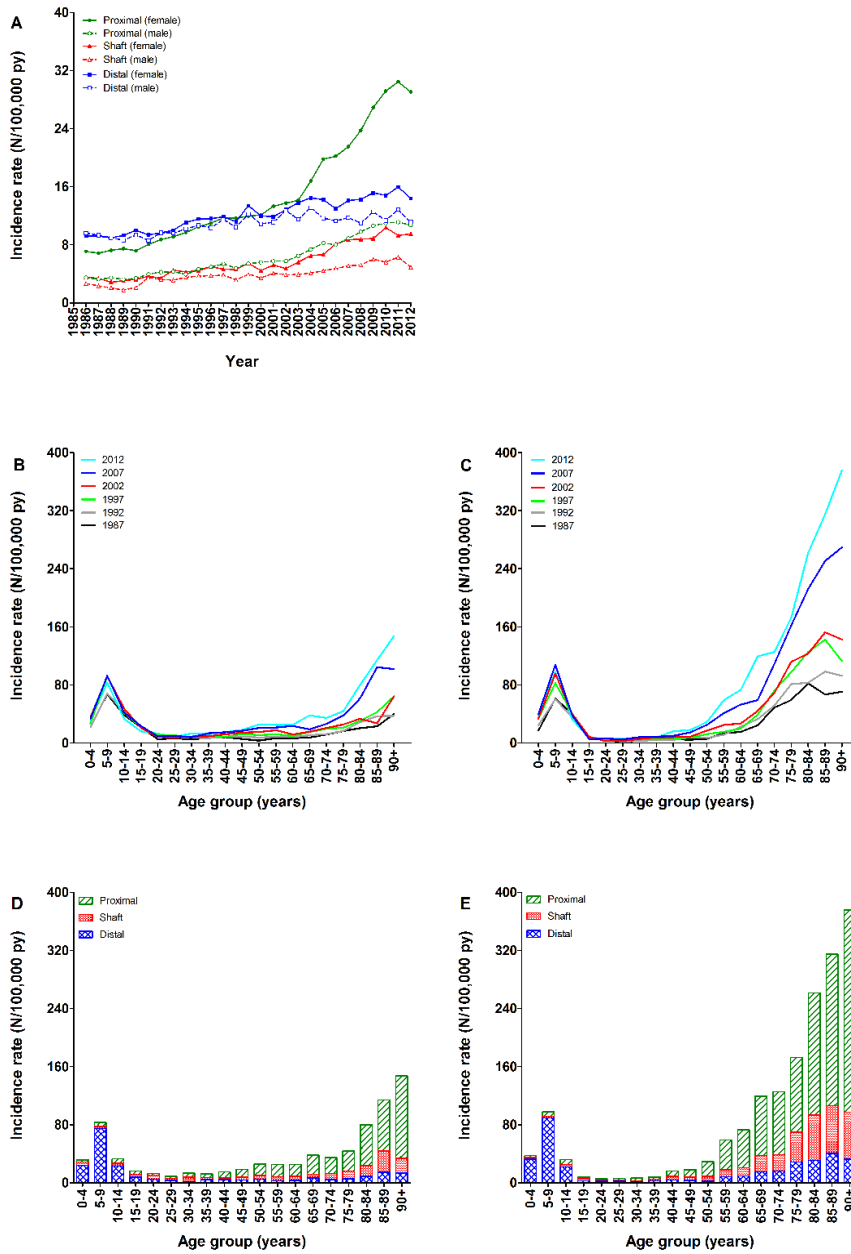
Figure 2. Age-related percentage of patients undergoing surgical treatment in males and females

Data are shown by anatomical region for 2012.
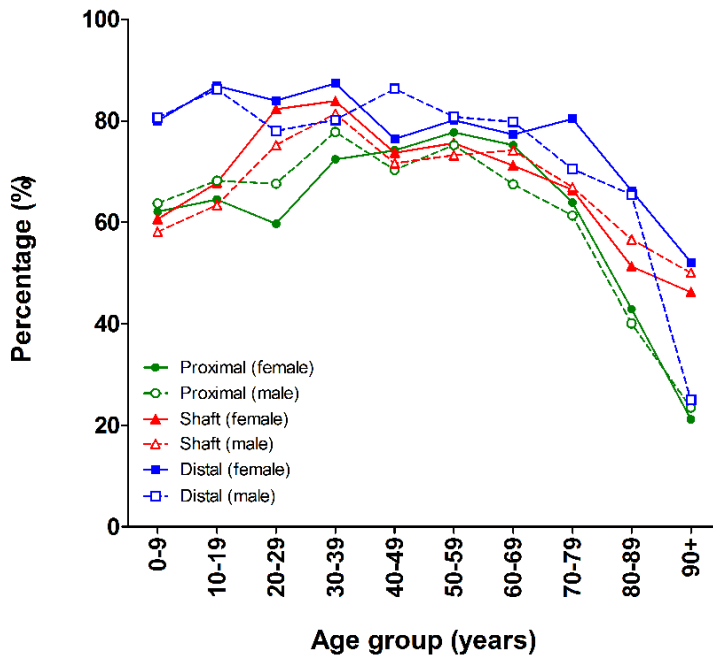
Figure 3. Hospital length of stay in males (A, C, E) and females (B, D, F)
Figures A and B show data of the entire humerus for four different time periods. Figures 4C to F

show data by anatomical region for 2012.
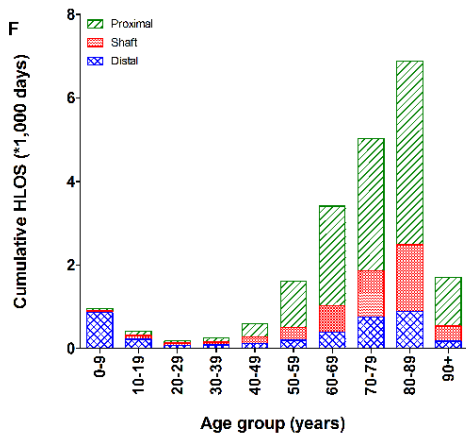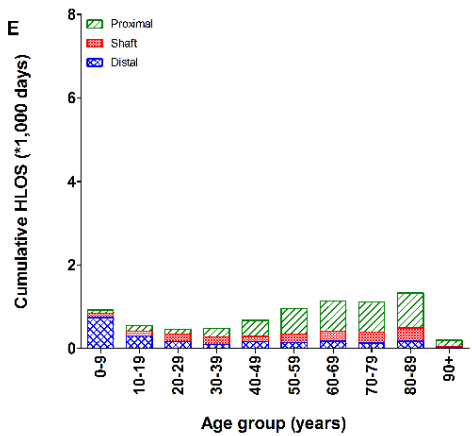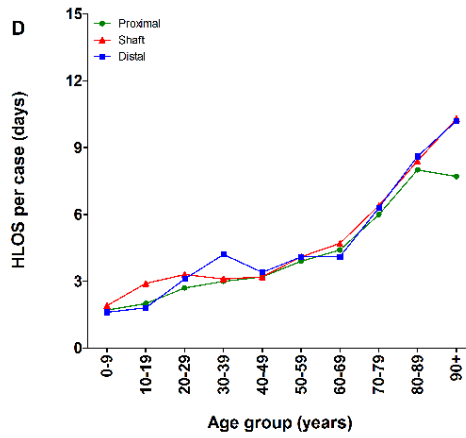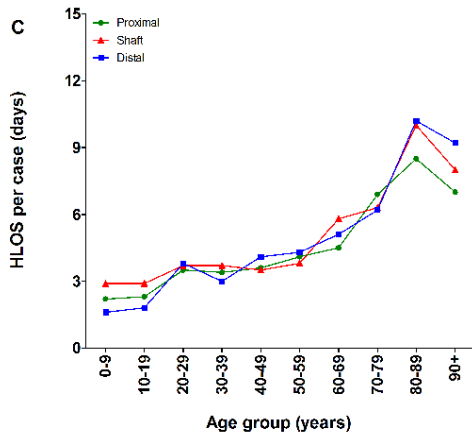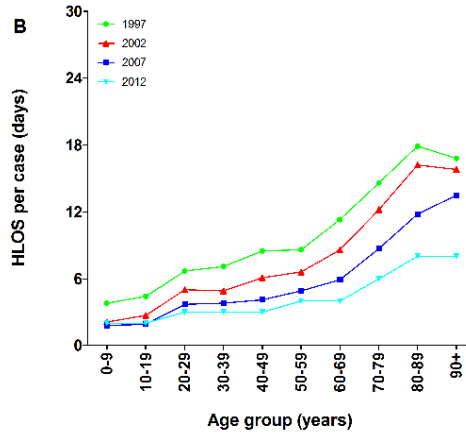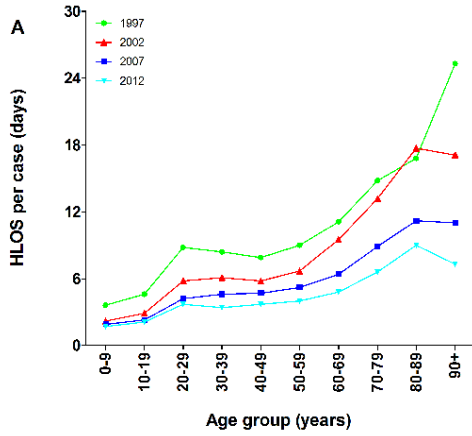
1 **Figure 4. Age-related cost per case due to humeral fractures in males (A, C, E) and females**

2 **(B, D, F) in proximal (A, B), shaft (C, D) and distal (E, F) humeral fractures in 2012**

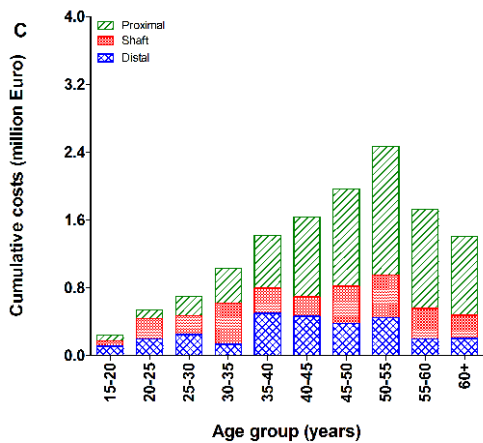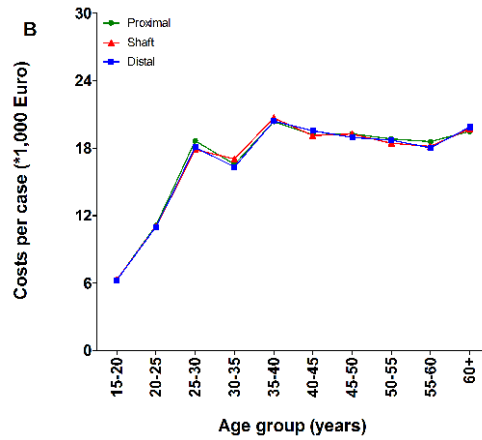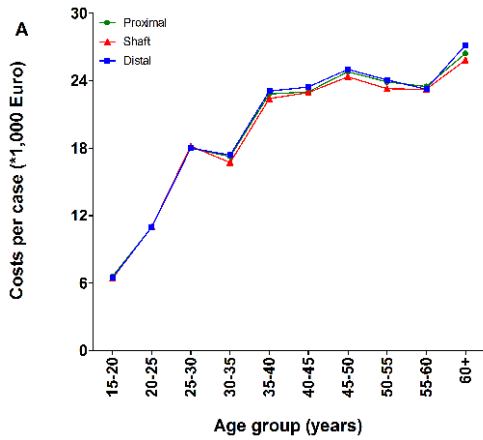3 Costs are separated in different cost determinants.

4
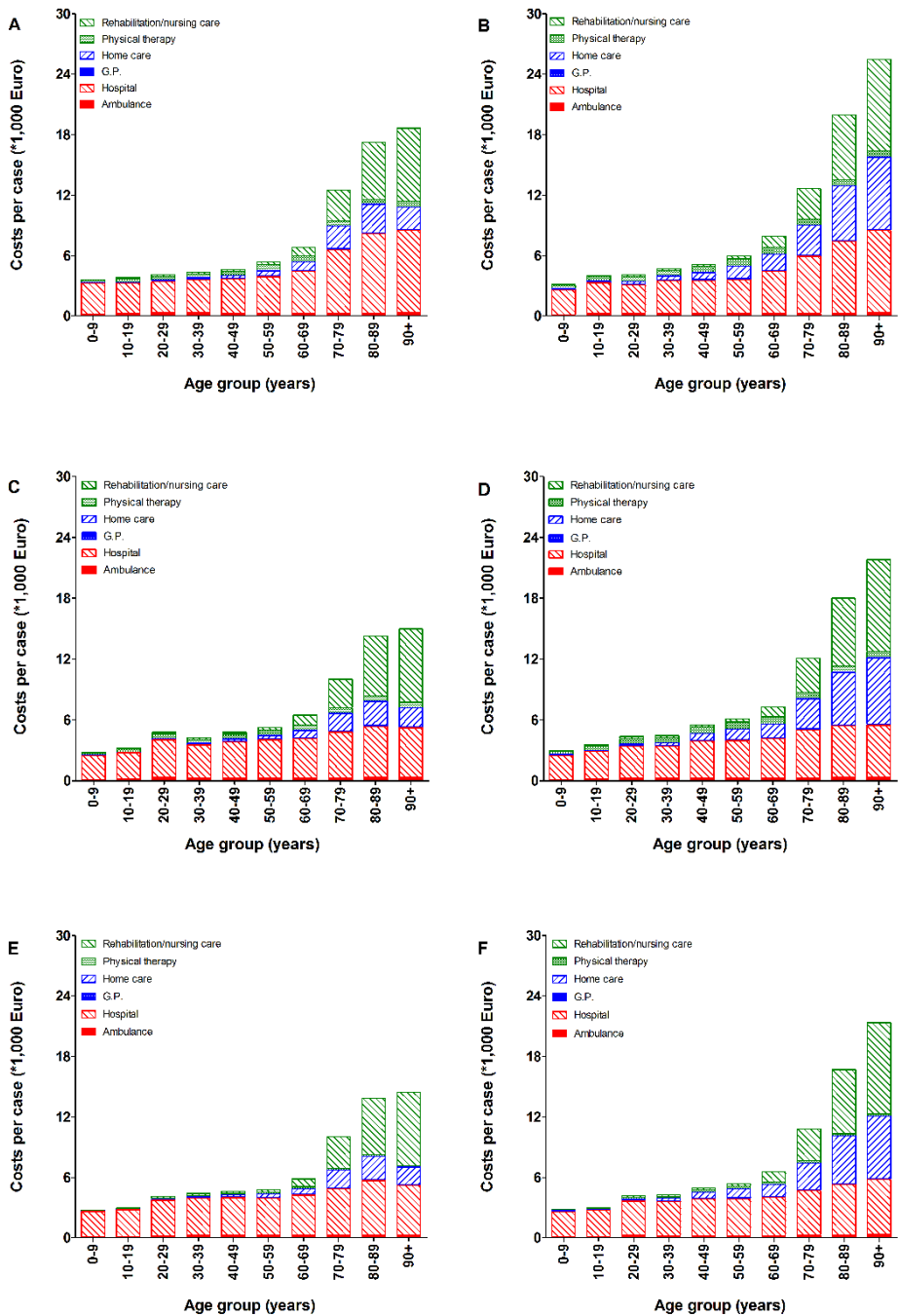
Figure 5. Age-related costs for lost productivity in males (A, C) and females (B, D) in 2012

6   Data are shown by age group and anatomical region. The upper panels show information about

7   cost per case, the lower panels show cumulative costs for the entire study population.

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