Journal of Frailty, Sarcopenia and Falls

Original Article

Shifts in Frailty in A Nationwide Cohort of Spinal Stenosis Patients in Germany During the COVID-19 Pandemic

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Abstract

Objectives: To examine shifts in frailty among spinal stenosis patients during the COVID-19 pandemic and associations with interventions and outcomes. **Methods**: This retrospective analysis compared types of management and rates of in-hospital mortality between pre-pandemic (January 1, through December 31, 2019) and pandemic phases (March 5, 2020 through May 17, 2022) among spinal stenosis patients across a network of 76 hospitals in Germany, utilizing logistic generalized linear mixed models. Frailty was quantified using the Hospital Frailty Risk Score (HFRS) and categorized as low (<5 points), intermediate (5-15 points), and high (>15 points). **Results**: Among the 59,130 patients with spinal stenosis, 39,448 were hospitalized during the pandemic, and 19,682 in 2019. During the pandemic, the proportion of patients with high frailty rose from 4.7%-5.5% to 6.2%-7.3% ($p < 0.01$), except in pandemic wave 5. Among low frailty patients, rates of decompressive surgery increased from 42.4%-46.0% to 48.4%-52.8% ($p<0.001$), and of fusion surgery from 15.7%-16.6% to 19.2%-22.8% ($p<0.001$). Throughout the pandemic, in-hospital mortality rates increased from 0.8%-1.0% to 1.0%-2.5% ($p<0.017$), yet without differences across frailty groups. **Conclusions**: Among those hospitalized for spinal stenosis during the COVID-19 pandemic in Germany, frailty increased and low frailty was associated with rising rates of spine surgery.

Keywords: COVID-19, Frailty, Hospital Frailty Risk Score, Spinal stenosis

Introduction

Spinal stenosis is the most prevalent reason for spine surgery among older individuals[1,2]. It is highly associated with frailty, especially regarding length of stay, types of management, and treatment outcomes[3]. According to the United Nations, the worldwide number of subjects aged over 65 will double between 2019 and 2050[4]. In this environment, frailty as an increasingly prevalent geriatric syndrome will continue to reshape diagnostic and therapeutic processes within clinical routine.

During the COVID-19 pandemic, the population of most parts of the world encountered an increase in frailty, potentially caused by decreased physical and social activities resulting from lockdowns and other restrictions[4,5]. In Germany, this translated to an increase in frailty among patients with any form of spinal disease. This effect was most pronounced during pandemic waves 1 through 3, while frailty in waves 4 and 5 returned to almost pre-

Julius Dengler received funding through the Helios Center for Research and Innovation via a grant (HCRI ID 2020-0458). Ralf Kuhlen holds shares in Fresenius AG. The remaining authors have nothing to declare.

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***Edited by:** Jagadish K. Chhetri*

***Accepted** 7 May 2025*

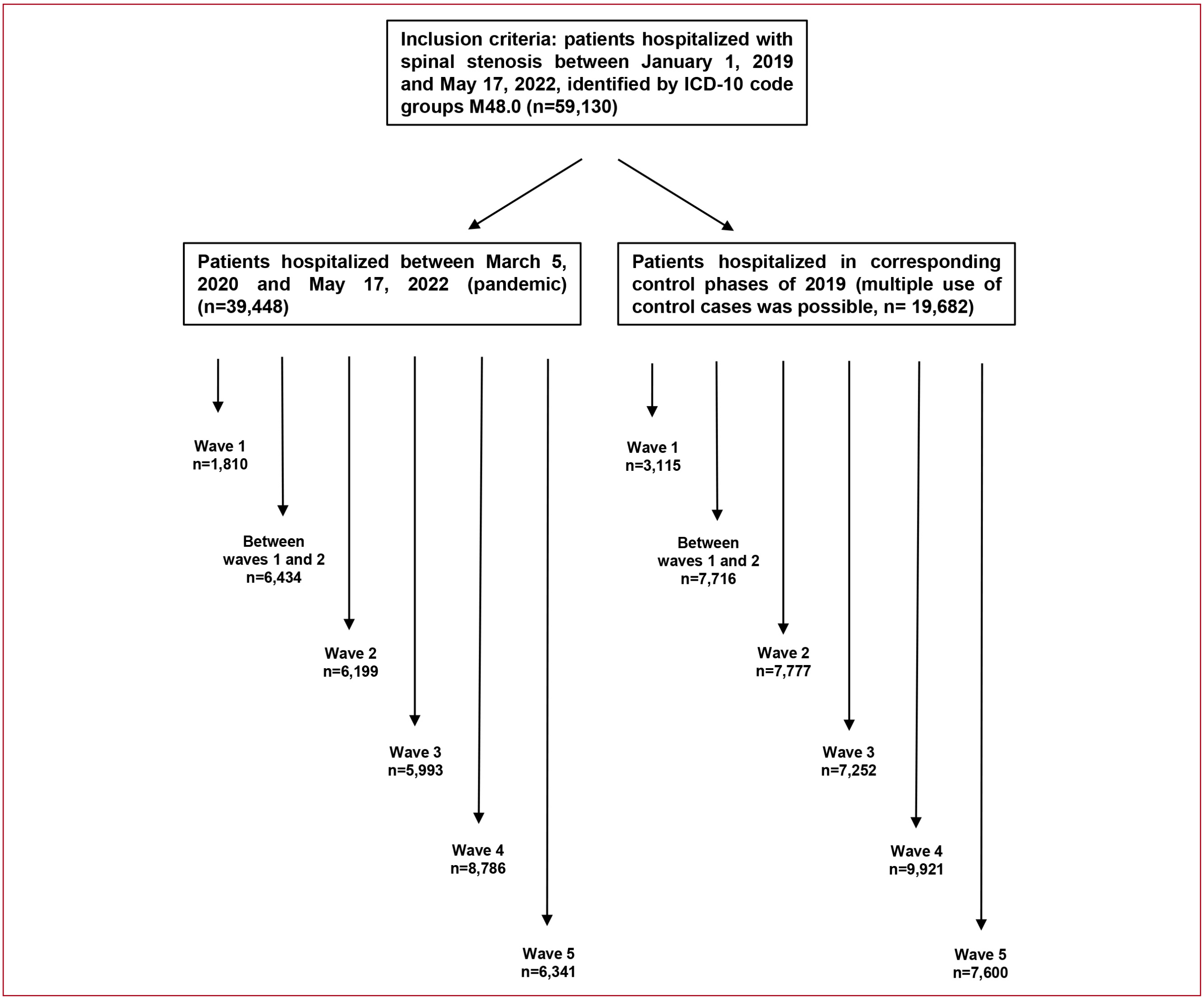

Figure 1. Flow chart describing patient inclusion.

pandemic levels[6]. However, those findings were derived from spine patients in general, including those suffering from diagnoses not typically associated with frailty, such as spine deformity, infection, and trauma. Therefore, a specific analysis of the relation between frailty and spinal stenosis during the pandemic is lacking.

Given that spinal stenosis is the main reason for spine surgery among older and frailer subjects, examining links between frailty and spinal stenosis management is of interest[1,2].Therefore, we examined the in-hospital management of spinal stenosis in relation to varying degrees of frailty between 2019 and 2022. We utilized data from a nationwide hospital network in Germany and analyzed overall admissions, patient characteristics, in-hospital mortality rates and therapeutic modalities from different pandemic periods and compared them to corresponding pre-pandemic phases.

Methods

Study population

For this observational study, administrative data from a nationwide network of 76 hospitals in Germany were retrospectively examined. The Helios hospital network covers urban and rural areas in 13 of the 16 federal states in Germany, managing 7% of all nationwide inpatient cases[7,8]. All admitted patients with the primary diagnosis of spinal canal stenosis were included, comparing data between 2019, which was the final year before the

	Wave 1			Between Waves 1 and 2			Wave 2			Wave 3			Wave 4			Wave 5		
	Pre	Pan	p	Pre	Pan	p	Pre	Pan	p	Pre	Pan	p	Pre	Pan	p	Pre	Pan	p
Total cohort																		
Wave 2	3,115	1,810	<0.01	7,716	6,431	0.02	7,777	6,199	<0.01	7,252	5,993	0.02	9,921	8,786	0.08	7,600	6,341	0.03
HFRS groups																		
Low	71.3% (2,220)	67.3% (1,218)	<0.01	69.6% (5,368)	69.0% (4,442)	0.51	71.6% (5,566)	68.8% (4,264)	<0.01	71.2% (5,162)	69.4% (4,157)	0.02	70.3% (6,973)	69.5% (6,107)	0.25	71.7% (5,449)	72.1% (4,570)	0.64
Intermediate	23.4% (728)	25.4% (459)	0.12	24.9% (1,924)	24.4% (1,570)	0.48	23.7% (1,842)	24.5% (1,521)	0.25	23.5% (1,705)	23.9% (1,434)	0.59	24.5% (2,430)	24.3% (2,137)	0.80	23.3% (1,773)	22.7% (1,441)	0.41
High	5.4% (167)	7.3% (133)	<0.01	5.5% (424)	6.6% (422)	<0.01	4.7% (369)	6.7% (414)	<0.01	5.3% (385)	6.7% (402)	<0.01	5.2% (518)	6.2% (542)	<0.01	5.0% (378)	5.2% (330)	0.56

Pre, pre-pandemic; pan, pandemic; HFRS, Hospital Frailty Risk Score

Table 1. Total numbers of cases and distribution of frailty risk groups.

pandemic, and the first five pandemic waves throughout years 2020 to 2022. The following pandemic phases were examined and compared to corresponding periods in 2019[8,9]: wave 1 (March 5, 2020 to May 1, 2020); between waves 1 and 2 (May 2, 2020 to September 19, 2020); wave 2 (September 20, 2020 to February 13, 2021); wave 3 (February 14, 2021 to June 25, 2021); wave 4 (June 26, 2021 to January 1, 2022); wave 5 (January 2, 2022 to May 17, 2022). No exclusion criteria were defined for this study. Figure 1 summarizes patient inclusion. Surgical management was examined as per standardized nationwide "Operations and Procedures Codes" (OPS) as follows: decompression surgery without fusion: 5-033.0; 5-83960-3; 5-030.4-7; 5-031.1-3; 5-032.2-9; excision of diseased vertebral disc tissue without fusion: 5-831.0-9; and spinal fusion procedures: 5-83b.0-8.

Measures

The primary diagnosis of spinal stenosis was identified as code M48.0 in accordance with the International Statistical Classification of Diseases and Related Health Problems (ICD-10).

The assessment of frailty was conducted using the Hospital Frailty Risk Score (HFRS), which examines 109 predefined ICD-10 codes[10]. These codes are assigned points with varying weights, and the cumulative score is categorized according to three levels of frailty: low (<5 points), intermediate (5-15 points), and high (>15 points).

Confounding factors

Patient age, sex, and the Elixhauser Comorbidity Index (ECI), a tool that gauges the burden of comorbidity, were examined for associations with frailty[10-14].

Statistical Analysis

QlikView (QlikTech, Radnor, Pennsylvania, USA[15]) was used for data retrieval from the administrative data base, which comprises the complete set of data from all 76 Helios hospitals in Germany and is located at the Heart Center in Leipzig, Germany. Inferential analyses were performed using generalized linear mixed models (GLMM) with hospitals as a random factor[16-18]. The lme4 package (Version 1.1-21) was used for effect estimation within the R environment for statistical computations (Version 4.0.2, 64-Bit-Build)[19]. For the random factor, different intercepts were assigned in all models. A two-sided 5% significance level was applied. To describe patient characteristics and frailty proportions, we used χ^2 tests for binary variables and analysis of variance for numerical variables. To compare the proportions of selected treatments and outcomes across cohorts, logistic GLMMs with logit link function were applied, providing odds ratios and confidence intervals. Count data

	Prevalence of SARS-CoV-2 infections	
Wave 1 (March 5 to May 1, 2020)	8/1,810	0,4%
Between waves 1 and 2 (May 2 to September 19, 2020)	8/6,434	0.1%
Wave 2 (September 20, 2020 to February 13, 2021)	155/6,199	2.5%
Wave 3 (February 14 to June 25, 2021)	51/5,993	0.9%
Wave 4 (June 26, 2021 to January 1, 2022)	96/8,786	1.1%
Wave 5 (January 2 to May 17, 2022)	210/6,341	3.3%

Table 2. Prevalence of SARS-CoV-2 infections among patients admitted for spinal stenosis during different phases of the study period.

were examined by negative binomial models. The weighted ECI was calculated using the AHRQ algorithm[20]. Interaction analyses with the high frailty group as reference were used to assess to what degree frailty affected differences between pre-pandemic and pandemic phases.

Results

Among the 59,130 cases admitted for spinal stenosis, 39,448 were managed during the pandemic period, while 19,682 were admitted during corresponding pre-pandemic periods in 2019. Table 1 shows the numbers of hospitalizations for spinal stenosis and frailty level distributions. During the pandemic, admissions for spinal stenosis decreased significantly, compared to pre-pandemic levels.

Compared to pre-pandemic levels, during the pandemic, a notable increase in the proportion of high frailty was identified in waves one through four, rising from 4.7%-5.5% to 5.2%-7.3% ($p < 0.01$). Conversely, a significant decrease in the proportion of patients with low frailty was identified in pandemic waves one and two. The proportion of patients with moderate frailty did not change significantly during pandemic periods, ranging between 22.7%-25.4%. Table 2 provides an overview of the SARS-CoV-2 infection rates in patients with spinal stenosis, which were in the low single-digit percentage range.

Frailty on admission

An overview of daily admissions and baseline characteristics is presented in Table 3. The only phase in which a frailty-associated change in daily admissions was observed, was in wave 2, with an increase among high frailty spinal stenosis patients versus decreases among low and intermediate frailty groups. There were no frailty-associated changes in patient age or sex distribution. Changes in rates of comorbidities, quantified using the ECI, were associated with patient frailty in only three of the examined periods. That is, with high frailty patients as reference, there were larger relative increases in ECI among low frailty patients in waves 1 and 3 versus more pronounced increases in patients with high frailty in wave 5.

Frailty in relation to treatment types and outcomes

Table 4 shows the rates of surgery and in-hospital mortality. In the entire cohort, throughout the entire pandemic phase, rates of all of the three examined types of spinal procedures increased significantly. These shifts in surgical rates were associated with frailty only between waves 1 and 2 and during wave 3, each with increases among low frailty patients versus decreases among those with high frailty.

There were no associations between frailty and changes in in-hospital mortality rates, which increased significantly during all of the examined pandemic wave periods from ranges between 0.8% and 1.0% up to between 1.0% and 2.5%.

Discussion

This nationwide study among 59,130 patients undergoing treatment for spinal stenosis in German hospitals disclosed a noteworthy increase in frailty in all pandemic phases, except wave 5. In two phases (between waves 1 and 2; and in wave 3), there was a rise in rates of surgery among subject with low versus high frailty for all of the examined types of intervention. This is in line with previously published results from a more general nationwide cohort of patients with any form of spine disease in Germany, including spine infections and trauma, in which low frailty patients were at lower risk of surgery prior to versus during the pandemic[6].

Previous evidence identified increased rates of frailty and pre-frailty among patients with spinal stenosis compared to control groups without spinal stenosis[3,21]. In addition, symptom severity and clinical outcomes for patients with spinal stenosis are significantly influenced by frailty levels[3,21]. According to Kim et al., the connection between lumbar spinal stenosis and frailty can be attributed to the physical inactivity caused by symptomatic spinal stenosis resulting in reduced muscle strength[3]. This mechanism aligns with the rise in frailty observed during the pandemic, which may be caused by decreased physical activity due to pandemic-associated restrictions[4,5].

In our study cohort, during the pandemic, the rate of

Table 3. Baseline characteristics and corresponding interactions among frailty risk groups

	Wave 1			Between Waves 1 and 2			Wave 2			Wave 3			Wave 4			Wave 5		
	Pre	Pan	p[†‡]	Pre	Pan	p[†‡]	Pre	Pan	p[†‡]	Pre	Pan	p[†‡]	Pre	Pan	p[†‡]	Pre	Pan	p[†‡]
Daily admissions																		
Total cohort	53.7	31.2	< 0.01	54.7	45.6	0.02	52.9	42.2	< 0.01	54.9	45.4	0.02	52.2		0.08	55.9	46.6	0.03
HFRS groups																		
low	38.3	21.0	0.08	38.1	31.5	0.14	37.9	29.0	< 0.01	39.1	31.5	0.05	36.7	32.1	0.11	40.1	33.6	0.77
intermediate	12.6	7.9	0.28	13.6	11.1	0.12	12.5	10.3	0.02	12.9	10.9	0.11	12.8	11.2	0.13	13.0	10.6	0.60
high	2.9	2.3	ref	3.0	3.0	ref	2.5	2.8	ref	2.9	3.0	ref	2.7	2.9	ref	2.8	2.4	Ref
Age (mean, SD)																		
Total cohort	70.1 ±12.9	70.2 ±13.4	0.90	70.7 ±12.7	70.9 ±13.0	<0.63	70.4 ±12.9	70.2 ±12.9	0.47	70.4 ±12.8	70.0 ±12.9	0.05	70.7 ±12.8	71.1 ±12.7	0.06	70.2 ±12.8	70.2 ±12.7	1.00
HFRS groups																		
low	67.4 ±13.0	66.6 ±13.1	0.40	67.9 ±12.8	67.9 ±13.1	0.61	67.7 ±12.8	67.3 ±12.8	0.84	67.7 ±12.9	66.9 ±12.8	0.25	67.9 ±12.8	68.1 ±12.7	0.75	67.5 ±12.8	67.5 ±12.6	0.60
intermediate	75.9 ±10.2	76.2 ±10.8	0.90	76.5 ±10.2	76.5 ±10.4	0.69	76.5 ±10.7	75.8 ±10.9	0.59	76.3 ±10.0	76.0 ±10.5	0.63	76.6 ±10.5	76.9 ±10.1	0.84	76.2 ±10.2	76.3 ±10.5	0.58
high	81.5 ±6.6	82.0 ±8.3	ref	80.4 ±7.7	80.8 ±8.0	ref	80.5 ±8.6	80.3 ±9.0	ref	80.8 ±7.2	81.0 ±7.9	ref	80.5 ±8.4	80.9 ±8.4	ref	81.1 ±7.1	80.7 ±8.1	ref
Sex (% female)																		
Total cohort	53.5% (1,668)	51.8% (937)	0.24	55.5% (4,279)	52.7% (3,393)	< 0.01	53.7% (4,176)	52.8% (3,270)	0.27	55.0% (3,989)	53.0% (3,175)	0.02	54.2% (5,378)	54.3% (4,771)	0.91	54.4% (4,133)	54.3% (3,445)	0.96
HFRS groups																		
low	49.9% (1,107)	49.3% (601)	0.42	52.4% (2,815)	51.2% (2,276)	0.29	51.6% (2,873)	49.8% (2,125)	0.55	52.5% (2,710)	50.7% (2,107)	0.60	51.3% (3,578)	51.8% (3,166)	0.83	52.0% (2,831)	52.3% (2,390)	0.77
intermediate	62.9% (458)	56.9% (261)	0.90	62.6% (1,204)	56.0% (879)	0.65	58.3% (1,074)	58.3% (886)	0.89	61.3% (1,046)	57.5% (824)	0.30	61.1% (1,485)	59.4% (1,269)	0.38	60.4% (1,071)	59.4% (856)	0.96
high	61.7% (103)	56.4% (75)	ref	61.3% (260)	56.4% (238)	ref	62.1% (229)	62.6% (259)	ref	60.5% (233)	60.7% (244)	ref	60.8% (315)	62.0% (336)	ref	61.1% (231)	60.3% (199)	ref
Elixhauser CI (mean, SD)																		
Total cohort	3.8 ±9.2	5.2 ±10.1	< 0.01	4.2 ±9.6	4.9 ±9.9	< 0.01	4.0 ±9.4	4.6 ±9.8	< 0.01	3.9 ±9.4	4.9 ±10.2	< 0.01	4.1 ±9.5	4.7 ±9.9	< 0.01	3.8 ±9.3	4.1 ±9.4	0.08
HFRS groups																		
low	1.2 ±6.6	1.7 ±6.9	0.03	1.3 ±6.6	1.9 ±6.9	0.42	1.3 ±6.6	1.5 ±6.5	0.30	1.3 ±6.7	1.8 ±7.0	< 0.01	1.3 ±6.5	1.6 ±6.8	0.08	1.3 ±6.6	1.3 ±6.5	< 0.01
intermediate	8.6 ±11.2	10.2 ±11.2	0.29	9.1 ±11.2	9.8 ±10.9	0.62	9.2 ±11.0	9.6 ±11.1	0.55	8.6 ±11.2	9.8 ±11.6	0.13	9.2 ±11.1	9.6 ±11.0	0.15	8.7 ±11.3	9.3 ±11.1	< 0.01

Table 3. *(Cont. from previous page).*

	Wave 1			Between Waves 1 and 2			Wave 2			Wave 3			Wave 4			Wave 5		
	Pre	Pan	p†‡	Pre	Pan	p†‡	Pre	Pan	p†‡	Pre	Pan	p†‡	Pre	Pan	p†‡	Pre	Pan	p†‡
high	16,9 ±10,3	19.6 ±10.5	ref	18.3 ±12.5	19.3 ±12.3	ref	18.0 ±12.1	18.8 ±12.0	ref	17.3 ±11.6	19.5 ±12.3	ref	18.7 ±11.9	20.0 ±13.0	ref	16.8 ±11.6	19.1 ±11.7	ref

Pre, pre-pandemic; pan, pandemic; HFRS, Hospital Frailty Risk Score; †For the total cohort, statistical comparisons were conducted between pre-pandemic and pandemic values. ‡Between HFRS groups, changes between pre-pandemic and pandemic values were statistically compared with the high HFRS group as reference category. Percentages presented for category "sex" represent the proportion of female sex within each frailty group separately, which is why they do not add up to 100%.

Table 4. Rates of surgical procedures and in-hospital mortality.

	Wave 1			Between Waves 1 and 2			Wave 2			Wave 3			Wave 4			Wave 5		
	Pre	Pan	p†‡	Pre	Pan	p†‡	Pre	Pan	p†‡	Pre	Pan	p†‡	Pre	Pan	p†‡	Pre	Pan	p†‡
Decompressive surgery																		
Total cohort	37.6% (1,171)	40.1% (726)	0.026	35.0% (2,703)	40.6% (2,609)	<0.001	38.0% (2,957)	41.7% (2,584)	<0.001	36.4% (2,638)	42.4% (2,541)	<0.001	36.4% (3,607)	39.8% (3,501)	<0.001	37.7% (2,865)	44.0% (2,791)	<0.001
HFRS groups																		
low	44.7% (993)	51.6% (628)	0.229	42.4% (2,276)	50.5% (2,244)	0.030	46.0% (2,563)	51.9% (2,212)	0.317	43.6% (2,253)	52.1% (2,167)	0.009	44.2% (3,083)	48.4% (2,956)	0.631	45.0% (2,454)	52.8% (2,412)	0.926
intermediate	22.0% (160)	18.7% (86)	0.923	19.5% (376)	20.4% (320)	0.163	19.1% (352)	21.5% (327)	0.507	19.8% (338)	23.4% (335)	0.081	19.3% (469)	22.9% (490)	0.520	21.0% (372)	23.0% (332)	0.290
high	10.8% (18)	9.0% (12)	ref	12.0% (51)	10.7% (45)	ref	11.4% (42)	10.9% (45)	ref	12.2% (47)	9.7% (39)	ref	10.6% (55)	10.1% (55)	ref	10.3% (39)	14.2% (47)	ref
Resection of disc tissue																		
Total cohort	17.5% (546)	19.1% (345)	<0.018	16.0% (1,234)	18.7% (1,206)	<0.001	17.6% (1,365)	17.8% (1,102)	0.407	17.1% (1,239)	19.1% (1,144)	<0.001	16.6% (1,651)	18.8% (1,650)	<0.001	17.7% (1,345)	20.4% (1,294)	<0.001
HFRS groups																		
low	20.9% (463)	24.7% (301)	0.078	19.4% (1,041)	23.6% (1,050)	0.588	21.4% (1,192)	22.3% (949)	0.915	20.7% (1,066)	24.0% (998)	0.044	20.2% (1,411)	23.2% (1,414)	0.851	21.4% (1,166)	25.1% (1,145)	0.483
intermediate	10.2% (74)	8.9% (41)	0.236	9.1% (175)	8.7% (136)	0.933	8.5% (157)	8.9% (136)	0.713	9.0% (153)	9.3% (134)	0.084	9.1% (221)	10.2% (217)	0.842	9.2% (163)	9.4% (135)	0.785
high	5.4% (9)	2.3% (3)	ref	4.2% (18)	4.7% (20)	ref	4.3% (16)	4.1% (17)	ref	5.2% (20)	3.0% (12)	ref	3.7% (19)	3.5% (19)	ref	4.2% (16)	4.2% (14)	ref

Table 4. *(Cont. from previous page).*

	Wave 1			Between Waves 1 and 2			Wave 2			Wave 3			Wave 4			Wave 5		
	Pre	Pan	p†‡	Pre	Pan	p†‡	Pre	Pan	p†‡	Pre	Pan	p†‡	Pre	Pan	p†‡	Pre	Pan	p†‡
Spine fusion																		
Total Total cohort	14.7% (459)	16.6% (301)	0.003	14.4% (1,113)	16.9% (1,089)	< 0.001	15.2% (1,182)	17.3% (1,073)	< 0.001	14.9% (1,078)	18.5% (1,109)	< 0.001	14.6% (1,453)	17.6% (1,546)	< 0.001	14.9% (1,136)	20.1% (1,276)	< 0.001
HFRS groups																		
low	15.9% (353)	18.8% (229)	0.197	15.7% (844)	19.2% (855)	0.049	16.6% (926)	20.4% (870)	0.103	16.2% (837)	21.0% (875)	0.015	16.1% (1,125)	19.8% (1,210)	0.946	16.2% (882)	22.8% (1,043)	0.510
intermediate	12.6% (92)	13.9% (64)	0.271	11.8% (227)	12.6% (198)	0.140	12.1% (223)	11.4% (173)	0.510	11.8% (202)	14.2% (204)	0.027	11.7% (285)	13.4% (287)	0.872	12.4% (220)	13.7% (197)	0.878
high	8.4% (14)	6.0% (8)	ref	9.9% (42)	8.5% (36)	ref	8.9% (33)	7.2% (30)	ref	10.1% (39)	7.5% (30)	ref	8.3% (43)	9.0% (49)	ref	9.0% (34)	10.9% (36)	ref
In-hospital mortality rate																		
Total cohort	0.8% (23)	2.5% (44)	< 0.001	1.0% (75)	1.0% (61)	0.863	0.9% (70)	1.5% (86)	0.006	0.9% (61)	1.3% (74)	0.016	1.0% (93)	1.4% (116)	0.016	0.9% (64)	1.4% (87)	0.002
HFRS groups																		
low	0.0% (0)	0.4% (5)	0.475	0.2% (9)	0.0% (2)	0.093	0.2% (11)	0.1% (4)	0.060	0.1% (6)	0.1% (6)	0.743	0.2% (12)	0.2% (14)	0.482	0.1% (7)	0.3% (13)	0.705
intermediate	1.8% (12)	4.8% (20)	0.802	1.9% (34)	1.7% (24)	0.603	2.2% (38)	3.3% (46)	0.805	1.6% (26)	2.8% (37)	0.137	2.0% (45)	2.0% (39)	0.058	2.1% (34)	2.9% (39)	0.493
high	7.2% (11)	15.8% (19)	ref	8.4% (32)	8.9% (35)	ref	6.2% (21)	9.6% (36)	ref	8.3% (29)	8.4% (31)	ref	7.8% (36)	13.1% (63)	ref	6.7% (23)	11.9% (35)	ref

Pre, pre-pandemic; pan, pandemic; HFRS, Hospital Frailty Risk Score; †For the total cohort, statistical comparisons were conducted between pre-pandemic and pandemic values. ‡Between HFRS groups, changes between pre-pandemic and pandemic values were statistically compared with the high HFRS group as reference category. Percentages presented for treatment rates represent the proportion of each type of treatment within each frailty group separately, therefore not adding up to 100%.

comorbidities among spinal stenosis patients showed a higher relative increase among low frailty individuals in waves 1 and 3, and among high frailty patients in wave 5. This may be explained by reluctance of more comorbid high frailty patients to present to hospitals at the onset of the pandemic, while, at the end of wave 4, with nationwide SARS-CoV2 vaccination rates of up to 66,3%, this higher risk demographic may have been more willing to present to hospitals with spinal stenosis symptoms.

Previously, discussions on the alterations in the management of spine pathologies during the pandemic predominantly focused effects like reductions in case numbers and workforce constraints[21-23]. Surprisingly, the connections between the pandemic and shifts in frailty in subjects with spinal stenosis have not been thoroughly explored, even though the influence of frailty on outcomes is well-established, particularly following spine surgery[24-28]. The investigation of pandemic-related frailty dynamics in spinal stenosis patients is crucial, especially considering the rapid aging of the general population over recent decades[29]. The frequently reported link between frailty and the COVID-19 pandemic may well have contributed to the acceleration of this demographic trend.

Our results suggest a selection for spinal stenosis patients with poorer health conditions in hospitals during the pandemic. Considering that the actual diagnosis of COVID-19 was an absolute exception among the examined cohort of patients, it most likely may not have had sufficient direct impact on the frailty trends observed. Instead, it may more likely be associated with elevated frailty levels in the community as a consequence of the general response to the pandemic leading to restricted activity[4,5]. This may seem somewhat counterintuitive, given that one could have expected that, in order to avoid contact with COVID-19 patients, more frail individuals with spinal stenosis would have avoided hospitalization, being aware that older age and comorbidities are linked to poor outcomes in COVID-19 infection[12,30-32]. Nevertheless, our results do not imply an increase in frailty within individual patients over time but simply a trend towards increased proportions of frailty at the threshold of hospitals in Germany.

Another important finding from our study is a potential link between low frailty and increased risk of surgical interventions during the pandemic, particularly between waves 1 and 2 and in wave 3. Wave 3 produced the most prominent changes in surgical treatment between highly and mildly frail subjects. Notably, during the beginning of wave 3 in Germany, the SARS-CoV-2 vaccination rate in the general population was relatively low at 2.3%, versus 66.3% in the final stages of wave 4[33]. Such discrepancies in vaccination rates might have influenced decision making for or against surgical intervention during this period. The link between low frailty and increased surgical rates throughout the pandemic may also have been caused by more severe symptoms among low frailty patients during this time, making hospitalization unavoidable. Additionally, spinal surgeons may have more readily opted for surgery on the mildly frail, as those were less likely to require intensive care.

Our findings may aid physicians in understanding surgical decision making in spinal stenosis patients in Germany during potential future similar scenarios, based on various factors, such as patient characteristics, surgeon preferences, and pandemic-induced alterations in the healthcare environment in general.

The application of Enhanced Recovery After Surgery (ERAS) protocols, which have shown positive impacts on outcomes after spinal interventions, becomes particularly relevant in this context[34,35]. ERAS seeks to improve in-hospital management by enhancing various elements, including preoperative patient information, the surgical processes, and postoperative mobilization protocols. Given the reduced application of ERAS in other surgical disciplines during the COVID-19 pandemic, despite its unchanged positive effects on outcomes and treatment costs[36-38], our findings emphasize the importance for spinal surgeons to consider frailty in the treatment of spinal stenosis and may assist in refining treatment protocols and enhancing patient safety.

Several limitations of this study need to be mentioned. First, a certain degree of misclassification of diagnoses using ICD-10 and OPS codes cannot be ruled out. However, it is important to note that all codes were audited a rigorously prior to data inclusion. Another limitation is that administrative data, especially billing data, are not generated for scientific purposes, and may therefore not provide a comprehensive overview of care. Additionally, our database lacked variables on clinical outcomes beyond in-hospital mortality rates. Furthermore, the analysis is not able to detect any level of causality between the COVID-19 pandemic and spinal stenosis care. Also, due to the design of the study, we did not include any data on imaging or medication or beyond May 17, 2022. Finally, our findings may not be generalizable to other countries.

Conclusions

During the COVID-19 pandemic in Germany, patients hospitalized for spinal stenosis were significantly more frail, compared to pre-pandemic periods. Also, there was an increase in rates of surgical management among low-frailty spinal stenosis patients, while rates among high frailty patients remained unaltered or even decreased.

Ethics approval

Study approval was granted by the Ethics Committee of the University of Leipzig on February 7, 2022 (490/20-ek).

Authors' Contributions

HvR, ND and JD conceived the study. HvR, ND and JD wrote the first draft of the manuscript. SH conducted all statistical analyses. HvR, ND, JD, NA, HG, RK and AB were involved in data interpretation. All authors reviewed and edited the manuscript and approved the final version of the manuscript.

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