

Treatment of Proximal Humeral Fractures in Older Patients During COVID-19 Pandemic in Germany

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Purpose: The COVID-19 pandemic had a severe influence on the entire health sector. Until today, the effect of a SARS-CoV-2 infection on older patients with a proximal humeral fracture (PHF) is unknown. This study examined the following questions: Did the incidence of PHF of older people in Germany vary during the pandemic? Did the treatment change between the lockdown and non-lockdown periods? Was a SARS-CoV-2 infection associated with a worse outcome?

Methods: Retrospective claims data of the BARMER health insurance were analysed. All in- and outpatient cases of insurance holders ≥ 65 years from 01/2010 to 09/2022, with coded diagnosis of PHF were analysed. Primary endpoints were the 1-month incidence of PHF per 100,000 insurance holders, number of operative therapies, in-hospital death and in-hospital major adverse events (MAEs).

Results: 174,898 inpatient PHF cases were included. During the lockdown periods, the total incidence fell, while the outpatient incidence partially increased during the pandemic-period. Regarding the therapy allocation, there were no relevant persisting changes. In a detailed analysis of 23,979 PHF cases from 01/2020 to 09/2022, 4.1% patients suffered from a SARS-CoV-2 infection and showed a notably higher in-hospital mortality (8.1% vs 2.5%; risk adjusted OR 2.79, 95% CI 2.11–3.70, $p < 0.001$) and more MAEs (17.0% vs 7.8%; risk adjusted OR 1.43, 95% CI 1.15–1.77, $p < 0.001$).

Conclusion: During the COVID-19 pandemic, the overall incidence of PHF in older patients was reduced. The treatment allocation did not change between the pre- and intra-pandemic period. An infection with SARS-CoV-2 was associated with higher mortality and more MAEs.

Keywords: COVID-19, geriatric surgery, health service research, proximal humerus fracture

Introduction

The COVID-19 pandemic had a major influence on the daily life and the health status of people worldwide. SARS-CoV-2 was identified not only as the trigger of an infectious respiratory disease but also other organ systems and mental health were severely affected.^{1–3} As the WHO declared the pandemic as public health emergency of international concern to be ended, it is necessary to describe the impact of SARS-CoV-2 on the health system and to investigate the interaction with other injuries and diseases. The proximal humeral fracture (PHF) has an incidence of 351 per 100,000 habitants amongst people 65 years and older in Germany.⁴ Hence, it is the third most frequent fracture amongst older patients after the proximal femoral and distal radius fracture.^{4,5} Almost 50% of the patients are more than 80 years old.⁶ The treatment algorithm of PHF is discussed controversially with varying proportions of surgically and non-surgically treated patients between countries.^{4,7–10} In case of operative treatment, most patients are treated with a locked plate fixation (LPF) but the number of reverse total shoulder arthroplasty (RTSA) is increasing sharply, whilst providing good post-operative

outcome.^{7,11,12} However, decision for surgical treatment of PHF in older patients greatly depends on patient-specific factors, such as age, sex, comorbidities defining outcome and benefit.^{7,8,10} The effect of a simultaneous SARS-CoV-2 infection has not been investigated yet.

During the lockdown periods, the number of elective orthopedic surgeries, like hip or knee arthroplasties, declined.¹³ In Germany, the number of admitted emergency patients was also reduced with 34% less polytraumatised patients, 19% less pertrochanteric femur fractures and 24% less femoral neck fractures.¹³ A recent systematic review analysing the orthopedic and trauma surgery in Europe during the COVID-19 pandemic also reported a reduction of trauma and emergency consultations.¹⁴ For patients with a SARS-CoV-2 infection and a hip fracture, the 30-day mortality rate was significantly elevated compared to patients without an infection during the pre-vaccination period.¹⁵ However, concerning PHFs, no systematic nationwide information about the treatment reality in Germany is available up to now.

The study at hand aimed to investigate the effect of the COVID-19 pandemic on the incidence and treatment of PHF in the older population in Germany. The three main questions were investigated: First, did the incidence of PHF change during the course of the pandemic in Germany, especially during the lockdowns. Second, did the treatment of older patients with PHF differ between the periods of lockdown versus non-lockdown periods. Third is a simultaneous SARS-CoV-2 infection associated with worse in-hospital outcome in older patients with PHF.

Material and Methods

Data Pool and Patient Cohort

The remuneration system in Germany is based on the “German Diagnosis Related Groups” (G-DRG) system, which is specified and regulated by mandatory coding instructions, including encoded diagnoses (International Statistical Classification of Diseases, German Modification; ICD-10 GM) and procedures (German procedure classification; OPS).¹⁶ About 30% of all inpatient cases were regularly reviewed by independent physician task forces (*Medizinischer Dienst der Krankenkassen*) to ensure correct coding.

For the study at hand, retrospective patient remuneration data (inpatient and outpatient data) of the BARMER health insurance from 2005 to 2022 were available. Inpatient and outpatient data were analysed separately. All cases of insurance holders aged 65 years or older from 01/2010 to 09/2022, with main or secondary coded diagnosis of proximal humeral fracture (ICD-10 S42.2) were analysed. All cases of patients with incomplete basic information were excluded from the analysis (inpatient N = 60, outpatient N = 120). All comorbidities, confirmed SARS-CoV-2 infection (defined using ICD U07.1, U07.2) and in-hospital outcomes were determined on a case-based set, including all coded secondary diagnosis during hospital stay (see [Supplementary Table S1](#) for all definitions). For inpatient cases, a SARS-CoV-2 infection was coded very reliably, since all patients in Germany were tested at admission during the considered period. Data of the 7-day incidence of SARS-CoV-2 infections in Germany were given by data of the Robert Koch institute (www.rki.de/inzidenzen, as of 11.09.2022).

Primary and Secondary Endpoints

Primary endpoints were defined as 1-month incidence of PHF per 100,000, ratio of cases with surgical treatment, in-hospital death, major adverse events (MAE; defined as resuscitation, acute myocardial infarction, stroke, sepsis, acute renal failure, acute liver failure, acute respiratory distress syndrome or death) and thromboembolic events (defined as deep vein thrombosis, pulmonary embolism, ischemic stroke) during hospital stay. Length of hospital stay (LOS), charges and 1-month outpatient incidence were defined as secondary endpoints.

Missing Values

Except of missing information about basic data, such as sex, date of birth or date of death, (which were defined as exclusion criteria), no missing data occur in the study, since all variables were defined by existing ICD or OPS codes. If no related code was found, the variable was set to zero.

Data Availability

The authors confirm that the data utilized in this study cannot be made available in the manuscript, the supplemental files, or in a public repository due to German data protection laws (“Bundesdatenschutzgesetz”, BDSG). They are stored on a server of the BARMER Institute for Health System Research, to facilitate replication of the results. In general, access to data of statutory health insurance funds for research purposes is possible only under the conditions defined in German Social Law (SGB V § 287).

Statistical Methods

The 1-month incidence of PHF were determined based on the total number of insurance holders aged 65 years and older. As a reference, the mean value (\pm standard deviation [SD]) per month from 2010 to 2019 were calculated. For binary endpoints, all proportions were presented with 95% Clopper-Pearson confidence interval (CI). To analyse differences between cases with and without SARS-CoV-2 infection, multivariable, generalized logistic regression models – using generalized estimating equations with binomial distribution and logit link function – were used to account for clustering due to multiple cases of the same patient. The model included age, sex, treatment (surgical treatment of PHF vs non-operative treatment), year of admission and all comorbidities presented in [Supplementary Table S1-S3](#). The study was conducted to be fully explorative (hypotheses generating), not confirmatory, and an adjustment for multiple testing was not performed. Statistical analyses were performed using SAS software V9.4, SAS Institute Inc., Cary, NC, USA, and R version 4.1.0, R foundation, Vienna, Austria. The analysis was performed by JK.

Results

Time Trends During COVID-19 Pandemic

In total, 174,898 inpatient cases with coded PHF were analysed from 2010 to 2022. During the COVID-19 pandemic in Germany, decreasing incidences per month were observed for people aged ≥ 65 years, when pandemic control policies have been implemented nationwide ([Figure 1A](#)). During the first lockdown in April 2020, the 1-month incidence per 100,000 population was decreased to 24.4, compared to the mean value of 28.4 in 2010–2019. Similar effects were observed during the second lockdown from 16.12.2020 to 31.01.2021 and contact restrictions (including limited number of contact person and access restrictions in public life only for double vaccinated people) from 02.12.2021 to 19.03.2022 ([Figure 1A](#)). Furthermore, in April 2020, a higher proportion of patients with surgical treatment of PHF was observed (Apr 2020: 61.9%, 95%-CI 58.0–65.7% vs 53.3%, 95%-CI 52.1–54.5% in Apr 2010–2019). Apart from April 2020, however, no relevant trends could be observed for the treatment strategy during the later pandemic course ([Figure 1B](#) and [Supplementary Figure S1](#)). Focusing on outpatient cases ($n = 181,237$), the 1-month incidence per 100,000 population is presented in supplementary [Figure S3](#). It was observed that the incidence was relevant higher from June 2021 to December 2021 and from March 2022 to the end of observation period (09/2022).

In-Hospital Outcomes with SARS-CoV-2 Infection

From 01/2020 to 09/2022, 23,979 cases with PHF of older insurance holders were included for further analysis, 976 (4.1%) from those with confirmed SARS-CoV-2 infection ([Table 1](#)). Patients with SARS-CoV-2 infection were older (ratio of cases with an age ≥ 80 years with SARS-CoV-2 64.5% vs 55.0% without SARS-CoV-2), less often treated surgically (with SARS-CoV-2 48.0% vs 58.2% without SARS-CoV-2) and had an adverse comorbidity profile ([Table 1](#)).

A SARS-CoV-2 infection was associated with higher economic burden for the treating hospital ([Figure 2B](#)). In detail, after adjustment of patient’s risk profile, a confirmed infection was in mean associated with 7.4 (95% CI 6.8–8.0, $p < 0.001$) days higher LOS per case and higher average charges of 3402.1EUR (95% CI 2967.1–3837.1, $p < 0.001$) per case compared to those without SARS-CoV-2 ([Figure 2A](#)). Furthermore, a SARS-CoV-2 infection was associated with an adverse course during hospital stay ([Figure 3](#)). Patients with infection had a higher in-hospital mortality rate (8.1% vs 2.5%; risk adjusted OR 2.79, 95% CI 2.11–3.70, $p < 0.001$) and suffered more from MAEs (17.0% vs 7.8%; risk adjusted OR 1.43, 95% CI 1.15–1.77, $p < 0.001$). After adjustment of patient’s comorbidity profile, no association between the date of fracture – ie, comparing patients injured in 2020, 2021 or 2022 compared to those with a fracture between 2009

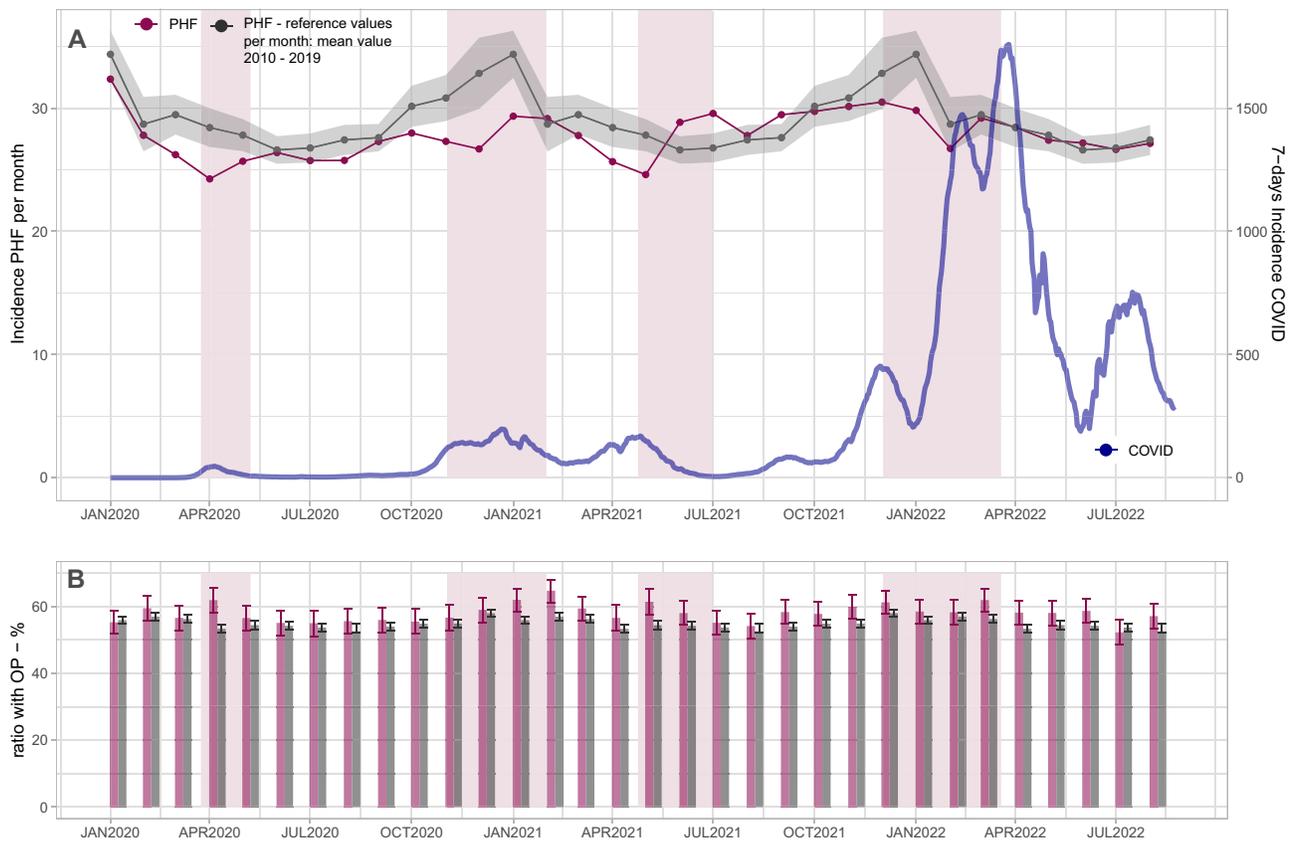


Figure 1 Time trends of incidence of PHF per 100,000/ person months (A) and proportion of cases with surgical treatment (B) during COVID-19 pandemic in Germany. Reference values were given by pooled data from 2010–2019. 7-day incidence for SARS-CoV-19 was given by the data of the Robert-Koch institute (www.rki.de/inzidenzen, as of 11.09.2022). Pandemic control policies were marked by red background.

and 2019 – and all observed in-hospital outcomes were noted (all $p > 0.05$; [supplementary Table S2](#)). Moreover, it was observed that patients without surgical treatment had more frequently worse in-hospital outcomes than patients with surgical treatment ([Supplementary Figure S2](#)). In addition, after adjustment of patient’s risk profile, the negative association between a SARS-CoV-2 infection and worse outcome was also observed, independent from treatment (all $p_{int} > 0.05$; [Table 2](#)).

Table 1 Comorbidities and in-Hospital Outcome of (Inpatient) Cases with Proximal Humeral Fracture, Depending and SARS-CoV-2 Infection from 01/2020 to 09/2022. P values are Fully Explorative and Determined Using Two-Sided Chi-Square Test (Categorical Variable) or Two-Sided Mann–Whitney–U Test (Continuous Variables). Possible Clustering of Cases Was Not Considered

	All cases	Cases with COVID	Cases Without COVID	P value
Total Number – N (%)	23,979 (100.0%)	976 (4.1%)	23,003 (95.9%)	n.a.
Female sex – N (%)	19,994 (83.4%)	788 (80.7%)	19,206 (83.5%)	0.024
Median Age (Q1, Q3)	81 (74, 85)	82 (77, 87)	80 (74, 85)	<0.001
Age ≥ 80 years – N (%)	13,280 (55.4%)	629 (64.5%)	12,651 (55.0%)	<0.001
Surgical treatment – N (%)				<0.001
No	10,129 (42.2%)	508 (52.1%)	9621 (41.8%)	
Yes, total	13,850 (57.8%)	468 (48.0%)	13,382 (58.2%)	

(Continued)

Table I (Continued).

	All cases	Cases with COVID	Cases Without COVID	P value
Comorbidities				
Osteoporosis – N (%)	3094 (12.9%)	147 (15.1%)	2947 (12.8%)	0.040
Cancer – N (%)	626 (2.6%)	29 (3.0%)	597 (2.6%)	0.471
Diabetes mellitus – N (%)	4640 (19.4%)	222 (22.8%)	4418 (19.2%)	0.006
Dementia – N (%)	1468 (6.1%)	94 (9.6%)	1374 (6.0%)	<0.001
Chronic polyarthritis – N (%)	481 (2.0%)	15 (1.5%)	466 (2.0%)	0.286
Obesity – N (%)	1370 (5.7%)	58 (5.9%)	1312 (5.7%)	0.753
Nicotine abuse – N (%)	164 (0.7%)	7 (0.7%)	157 (0.7%)	0.898
Alcohol abuse – N (%)	424 (1.8%)	14 (1.4%)	410 (1.8%)	0.419
Parkinson – N (%)	681 (2.8%)	46 (4.7%)	635 (2.8%)	<0.001
Rotator cuff rupture – N (%)	730 (3.0%)	25 (2.6%)	705 (3.1%)	0.370
Atrial fibrillation and flutter – N (%)	4187 (17.5%)	217 (22.2%)	3970 (17.3%)	<0.001
Hypertension – N (%)	16,294 (68.0%)	678 (69.5%)	15,616 (67.9%)	0.300
Chronic heart failure – N (%)	2714 (11.3%)	194 (19.9%)	2520 (11.0%)	<0.001
Coronary heart disease – N (%)	2646 (11.0%)	139 (14.2%)	2507 (10.9%)	0.001
Atherosclerosis – N (%)	610 (2.5%)	31 (3.2%)	579 (2.5%)	0.200
Chronic kidney disease – N (%)	4122 (17.2%)	229 (23.5%)	3893 (16.9%)	<0.001
In-hospital outcomes				
Mean (\pm SD) LOS – days	12.0 (\pm 9.9)	20.1 (\pm 15.8)	11.7 (\pm 9.4)	<0.001
Mean (\pm SD) charges – EUR	8074.0 (\pm 7148.1)	11,414.2 (\pm 9219.0)	7932.3 (\pm 7012.0)	<0.001
Acute liver failure – N (%)	45 (0.2%)	4 (0.4%)	41 (0.2%)	0.102
Acute renal failure – N (%)	1050 (4.4%)	76 (7.8%)	974 (4.2%)	<0.001
Acute myocardial infarction – N (%)	145 (0.6%)	11 (1.1%)	134 (0.6%)	0.032
ARDS – N (%)	17 (0.1%)	5 (0.5%)	12 (0.1%)	<0.001
Blood transfusion – N (%)	2801 (11.7%)	176 (18.0%)	2625 (11.4%)	<0.001
Delirium – N (%)	1374 (5.7%)	96 (9.8%)	1278 (5.6%)	<0.001
Hemorrhagic stroke – N (%)	78 (0.3%)	4 (0.4%)	74 (0.3%)	0.636
Ischemic stroke – N (%)	247 (1.0%)	15 (1.5%)	232 (1.0%)	0.109
Need of intensive care unit – N (%)	788 (3.3%)	67 (6.9%)	721 (3.1%)	<0.001
Pulmonary embolism – N (%)	107 (0.5%)	11 (1.1%)	96 (0.4%)	0.001
Deep vein thrombosis – N (%)	49 (0.2%)	4 (0.4%)	45 (0.2%)	0.147
Resuscitation/ cardiac arrest – N (%)	143 (0.6%)	7 (0.7%)	136 (0.6%)	0.617
Sepsis – N (%)	221 (0.9%)	32 (3.3%)	189 (0.8%)	<0.001

Abbreviations: ARDS, acute respiratory distress syndrome; CI, confidence interval; LOS, length of hospital stay; n.a., not applicable; SD, standard deviation.

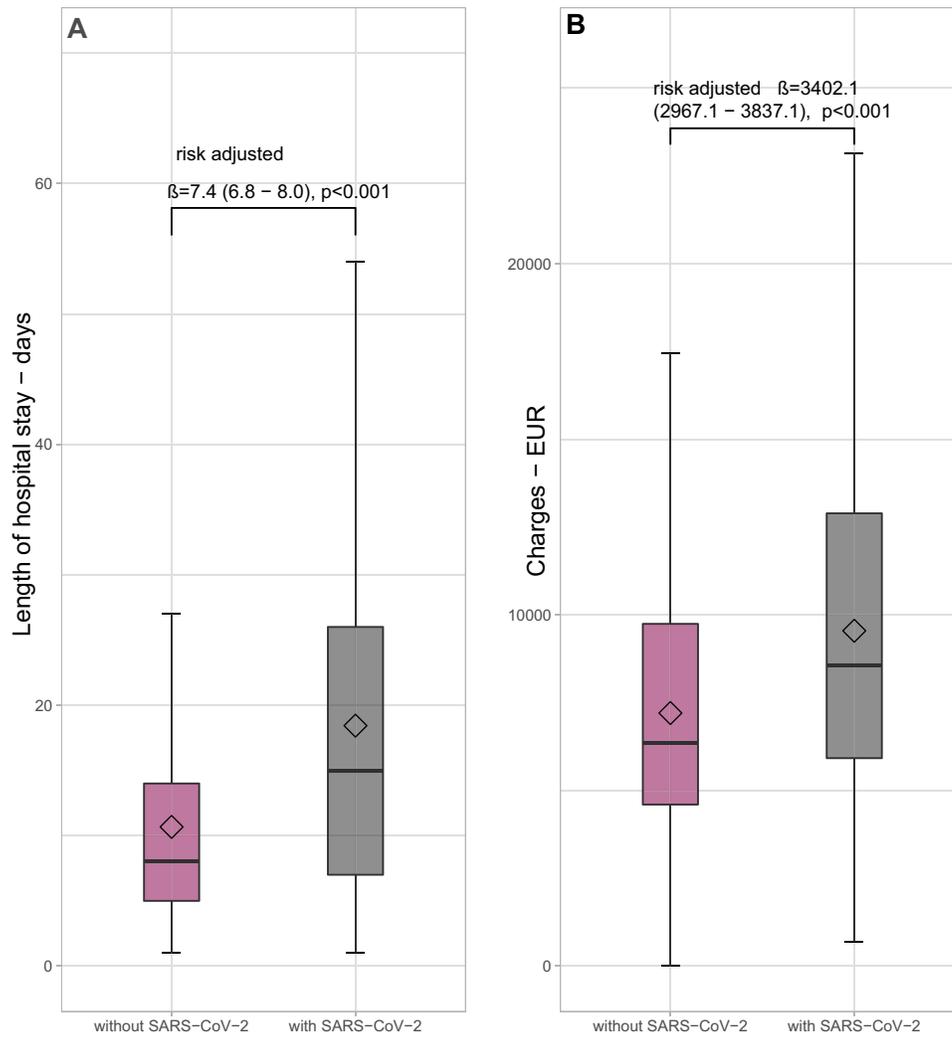


Figure 2 Length of hospital stay (LOS) (A) and charges per cases (B) depending on SARS-CoV-19 infection during hospital stay. Risk adjusted effects (β) were determined using multivariable linear regression models including age, sex, year of hospitalization and patient’s comorbidity profile. Full results of regression analyses were presented in [Supplementary Table S2](#).

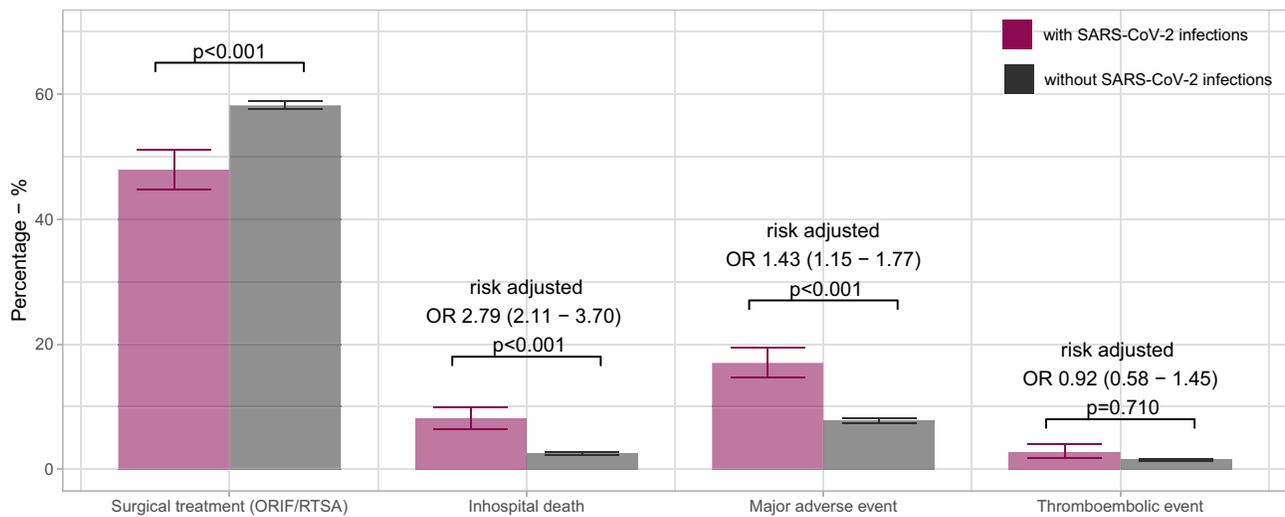


Figure 3 In-hospital outcome depending on SARS-CoV-19 infection during hospital stay. Risk adjusted effects were determined using multivariable, generalized logistic regression models including age, sex, year of hospitalization and patient’s comorbidity profile. Full results of regression analyses were presented in [Supplementary Table S2](#). **Abbreviations:** OR, odds ratio; ORIF, open reduction internal fixation; RTSA, reverse total shoulder arthroplasty.

Table 2 Association of SARS-CoV-19 Infection During Hospital Stay and Different in-Hospital Outcomes Depending on Treatment. Risk Adjusted Effects Were Determined Using Multivariable, Generalized Logistic Regression Models Including Age, Sex, Year of Hospitalization and Patient's Comorbidity Profile. Differences Between Treatment (Surgical Treatment Yes/No) Was Conducted Using Additional Interaction Term Treatment* SARS-CoV-19. Full Results of Regression Analyses Were Presented in [Supplementary Table S2](#)

Outcome	Odds Ratio (SARS-CoV-19)	95% - CI	p-value	P value of Interaction
Thromboembolic event				0.192
Non-surgical treatment	0.77	(0.44–1.34)	0.357	
Surgical treatment	1.39	(0.67–2.89)	0.376	
Major adverse event				0.172
Non-surgical treatment	1.28	(0.97–1.70)	0.081	
Surgical treatment	1.71	(1.25–2.33)	<0.001	
In-hospital death				0.498
Non-surgical treatment	2.63	(1.87–3.69)	<0.001	
Surgical treatment	3.18	(2.03–4.99)	<0.001	

Abbreviations: CI, confidence interval; OR, odds ratio.

Discussion

The most important findings of the present study are that patients with a PHF and simultaneous SARS-CoV-2 infection are associated with a higher complication rate and mortality. A higher economic burden with increased LOS and higher average charges were found. During the lockdown periods, due to SARS-CoV-2, the incidence of PHF decreased. Overall changes regarding the frequencies of the different therapeutic procedures could not be observed during the pandemic period.

In the pre-COVID-19 time, the number of proximal humeral fractures rose continuously.¹⁷ However, the present study showed a reduction of PHF during the COVID-19 lockdown periods. This is consistent with several other analyses that reported fewer trauma patients and fractures in major trauma center during this time.^{13,18} The number of fragility fractures including PHF also declined during the COVID-19 pandemic, as a recent study analysing the incidence in Japan pointed out.¹⁹ In contrast, a study of patients 65 years or older in Germany did not find a significant difference.²⁰ A frequent explanatory approach is that the reduced mobility due to the lockdown also reduced the fracture causes. Concerning the mobile phone GPS-data, a massive drop of mobility was observed during the lockdown periods in Germany ([Supplementary Figure S4](#)). However, the PHF belongs to the fragility fractures, and a frequent fracture cause is a fall from standing height, which can occur easily at home. Explanatory, Maniscalco et al observed a decreased rate of PHF as well as fractures in the context of retirement housing in three different Italian hospitals. They stated that older patients might try to avoid hospitals in case of non-severe injuries maybe voting for an outpatient treatment.²¹ As in most of the studies examining the fracture incidence during the COVID-19 pandemic, only hospital and inpatient data were analysed, the outpatient data remained a blind spot.^{13,18,20} This study at hand also included the outpatient data, which support the hypothesis of Maniscalco et al as an increase of outpatient PHF diagnosis in the pandemic period was seen.

Concerning the choice of treatment, no significant differences between the pre-pandemic, lockdown and non-lockdown pandemic course were observed in the study at hand. This is consistent with a French study, which found no significant difference in the therapy allocation analysing the treatment of fragility PHF in 2019 in comparison to 2020.²² In addition, for the fragility hip fractures, no significant changes in the choice of treatment were seen between the pre-, intra- and post-lockdown period.²³

A simultaneous SARS-CoV-2 infection with PHF was associated with higher complication rates and a longer hospital stay in the analysed cohort. A recent Spanish study found a mortality of 21% for PHF and 10% for osteoporotic vertebral fractures with a simultaneous SARS-CoV-2 infection.²⁴ This is higher than the presented data. However, it must be considered that the analysed data are mostly focusing on the pre-vaccination period, so the elevated complication rate cannot be directly transferred in the post-vaccination era. A worse outcome for patients without surgical treatment was observed, also after multivariable adjustment. However, especially in the case of the examined intra-hospital complications/mortality, the negative association should be interpreted with caution, due to different sources of bias. The observed association is probably due to the fact that there was a reason, why a patient was not (or no longer) treated surgically, rather than that the surgery itself reduced complications, eg, the treating doctors may vote for a non-operative treatment, because anesthesia and surgery were an unacceptable risk for the patient. Such type of bias can be reduced to a certain extent, if, eg, propensity score matching is performed as in Katthagen et al.¹⁰

Strengths of the study are the large underlying data source based on the insurance data of one of the largest German insurance fund, with more than 8 million policyholders.⁴ Hence, the study at hand is not based on the data of a certain hospital type, like a regional or level-1 trauma centrum, it rests on nationwide diverse case data. Another strength of this study is, as mentioned above, the inclusion of outpatient data. Limiting the presented results, clinical data and the cause of treatment decision were not available. The analyses were on a case-based study, and secondary hospitalizations might be included. However, all multivariable analyses take into account the possible clustering of patient cases. Data were initially collected for financial purposes, not for scientific research.

Conclusions

During the COVID-19 pandemic, the overall incidence of PHF in older patients decreased. The treatment allocation did not change between the pre-pandemic and intra-pandemic period. An infection with SARS-CoV-2 was associated with an inferior outcome with or without surgery. Therefore, the protection against a SARS-CoV-2 infection has a particular relevance for older patients.

Ethical Committee Approval

The study was conducted in accordance with the Declaration of Helsinki and was approved by Ethics Committee Westfalen-Lippe (no. 2022-300-f-S). As for anonymity of insurance data, no prior written informed consent for the analysed data had to be obtained.

Acknowledgments

The abstract of this paper was presented at the DCK 2023 – 140th German Congress of Surgery, Munich under the name “Incidence and treatment of proximal humeral fractures in the elderly during the COVID-19 pandemic in Germany – A health claims data analysis” as a conference talk with interim findings. The abstract was published in *Innovative Surgical Science*. (DOI 10.1515/iss-2023-9007). Furthermore, the abstract of this paper was presented as a poster at the congress for geriatric traumatology, Essen in 2024 – “Effekt der COVID-19-Pandemie auf die Versorgungsrealität proximaler Humerusfrakturen bei älteren Patient*innen”. The abstract was published in the section “Poster Abstracts” and can be found under the DOI: 10.3205/24altra35.

Additionally, the abstract was presented as a poster at the congress of the German, Austrian and Swiss Shoulder and Elbow Society, Düsseldorf in 2024 under the title “Proximale Humerusfrakturen bei älteren Patienten während der Covid-19 Pandemie in Deutschland”.

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Disclosure

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