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ORIGINAL ARTICLE

Epidemiology of distal radius fractures in Germany - incidence rates and trends based on inpatient and outpatient data

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Abstract

Summary We examined incidence rates (IR) for all distal radius fracture (DRF) events based on inpatient and outpatient data from a large statutory health insurance in Germany. Of all DRF, 56% were treated as inpatients, and thus, 44% treated as outpatients. IR were higher in women than in men.

Purpose Although a distal radius fracture (DRF) is one of the most common fractures in the elderly population, epidemiological data are limited. Many studies examine only hospitalized patients, do not analyze time trends, or include only small populations. In this retrospective population-based observational study, routine data on inpatient and outpatient care of persons aged ≥ 60 years insured by a large statutory health insurance in Germany were analyzed from 2014 to 2018.

Methods DRF were identified by ICD-10 codes. All DRF events of an individual were considered with a corresponding individual washout period. Incidence rates (IR) and time trends were estimated assuming a Poisson distribution per 100,000 person-years, with 95% confidence intervals [95% CI] and age-sex standardization to the German population in 2018. Associations of calendar year, age, sex, and comorbidity with IR were examined using Poisson regression estimating incidence rate ratios (IRR) with CI.

Results The study population consists of 974,332 insured individuals, with 16,557 experiencing one or more DRF events during the observation period. A total of 17,705 DRF events occurred, of which 9961 (56.3%) were hospitalized. Standardized IR were 439 [424–453] (inpatient: 240 [230–251], outpatient: 199 [189–209]) in 2014 and 438 [423–452] (inpatient: 238 [227–249], outpatient: 200 [190–210]) in 2018. Female sex, older age, and comorbidity were associated with higher IR and adjusted Poisson regression showed no significant time trend (IRR overall 0.994 [0.983–1.006]).

Conclusion A relevant proportion of DRF were treated in outpatient settings, so both inpatient and outpatient data are necessary for a valid estimate.

Keywords Distal radius fractures · Epidemiology · Incidence · Population-based observational study · Trend analysis

Introduction

Fractures of the upper extremity—especially those of the distal radius as well as the proximal humerus—are among the most common fractures in persons 65 years of age and older, following only fractures of the proximal femur [1] and are the most common fracture of all in the 50–80 age group [2]. The mechanism of injury for patients in the upper age group is usually a low-energy trauma such as a fall from low height onto the outstretched arm [3, 4]. Due to demographic

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changes with an increasing proportion of older people in the population, a pronounced challenge for society and the health care system is expected in the coming decades [5]. Studies from surrounding European countries show a trend toward higher hospitalization expressed as hospitalization rate or risk of hospitalization and associated increased costs of care [6, 7]. There is also evidence of impaired ability to self-care after a distal radius fracture (DRF) [8] and an increased risk of subsequent hip fracture [9] indicating that the burden on the affected individual goes beyond the mere fracture of the wrist.

There is a clear age and sex dependency for DRF: Higher incidence rates are reported with increasing age and for women [1, 3, 6, 10–14]. In contrast, the international study based on overall incidence time trends of DRF is inconsistent: While some authors report increasing incidence rates [10, 11, 15–17], there are also data on stable or decreasing incidence rates over time [6, 7, 18–20]. In addition, there is also heterogeneity within the studies with respect to the time trend development of different age and sex classes [7, 17, 20]. Many studies only take into account hospital or registry data, which exclusively cover the inpatient care sector [12, 13, 18, 21]. It can be assumed that, despite increasing hospitalization, a relevant proportion of DRF is currently treated as outpatients [7, 14]. There is a comprehensive range of outpatient surgeons in Germany, so that the occurrence and burden of DRF are not fully reflected by hospital or registry data. In addition, studies without individual patient data cannot discriminate real subsequent fractures, so inpatient readmissions due to complications or a change of hospital may cause an overestimation of the incidence rate by counting the same fracture again.

Published studies on the epidemiology of DRF in Germany are either based on hospital diagnosis statistics, which only consider inpatient treated fractures and do not report an explicit time trend analysis [12, 13] or only cover a small regional area with a small sample size [14].

The aim of this study was to determine incidence rates and time trends of DRF in the German population aged 60 years and over based on statutory health insurance data from inpatient and outpatient settings. In addition, associations of fracture incidence rates with age, sex, calendar year, and comorbidity were examined.

Methods

Study design, data source, and population

This is a retrospective, population-based observational study based on secondary data. Routine data on inpatient and outpatient care was provided by AOK Rheinland/Hamburg for the period January 1, 2013, to December 31, 2018. As the eighth-largest health insurer in Germany, AOK Rheinland/Hamburg has a total of more than 3 million insured persons (as of 2018), of whom approximately a quarter are 60 years of age or older. With 28% share of the total population, it is the largest health insurer in North Rhine-Westphalia and covers around 16% of the total population in the Hamburg region. The analysis was performed for all insured persons aged 60 years and older for the observation period 2014–2018. To control for underestimation due to fractures outside the insurance period with AOK Rheinland/Hamburg (for example, when changing insurance), only the last insurance period in the observation period was considered, with billing-related gaps of a maximum of 7 days accepted.

Identification of distal radius fracture events

DRF treated in inpatient and outpatient settings were identified using diagnosis codes according to the International Classification of Diseases (ICD-10) and the corresponding time information. In the inpatient setting, both main and minor diagnoses within the primary diagnoses were considered. Within our study, we aimed to evaluate the whole fracture burden. A DRF event, which constitutes one observation unit, was defined by the codes S52.5 (distal fracture of the radius) including subcodes and S52.6 (distal fracture of the ulna and radius, combined). A DRF event usually includes multiple ICD codes (during the therapy period). To discriminate between possible subsequent fracture events of an individual within the observation period, a washout period of at least 184 days (corresponding to the duration of at least two quarters) was defined based on existing literature and clinical assessments of the duration of therapy after a fracture, which was not allowed to contain any target diagnoses. Whereas for inpatient diagnoses, date-specific data were available, in the outpatient sector, billing was predominantly carried out on a quarterly basis, so that the therapy times up to the next washout period were dated to the respective end of the quarter. After an expired washout period, the individual was again at risk and possible subsequent DRF were recorded. Figure 1 in the supplement visualizes the concept of ascertainment of DRFs. A DRF was counted as an inpatient event if an in-hospital DRF diagnosis was coded within the therapy period, i.e., during the time until the start of the next washout period or until the end of the study. Otherwise, the DRF was classified as outpatient care only. If a DRF ICD-10 code was billed during an inpatient stay along with an operation and procedure code (OPS) for removal of osteosynthesis material in the distal radius or radius shaft, the DRF diagnosis was not selected for calculation of incidence rates but was excluded from the analyses. The OPS for metal removal used for this purpose are shown in Table 1 of the supplement.

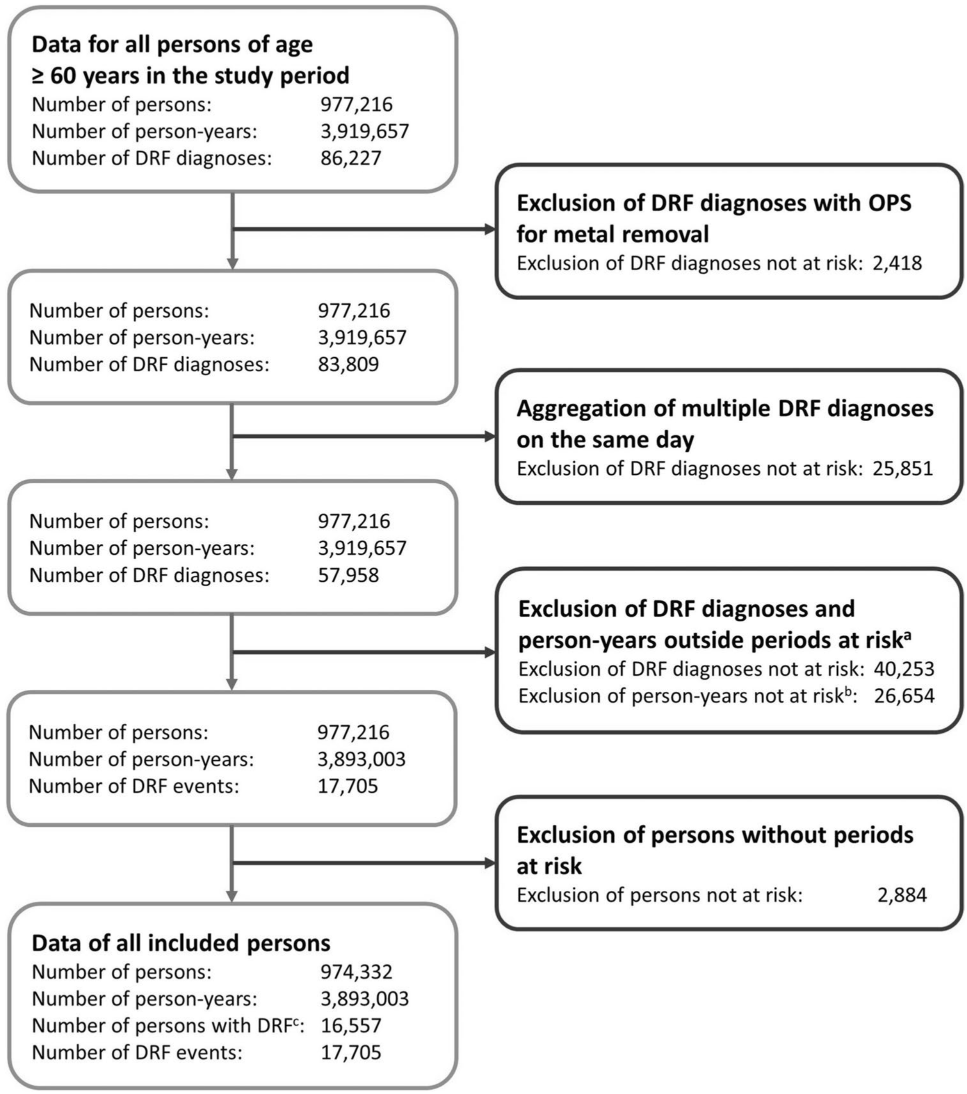

Fig. 1 Flow chart of the selection process (all DRF events of an individual and corresponding person-years in which the individual is at risk). DRF, distal radius fracture; OPS, operation and procedure code. [a]In the third selection step, the DRF events are formed as observation unit from the coded DRF diagnoses (ICD-10 codes). [b]The person-years not at risk are composed of a person's therapy and washout periods during which no subsequent DRFs are counted. [c]Including persons with subsequent DRF events (subsequent fractures)

Ascertainment of person-years

The person-years for being at risk of experiencing a DRF were determined by summing the individual times at risk of each insured person stratified by the actual calendar year and quarter, sex/age classes and comorbidity classes. Individuals could have multiple periods at risk in the observation period. At the same time, we excluded DRF diagnoses that were not valid, periods during which insured persons were not at risk for a new DRF (e.g., the next 184 days after a DRF event, outpatient DRF diagnoses were counted until the end of the quarter), and insured persons themselves who no longer had periods at risk after accounting for the underlying inclusion criteria. The selection process of the study population is illustrated as a flow chart in Fig. 1. The summed person-years at risk (n=3,893,003) were evenly distributed over the calendar years 2014–2018. The majority of persons were insured with AOK Rheinland/Hamburg for the entire observation period (median insurance period 4.999 years).

Adjustment variables

Other variables examined were start and end of the insurance period, age, and comorbidity. Comorbidity was assessed using the enhanced Charlson comorbidity index, where comorbidity diagnoses (for example diabetes mellitus, heart failure, and peripheral vascular disease) were considered via inpatient and outpatient ICD-10 codes from the quarter prior to DRF, resp. for person years of controls stratified by quarters (cumulated from individual control patients in these quarters) using ICD-10 codes in the quarter before (of these individual control patients) [22, 23]. A score variable was calculated as a weighted sum of these comorbidities, being analyzed in five categories 0, 1, 2–3, 4–5, ≥ 6. All variables were available for the entire study population.

Table 1 Characteristics of the study population with DRF for all fracture events

	Number of all DRF events incl. subsequent fractures
Total [*n* (%)]	17,705 (100.0)
Thereof subsequent fractures	1148 (6.5)
Sex [*n* (%)]	
Men	2776 (15.7)
Women	14,929 (84.3)
Age in years [mean, standard deviation; median]	76.8 ± 9.3; 77.0
Age in 5-year age groups [*n* (%)][a]	
60–64 years	2366 (13.4)
65–69 years	2269 (12.8)
70–74 years	2248 (12.7)
75–79 years	3457 (19.5)
80–84 years	3338 (18.9)
85–89 years	2550 (14.4)
≥90 years	1477 (8.3)
Type of care [*n* (%)]	
Inpatient	9961 (56.3)
Outpatient	7744 (43.7)
Comorbidity score [*n* (%)][a, b]	
0	5485 (31.0)
1	3755 (21.2)
2–3	4756 (26.9)
4–5	2195 (12.4)
≥6	1514 (8.6)
Number of DRF per insured [*n* (%)][a, c]	
1	15,535 (93.8)
2	912 (5.5)
3	95 (0.6)
4	14 (0.1)
5	1 (< 0.1)
Number of DRF per calendar year [*n* (%)][a]	
2014	3572 (20.2)
2015	3604 (20.4)
2016	3466 (19.6)
2017	3494 (19.7)
2018	3569 (20.2)

n, number

[a]Deviations from 100% due to rounding

[b]The Charlson comorbidity index was calculated like all other possible adjustment variables for the entire study population

[c]Number of all fracture events per person / percentages shown corresponding to 16,557 persons

Statistical analyses

Incidence rates (IR) of all DRF events of an individual were calculated for both settings of care together and also stratified for inpatient and outpatient care. IR were estimated assuming a Poisson distribution per 100,000 person-years with 95% confidence intervals [95% CI] in different subgroups. Notably, stratified IR by age and sex (in 5-year age classes with last class ≥ 90 years) were calculated in addition to the overall group. Additionally, results were age- and sex-standardized to the 2018 German population using data from the German Federal Statistical Office. To analyze possible associations between fracture incidence rate as outcome and calendar year as ordinal difference from 2014, sex, age class, and comorbidity as independent variables, Poisson regression models were fitted. Time trends were estimated as annual change based on the incidence rate ratio (IRR) along with 95% confidence intervals [95% CI] corresponding to 1-year difference and additionally as average change (IRR^4) over the entire study period from the same model, where IRR^4 =IRR×IRR×IRR×IRR corresponding to four 1-year changes 2014–2015, 2015–2016, 2016–2017, 2017–2018 in the model. Poisson regression models were fitted with adjustment for overdispersion (dscale adjustment) [24] based on incidence data (DRF events and person-years) stratified by year, quarter, sex, age classes, and comorbidity classes. In addition, a sensitivity analysis that included an adjustment for repeated measurements in the Poisson model was conducted. Analyses were performed using Statistical Analysis Systems SAS release 9.4 (SAS Institute Inc. Cary, NC, USA).

Results

Characteristics of the study population with distal radius fracture events

The study population consists of 974,332 insured persons. Among these, 16,557 individuals (84.1% women, mean 76.8 ± 9.4 years, median 78.0 years) experienced one or more DRF events during the observation period. 1,022 (6.2%) persons had more than one DRF event in the time course, mostly two fracture events. Up to five fracture events per person were counted.

As shown in Table 1, a total of 17,705 DRFs occurred, of which 9961 (56.3%) were hospitalized. In total, 1148 subsequent fractures were counted (6.5%) of all 17,705 DRF events. Women were considerably more frequently affected with 14,929 fracture events (84.3%) than men, who sustained 2776 DRF events (15.7%). The mean age of all cases was 76.8 ± 9.3 years (median 77.0 years).

Standardized incidence rates of all distal radius fracture events

Table 2 shows standardized incidence rates overall and for women and men, also stratified by age for the years 2014 to 2018. Over the entire study period, the standardized incidence rate was higher for women compared to men. When stratified by type of care, the incidence rates in the inpatient setting were 71 [61–81] for men and 367 [349–384] for women in 2014 and 87 [76–97] and 353 [336–370] per 100,000 person-years in 2018, respectively. In the outpatient setting, IR were 92 [81–103] and 280 [265–296] for men and women in 2014, and 91 [81–102] and 286 [270–302] per 100,000 person-years, respectively, in 2018.

In Fig. 2, age-adjusted incidence rates from the year 2018, as the last year of the observation period and reference year for standardization, are shown overall and stratified by sex and type of care. Again, the age- and sex-dependence of DRF occurrence were evident. However, while in men, the incidence rates for both types of care were balanced, in women aged 80 years and older the incidence rates for fractures treated as inpatients were significantly higher than the incidence rates for fractures treated as outpatients (non-overlapping 95% CI).

Time trends of all distal radius fracture events

Table 2 additionally displays the average annual changes of the IR of all DRF events adjusted for age and sex as incidence rate ratios and the changes over the entire 5-year observation period as 4-year average changes (IRR^4). Over time, incidence rates were stable (average annual IRR 0.99 [0.98–1.01]) except for women in the age group 80–84, for whom a significant decrease was observed (average annual IRR 0.96 [0.94–0.99]). The IRR^4 from 2014 to 2018 was 0.98 [0.93–1.02] for the entire population. Only for the subgroup of women aged 80–84 years, there was a decrease of approximately 14% (IRR^4 0.86 [0.78–0.95]), but the confidence interval was large.

Associations with age, sex, and comorbidity

As expected, the Poisson regression (Table 3) showed a significant association of sex and age with incidence rate of all DRF events. Furthermore, a higher risk was evident in the presence of comorbidity: The IRR for presence of comorbidity (in each category > 0 of the Charlson index compared to 0) was about 1.3 to 1.4 (95% CI between 1.2 to 1.5).

In a sensitivity analysis involving adjustment for repeated measurements in the Poisson model, the final model converged with stable and very similar results (data not shown).

Discussion

By using longitudinal inpatient and outpatient statutory health insurance data from a large population-based sample, we assessed incidence rates and time trends of DRF in the German population aged 60 years and older. In addition, associations of fracture incidence rates with age, sex, calendar year, and comorbidity were examined. In our analysis, where also subsequent fractures of an individual were considered, incidence rates for all DRF events remained predominantly stable over time, but at a high level. Interestingly, in our study, about half of all fracture events were treated in the inpatient setting, implying that a relevant proportion of DRF is not accounted for if only inpatient data are used.

Table 2 Standardized incidence rates per 100,000 person-years including 95% confidence intervals and time trends of all DRF events from 2014-2018 as average annual changes (IRR) and changes over the entire study period (IRR[4]), IRR was adjusted for sex, age classes, and comorbidity classes

	2014	2015	2016	2017	2018	Average IRR per year	IRR[4] 2014–2018
Total[a]	439 [424–453]	441 [427–456]	423 [409–437]	427 [413–441]	438 [423–452]	0.99 [0.98–1.01]	0.98 [0.93–1.02]
Men[b]	163 [148–177]	183 [168–198]	167 [152–181]	165 [150–179]	178 [163–193]	1.00 [0.97–1.03]	1.01 [0.90–1.13]
Women[b]	647 [624–670]	637 [614–660]	618 [595–641]	627 [604–650]	639 [616–662]	0.99 [0.98–1.01]	0.97 [0.93–1.02]
Men, age group (years)							
60–64	151 [123–178]	156 [128–184]	155 [128–182]	133 [109–158]	137 [113–162]	0.96 [0.91–1.02]	0.87 [0.68–1.10]
65–69	143 [115–172]	130 [103–157]	122 [97–148]	124 [98–149]	144 [116–172]	0.99 [0.93–1.06]	0.97 [0.76–1.25]
70–74	129 [102–157]	164 [131–196]	132 [102–162]	155 [123–188]	172 [137–206]	1.05 [0.98–1.12]	1.20 [0.91–1.59]
75–79	167 [136–198]	182 [150–215]	162 [131–193]	168 [136–201]	156 [123–188]	0.98 [0.91–1.04]	0.91 [0.70–1.18]
80–84	151 [111–190]	218 [171–264]	186 [144–227]	184 [144–225]	205 [163–247]	1.04 [0.97–1.11]	1.16 [0.87–1.54]
85–89	227 [154–300]	292 [212–373]	323 [240–405]	244 [174–315]	267 [194–340]	1.01 [0.91–1.11]	1.02 [0.69–1.52]
≥90	422 [242–603]	439 [259–618]	331 [182–480]	423 [261–586]	535 [360–710]	1.06 [0.92–1.21]	1.26 [0.73–2.17]
Women, age group (years)							
60–64	401 [358–445]	426 [381–471]	438 [393–483]	412 [368–455]	448 [403–492]	1.02 [0.98–1.05]	1.08 [0.94–1.23]
65–69	482 [431–532]	433 [386–480]	440 [394–486]	475 [427–522]	493 [445–542]	1.01 [0.98–1.05]	1.06 [0.92–1.22]
70–74	511 [461–561]	522 [469–575]	506 [452–560]	497 [443–551]	561 [504–618]	1.01 [0.98–1.04]	1.05 [0.93–1.19]
75–79	703 [647–759]	752 [694–810]	673 [618–728]	700 [642–758]	712 [652–772]	0.99 [0.97–1.02]	0.98 [0.88–1.09]
80–84	1032 [951–1112]	888 [814–962]	875 [803–947]	925 [853–998]	840 [772–909]	0.96 [0.94–0.99]	0.86 [0.78–0.95]
85–89	1181 [1074–1288]	1169 [1064–1275]	1198 [1091–1305]	1116 [1012–1219]	1116 [1012–1221]	0.98 [0.96–1.01]	0.94 [0.83–1.06]
≥90	1172 [1032–1313]	1274 [1128–1421]	1076 [943–1209]	1162 [1024–1300]	1138 [1003–1274]	0.99 [0.95–1.03]	0.94 [0.80–1.11]

[a]Age and sex standardized

[b]Age standardized

IRR = average annual changes corresponding to 1-year difference

IRR[4] = IRR × IRR × IRR × IRR changes over the entire study period

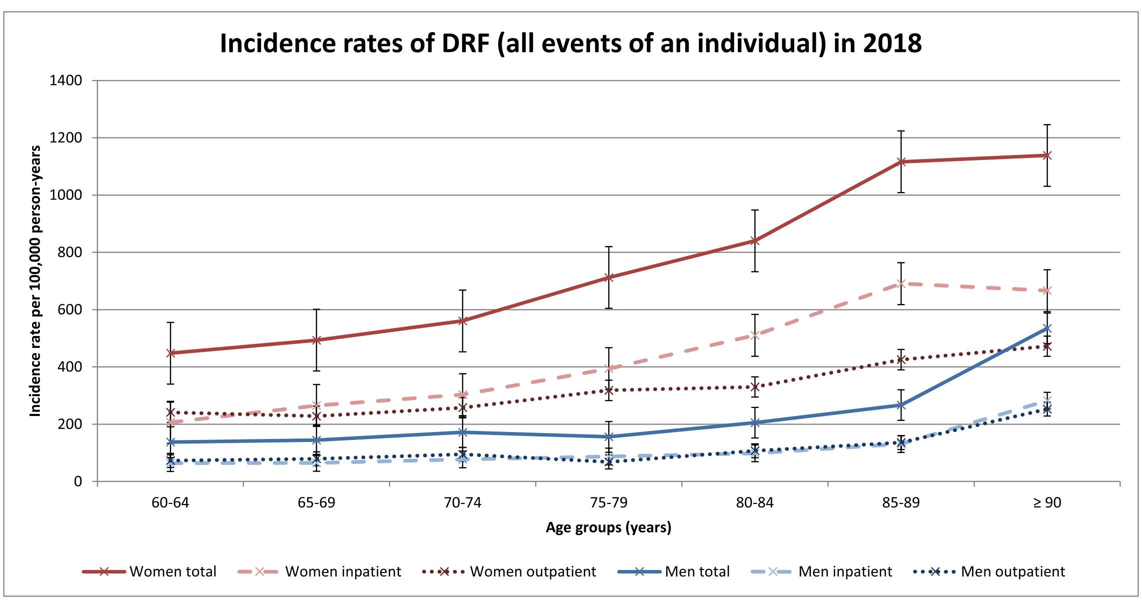

Fig. 2 DRF incidence rates of all DRF events of an individual in 2018 stratified for type of care, sex, and age groups with 95% confidence intervals indicated

Table 3 Poisson regression model for estimating the incidence rate ratio for all fracture events of an individual including 95% confidence interval and p-value as a function of the independent variables calendar year trend, sex, age group, and comorbidity class

Variable	Incidence rate ratio (IRR) [95% CI]	*p*-value
Calendar year trend (per year)	0.99 [0.98–1.01]	0.327
Sex		
Men	1.00 (reference)	
Women	3.79 [3.63–3.96]	<0.001
Age group (years)		
60–64	1.00 (reference)	
65–69	1.03 [0.97–1.10]	0.291
70–74	1.15 [1.08–1.22]	<0.001
75–79	1.48 [1.40–1.57]	<0.001
80–84	1.84 [1.74–1.95]	<0.001
85–89	2.35 [2.21–2.50]	<0.001
≥90	2.42 [2.25–2.61]	<0.001
Charlson comorbidity index		
0	1.00 (reference)	
1	1.36 [1.30–1.43]	<0.001
2–3	1.36 [1.30–1.42]	<0.001
4–5	1.30 [1.23–1.37]	<0.001
≥6	1.40 [1.32–1.49]	<0.001

Further results are broadly in line with our expectations, as a significant association of sex and age with incidence rate of all DRF events was found, and a higher risk was observed in the presence of comorbidity.

Compared with the international literature, the IR for the population aged 60 years and older determined in our study for the year 2018 lies in the upper range with 178 [163–193] for men and 639 [616–662] per 100,000 person-years for women. In studies with similar designs but a slightly younger age range (the studies included people being 50 years and older), IR range from 151 to 171 for men and 475 to 712 for women [3, 7, 11, 17]. As reported here, studies using a similar methodology present higher incidence rates for women and with increasing age, sometimes showing a plateauing or decreasing IR in the oldest age groups [3, 7, 17].

To our knowledge, there are only a few studies, which examine incidence time trends of all distal radius fracture events based on inpatient and outpatient data. In our analysis, where subsequent fractures, which accounted for 6.5% of all fracture events, were considered, stable incidence rates were observed over time. This conflicts with existing publications that have already taken a similar approach to our study. Kwon et al. examined DRF time trends considering also subsequent fractures from inpatient and outpatient care settings in Korea (2008–2012) and demonstrated a significant increase for the population aged 50 years and older [11]. Jerrhag et al. demonstrated in a Swedish study significant increases for females ≥ 50 years but no time trend for men and likewise a stable development in the population ≥ 65 years of both sexes from 1999 to 2010 in both inpatient and outpatient care settings when subsequent fractures were considered as well [17]. Dimai et al. reported increases in annual IRR for the population ≥ 50 years in Austria from 1989 to 2010, but exclusively in inpatient care. Taking both care settings into account a decrease in IRR for women and a stable development for men was observed [7]. Similar results were published by Leslie et al. for Manitoba (Canada): From April 1986 to March 2006, considering both care settings and also subsequent fractures, significant annual decreases in women were shown and a stable time trend in men [20].

Interestingly, in our study, 56% of all fracture events in insured persons older than 60 years were treated in the inpatient setting, which means that nearly half of the cases were left out when only individual inpatient data were used. Using a prospective approach for the German city of Rostock, Bäßgen et al. were able to demonstrate an underreporting of inpatient and outpatient DRF of almost 50% when using only data from the state statistical office [14]. Taking these and our own findings into account, it becomes clear that the exclusive use of data from inpatient care results in a significant underestimation of incidence rates.

In our study, the presence of comorbidity was associated with a higher risk for DRF. While it is known that patients with DRF are younger and have fewer comorbidities compared with patients with proximal humerus fracture or hip fracture, studies examining the impact of comorbidity on DRF incidence rates in the elderly population are rare [25, 26]. Hansen et al. used a case-control approach to examine the association of comorbidity and fracture incidence rates in a multivariate conditional logistic regression model for hospitalized patients only. Consistent with our results, the presence of comorbidity was associated with a higher incidence [25]. On the one hand, several diseases included in the Charlson comorbidity index (e.g., renal insufficiency, diabetes mellitus) may cause an increased tendency to fall [27, 28]. On the other hand, these diseases may lead to secondary osteoporosis, so this may explain an association with increased fracture incidence because osteoporosis is a known and important risk factor for fragility fractures such as DRF [29], although primary osteoporosis (senile or postmenopausal) clearly dominates in the distribution.

Several limitations must be considered when evaluating the present study. Errors in the classification and coding of DRF may be included in statutory health insurance data, without allowing for a radiological verification. Wrong diagnoses cannot be excluded. It is possible that the quality of diagnosis is better in the inpatient setting than in the outpatient setting. Correct outpatient coding in general has a direct financial impact on health insurers, since the morbidity-oriented risk structure compensation (Morbi-RSA) and the health fund make different co-payments to health insurers for certain diseases based on inpatient and outpatient ICD-10 diagnoses. Outpatient practitioners are therefore encouraged to apply ICD-10 as accurately as possible. Studies have shown that the quality of coding of physician diagnoses according to the German Version ICD-10-GM can be improved but is considered suitable [30, 31]. In a German study by Bäßgen et al., the percentage of miscoding comparing prospectively collected inpatient and outpatient data (fractures confirmed on radiographs) with retrospective administrative data for proximal humerus fractures, proximal femur fractures, clinically evident vertebral fractures, and distal radius fractures combined was less than 6% [14]. There are also non-specific diagnosis codes in the ICD-10 system (e.g., S52.30, S52.9, and S62.8) that may include DRF. Considering the existing literature, the decision was made not to include these non-specific codes. To discriminate subsequent fractures, existing literature and clinical assessments of the duration of therapy after a fracture were also used to guide the selection of the washout period and a sensitivity analysis was performed for different lengths of washout periods. Nevertheless, in individual cases there may be an overestimation due to multiple registrations or an underestimation due to the occurrence of a second fracture during the therapy period of the previous fracture. On the basis of routine data of the statutory health insurance in Germany, no statements can be made about the causes of a fracture. In addition, no clinical parameters can be evaluated and no mapping to relevant classification systems (i.e., AO/OTA) can be performed. Furthermore, no conclusions can be drawn about the relationship between sociodemographic background and the incidence rate of DRF. It should be noted that the statutory health insurance population sample may not be representative with regard to characteristics such as socioeconomic status or morbidity of the entire German population. For example, they were found to be older, more likely to belong to socially disadvantaged groups and to have a higher prevalence of chronic diseases compared to members of other health insurances [32]. For historical reasons, there are some differences in the structure of the insured populations among the more than 100 existing statutory health insurance companies. In addition to the statutory health insurance, there are also private health insurance companies in Germany that cover about 10% of the rather wealthier population [33]. To compensate for differences in age and gender structure, the standardization was applied to the entire German population from 2018. Nevertheless, a generalization of the study results to Germany as a whole has to be questioned. We based our analyses on the population aged 60 and over and did not include the 50 to 60 years age group, as is the case in other publications [7, 11, 20]. When considering younger age groups, it must be noted for the German population that other payers than the statutory health insurance are responsible for fractures occurring at the workplace or on the way to work. For this reason, it could be possible that not all fractures are recorded and thus the incidence might be underestimated. In addition, in the younger population, the underlying accident mechanism is often different with a higher proportion of high-energy trauma. Still, we are aware that if a lower age cutoff were used, the overall incidence rates by sex would likely be lower. Finally, it should also be noted that results on trends may depend on the observation period and its length. In general, results on trends should only be related to the observation period and extrapolations beyond this period should be considered critical.

At the same time, our study also has important strengths. By using data from a large German statutory health insurance company, both incidence rates and especially their time trends can be validly estimated for a large German sample. Contrary to the hospital diagnosis statistics, the outpatient care sector is also taken into account, within almost half of the DRF were treated. The use of individual data allows a valid estimation of subsequent fractures and a better avoidance of multiple registrations, which may occur especially in studies based on diagnosis registers due to readmissions for complications, transfers or at year changes. To account for the problem of double-counting in studies without individual data calculated correction factors can be used [7, 34]. In addition, the comprehensive data on diagnosis and therapy codes allow a reduction of overestimation resulting from diagnoses in the context of metal removals and permit statements on the comorbidity of the insured persons.

To summarize, incidence rates for all DRF events remained predominantly stable over time but at a high level. As expected, a significant association of sex and age with incidence rate of all DRF events was found, and a higher risk was observed in the presence of comorbidity. In Germany, a relevant proportion was treated exclusively on an outpatient basis, so these cases are not taken into account when using data from hospital diagnosis registers. Based on the results, further need for prevention becomes apparent, in order to reduce the individual and societal burden in the future. Especially in the groups at risk, possible approaches include fall prevention and assessment or prophylaxis and treatment of postmenopausal osteoporosis, noting that DRF are often considered index fractures for the presence of osteoporosis with the risk of further fractures. For prospective orthopedic trauma demand planning in the coming decades, it can be assumed that there will be a continuously pronounced need for treatment options in the inpatient and outpatient care sector, so that the results presented in this study are also relevant to health care professionals and health policy makers.

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Data availability Data are subject to the legal data protection laws and only available in an aggregated form upon formal request. The contact person is Dr. Burkhard Haastert, responsible Biostatistican of the project group, mediStatistica, 42329 Wuppertal, and associate researcher at the Institute for Health Services Research and Health Economics, Faculty of Medicine, Heinrich-Heine-University Düsseldorf, Germany, who needs to be contacted at haastert@medistatistica.de.

Declarations

Ethics approval The study was approved by the ethics committee of the Faculty of Medicine, Heinrich-Heine University Düsseldorf (approval reference 5455). The survey and utilization of secondary health administration data was conducted retrospectively and in compliance with the applicable standards and legal rules on data protection. All procedures performed were in accordance with the Declaration of Helsinki and comparable ethical standards (e.g., Good Epidemiological Practice (GEP) [35] and Good Practice Secondary Data Analysis (GPS) [36]). The data were analyzed anonymously; informed patient consent is not required.

Consent to participate Not applicable.

Consent for publication Not applicable.

Conflicts of interest None.

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