

Shift from inpatient to outpatient treatment in all age groups of anterior cruciate ligament surgery in Germany: An analysis of the public healthcare system

Dominik Szymski^{1,2}  | Werner Krutsch^{1,2,3} | Johannes Weber^{1,2} | Gero Knapp⁴ | Lorenz Huber^{1,2} | Nike Walter¹ | Christian Heiss⁴ | Volker Alt^{1,2} | Markus Rupp⁴

¹Department of Trauma Surgery, University Medical Centre Regensburg, Regensburg, Germany

²FIFA Medical Centre of Excellence, University Medical Centre Regensburg, Regensburg, Germany

³SportDocs Franken, Nuremberg, Germany

⁴Department of Trauma, Hand and Reconstructive Surgery, University Hospital Giessen, Giessen, Germany

Correspondence

Dominik Szymski, Department of Trauma Surgery, University Medical Centre Regensburg, Franz-Josef-Strauss Allee 11, 93053 Regensburg, Germany.
Email: dominik.szymski@ukr.de

Abstract

Purpose: Ruptures of the anterior cruciate ligament (ACL) are among the most common orthopaedic diagnoses with severe short- and long-term consequences for patients. The aim of the study was to analyze trends of inpatient and outpatient treatment of ACL injuries in Germany.

Materials and Methods: All ACL reconstructions in Germany in public health insurance patients between 2019 and 2024 were included. The data of the Institute for the hospital remuneration system (InEK) were used for inpatient cases, while data of the Central Institute for Statutory Health Insurance Physicians in Germany (ZI) were used for outpatient treatments.

Results: Between 2019 and 2024, a total of 242,423 operatively treated ACL ruptures were identified in Germany, corresponding to an overall annual incidence of 48.39 ± 6.63 per 100,000 inhabitants. While the overall incidence declined slightly by 5.5% over the study period, substantial shifts in treatment setting were observed: outpatient cases increased by 70.8%, whereas inpatient cases decreased by 26.8%. Across all age groups, inpatient incidence rates declined, especially among younger and middle-aged adults, while outpatient incidence increased significantly, most notably in working-age populations (18–65 years). The relative difference between inpatient and outpatient care narrowed over time (RR 4.99 in 2019 vs. 2.35 in 2024), indicating a pronounced shift towards outpatient management.

Conclusion: This nationwide move towards outpatient ACL reconstruction signifies a fundamental change in care delivery, offering potential benefits in efficiency and resource use. However, it also emphasizes the importance of careful patient selection, standardized perioperative protocols and ongoing

Abbreviations: ACL, anterior cruciate ligament; ANOVA, analysis of variance; CI, confidence interval; COVID-19, coronavirus disease 2019; Destatis, Federal Statistical Office of Germany; DRG, Diagnosis-Related Group; EQ-5D, EuroQol Five-Dimension Questionnaire; EQ-VAS, EuroQol Visual Analogue Scale; ESSKA, European Society of Sports Traumatology, Knee Surgery and Arthroscopy; GKV, Statutory Health Insurance (Gesetzliche Krankenversicherung); InEK, Institute for the Hospital Remuneration System (Institut für das Entgeltsystem im Krankenhaus); IRB, institutional review board; NCLR, Norwegian Cruciate Ligament Registry; OPS, German Procedure Classification (Operationen- und Prozedurenschlüssel); PKV, Private Health Insurance (Private Krankenversicherung); PTV, planning target volume; QoL, quality of life; RCT, randomized controlled trial; RR, rate ratio; SD, standard deviation; SGB, German Social Code (Sozialgesetzbuch); TTO, time trade-off; UK, United Kingdom; USA, United States of America; ZI, Central Institute for Statutory Health Insurance Physicians in Germany (Zentralinstitut für die kassenärztliche Versorgung).

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outcome monitoring to make sure clinical safety and effectiveness are maintained.

Level of Evidence: Level IV.

KEYWORDS

ambulatory, inpatient, insurance, outpatient, sports medicine, treatment

INTRODUCTION

Tears of the anterior cruciate ligament (ACL) are among the most frequent severe knee injuries [2] and represent a substantial public health concern. Beyond their individual clinical effects, ACL injuries place a significant strain on healthcare systems because of frequent surgeries, ongoing rehabilitation and long-term consequences like posttraumatic osteoarthritis [9]. Given their typical occurrence in physically active populations and younger age groups, ACL injuries may result in prolonged healthcare utilization and socioeconomic consequences [25].

Population-based incidence data are essential to quantify the burden of ACL injuries at a national level [22]. Sanders et al. reported an age- and sex-adjusted incidence of 68.6 ACL tears per 100,000 person-years in the United States [24]. However, epidemiological data may vary substantially between countries due to differences in demographics, sports participation, healthcare systems and reporting structures [1, 4, 15]. In Germany, comprehensive and up-to-date nationwide data covering both inpatient and outpatient treatment settings remain limited.

A detailed understanding of national ACL injury rates and treatment patterns is particularly relevant in light of ongoing structural changes in healthcare delivery, including the shift from inpatient to outpatient surgical management. Age-specific analyses may further help to identify high-risk groups and optimize prevention strategies and resource allocation.

Therefore, the aim of this study was (1) to present the nationwide incidence of surgically treated ACL injuries in Germany from 2019 to 2024, and (2) to compare inpatient and outpatient treatment patterns over this period, with a specific focus on age groups. We hypothesized that ACL reconstruction in Germany has undergone a structural transition towards predominantly outpatient care, marked by an increase in outpatient procedures across all age groups, a narrowing gap between treatment settings, and a stable or slightly declining overall surgical incidence.

MATERIALS AND METHODS

This retrospective analysis included all patients who underwent surgical treatment for ACL injury in Germany between January 2019 and December 2024.

Surgical procedures were identified using OPS codes corresponding to ACL reconstruction, suture, or augmentation techniques (Table 1). Inpatient cases were obtained from the Institute for the Hospital Remuneration System (InEK GmbH) and compared with outpatient cases from the Central Institute for Statutory Health Insurance Physicians in Germany (ZI).

The ZI database includes nationwide outpatient billing data in accordance with §295 of the German Social Code (SGB), covering patients insured under the statutory health system who received outpatient treatment for a diagnosed ACL rupture. Outpatient cases were identified based on the presence of a corresponding procedural code in the quarter of diagnosis or the following quarter (Table 1). Simultaneously, the InEK data set encompassed all statutorily insured patients who underwent inpatient surgical treatment for ACL rupture identified by an appropriate diagnostic and procedural code (Table 1). Public health insurance covers 74.26 million residents, representing 90% of the German population in 2024 [5]. Since the study used anonymized data from a centralized administrative database, there was no need for informed consent or IRB approval.

Statistical analysis

Inpatient and outpatient data were analyzed for patients between 2019 and 2024, focusing on total case

TABLE 1 The table lists OPS codes and their corresponding medical procedures.

OPS codes	Surgical procedure
5-813.0	Suture of the ACL
5-813.3	Reconstruction of the ACL with autologous patellar tendon
5-813.4	Reconstruction of the ACL with any other autologous tendon
5-813.5	Reconstruction of the ACL with alloplastic tendon
5-813.g	Reconstruction of the ACL with allogeneic tendon
5-813.j	Augmentation of the ACL

Abbreviations: ACL, anterior cruciate ligament; OPS, German Procedure Classification (Operationen- und Prozedurenschlüssel).

numbers, incidence, demographic details, costs, and hospital days. The data are presented as absolute and relative frequencies. Rate ratios (RRs) were calculated as the ratio of aggregated incidence rates (per 100,000 inhabitants) between predefined groups and time periods to quantify relative differences in inpatient versus outpatient care and age-specific trends. The incidence was calculated based on Germany's historical population provided by Destatis (Federal Statistical Office of Germany). Proportions between groups were compared using Fisher's exact test, and continuous variables using the *t*-test. Data collection was performed using Microsoft® Excel v16.85 (Microsoft Corporation), and statistical analyses and figure design were conducted using GraphPad Prism v10.2.2 (GraphPad Software).

Parts of the underlying administrative data set have previously been reported in a short communication addressing overall administrative prevalence of surgically treated ACL injuries in Germany [27]. The present study substantially extends this prior work by providing age-stratified incidence analyses, RRs and a detailed assessment of temporal shifts between inpatient and outpatient treatment settings.

RESULTS

A total of 242,423 surgically treated ACL ruptures were identified in Germany between 2019 and 2024, including 62,243 outpatient and 180,180 inpatient cases. The overall annual incidence was 48.39 ± 6.63 per 100,000 inhabitants and declined slightly by 5.5% over the study period. A marked shift in treatment setting was observed. While inpatient cases decreased by 26.8%, outpatient cases increased by 70.8%, resulting in 23.6% of all procedures being performed in an outpatient setting. This trend was particularly evident in younger and working-age populations (Figures 1 and 2, Table 2).

Across all age groups, inpatient incidence rates declined, whereas outpatient incidence increased consistently. The greatest relative changes were observed in young and middle-aged adults, while rates in older patients remained largely stable. Detailed age-specific incidence data are presented in Tables 2 and 3.

Temporal trends showed a pronounced decline in ACL surgery rates between 2019 and 2021, with the lowest levels observed during the COVID-19 pandemic. From 2022 onwards, incidence increased again across all groups; however, by 2024, inpatient rates remained below baseline levels, whereas outpatient rates exceeded those observed in 2019 in most age categories. The relative difference between inpatient and outpatient care decreased over time, reflecting a progressive convergence of treatment settings.

In inpatient cases, the mean length of hospital stay decreased from 2.8 to 2.1 days between 2019 and 2024, without reaching statistical significance ($p = 0.783$) (Figure 3).

Across all years, inpatient care was associated with substantially higher incidence rates than outpatient care, although this difference decreased over time (RR 4.99 in 2019 vs. 2.35 in 2024; cumulative RR 3.45 for 2019–2024). From 2019 to 2024, outpatient incidence increased markedly (RR 1.72), whereas inpatient incidence declined (RR 0.81), indicating a clear shift in patterns of care. Younger patients consistently showed higher incidence rates than older patients in both settings, with age-related gradients over time (outpatient RR < 35 vs. > 35 years: 3.01 in 2019 and 2.90 in 2024; inpatient RR < 39 vs. > 40 years: 3.26 in 2019 and 2.76 in 2024). Notably, the ratio of outpatient to inpatient care increased in both younger and older patients between 2019 and 2024, reflecting a pronounced shift towards outpatient management across age groups (Table 4).

DISCUSSION

In this retrospective analysis of 242,423 surgically treated ACL cases, a decreasing trend in inpatient treatment was observed, while an increasing number of outpatient treatment cases were evidenced. The latter demonstrated growth of over 70% within a 6-year observation period in Germany.

The incidence of surgically treated ACL injuries decreased by 5.5%. The trend of a decreasing incidence in Germany could be associated with a constantly ageing population, while ACL injuries are mostly sports injuries in pivot-shifting sports [2, 26]. A similar pattern can be observed in Norway, analyzing the compensation claims in the Norwegian cruciate ligament registry (NCLR) between 2005 and 2015. From 2010, a slight reduction in overall treated cases was also reported here [21]. However, worldwide, Dubé et al. described a 'global sporting epidemic' with rising incidence of ACL injuries and a high number of outpatient-treated patients [6, 18].

We identified in Germany a growth of 70.8% between 2019 and 2024 for outpatient-treated ACL injuries, while inpatient treatments were reduced during the same period. This trend of increased number of outpatient treatments is also reported in several other countries worldwide [17, 23]. This trend was most pronounced among younger and working-age populations, who consistently exhibited the highest incidence rates and the strongest relative movement towards outpatient treatment. In addition to structural and economic drivers, alternative explanations for the observed trends should be considered. Changes in surgical indication thresholds may have contributed to the

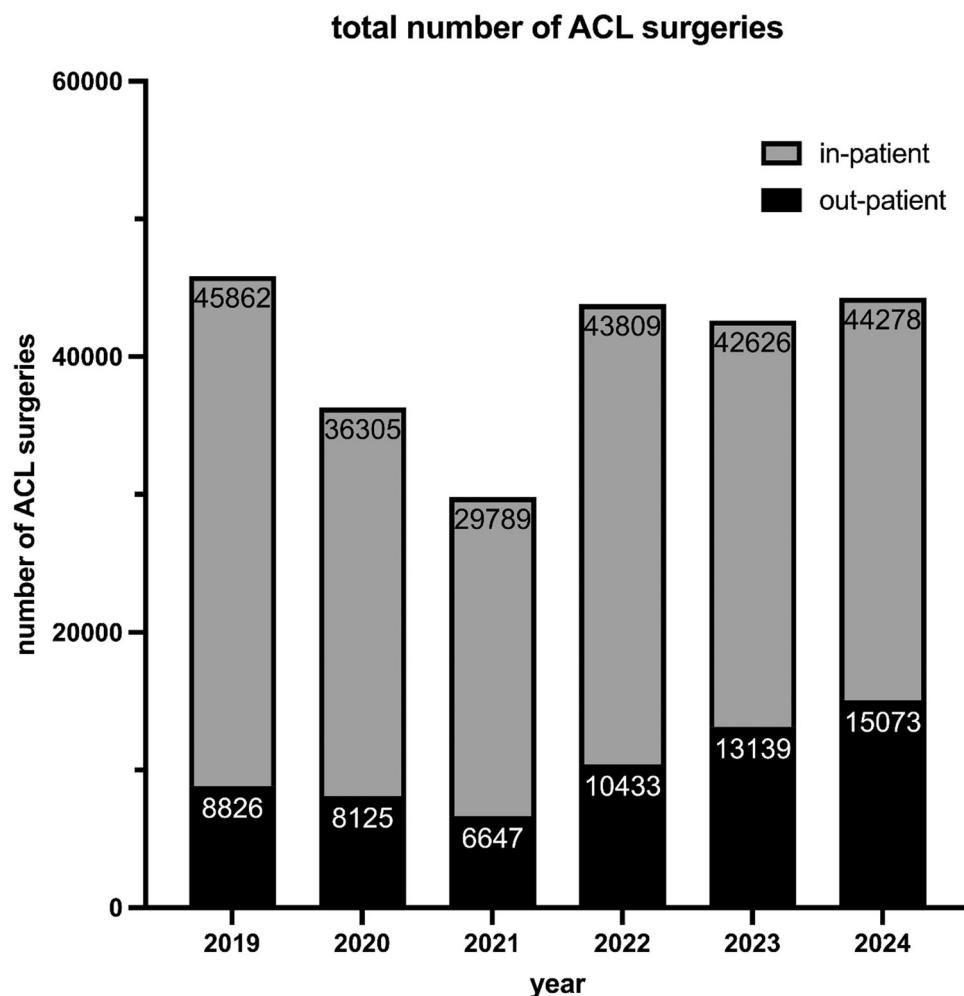


FIGURE 1 Inpatient and outpatient cases of surgically treated ACL patients between 2019 and 2024 in Germany. ACL, anterior cruciate ligament.

declining inpatient incidence, particularly in older patients, where conservative management strategies are increasingly favoured due to lower functional demands and higher comorbidity burden [14]. Recent evidence suggests that non-operative treatment can provide satisfactory outcomes in selected patient populations, which may have influenced clinical decision-making over time [11, 13]. In parallel, improvements in perioperative pathways and surgical techniques have facilitated outpatient treatment for appropriately selected patients, thereby reinforcing the observed shift. In addition to governmental and structural changes in healthcare systems promoting ambulatory care, advances in surgical techniques and perioperative management have made outpatient ACL reconstruction increasingly feasible and safe [9, 10]. A similar pattern was already found previously in the United States with an increasing number of outpatient treatments and a decrease in inpatient cases and an overall increase of surgical volume by 37% between 1997 and 2006 [3]. However, the COVID-19 pandemic was also a driver

towards outpatient treatment due to restrictions on inpatient elective surgeries [12, 20].

In addition, surgical complexity and appropriate patient selection remain important considerations when determining the treatment setting [7]. The narrowing RRs between inpatient and outpatient care over time support the interpretation of a sustained transformation in treatment pathways rather than a temporary effect [10, 29]. Notably, stable age-related gradients suggest that patient selection patterns remained largely consistent, with younger patients continuing to represent the majority of surgically treated ACL ruptures [19].

International data demonstrate that the shift towards outpatient ACL reconstruction is not unique to Germany. In the United States, the proportion of ACL reconstructions performed in an outpatient setting increased dramatically from approximately 43% in 1994 to about 95% by 2006, reflecting longstanding ambulatory care models and economic incentives in the US healthcare system [17]. This trend has been mirrored in other settings, with same-day or outpatient

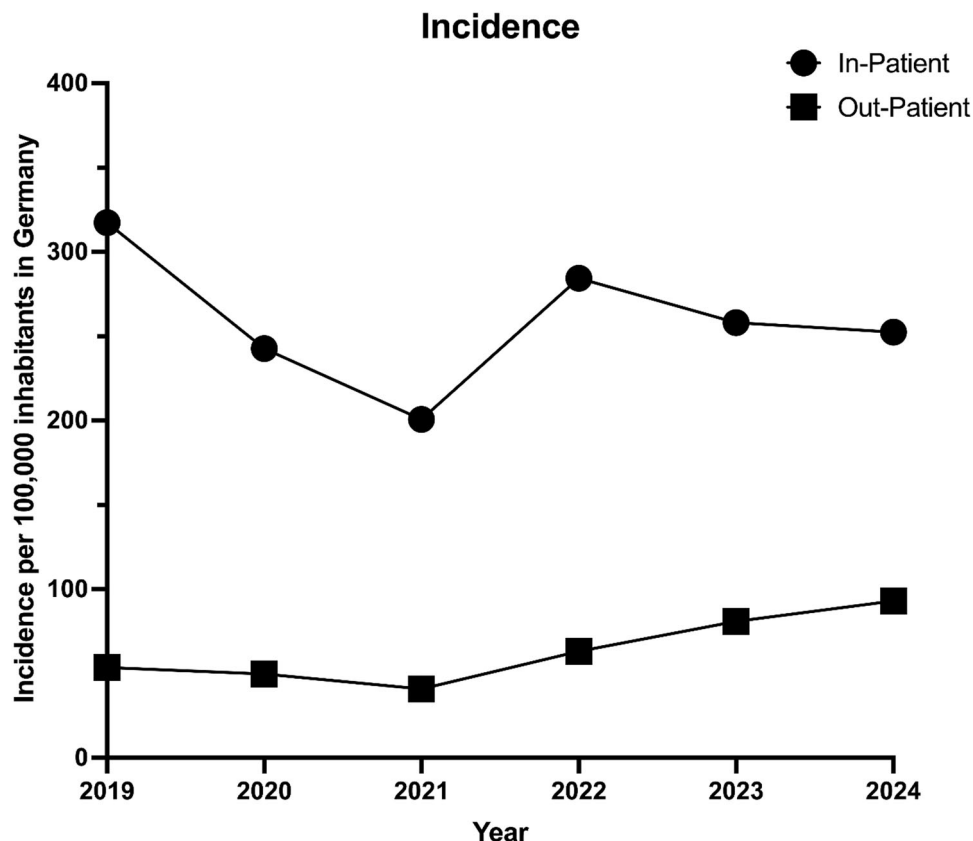


FIGURE 2 Incidence per 100,000 inhabitants in Germany for inpatient and outpatient ACL surgeries. ACL, anterior cruciate ligament.

TABLE 2 Absolute number and trend of ACL reconstructions of inpatient and outpatient cases in Germany.

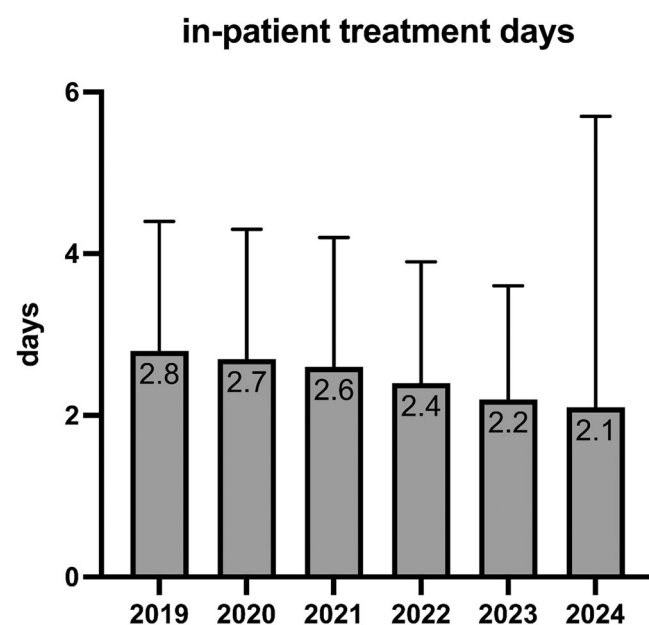
Age	2019	2020	2021	2022	2023	2024	Growth rate for number of surgeries between 2019 and 2024
Inpatient							
<18	3389	2396	1900	3084	2882	2718	−19.8%
18–29	16,139	11,488	9840	14,358	12,560	11,848	−26.6%
30–39	8115	6449	5465	7640	7340	7128	−12.2%
40–49	5570	4504	3377	4729	4431	4370	−21.5%
50–64	3663	3230	2470	3441	2156	2796	−23.7%
≥65	126	118	93	127	122	118	−6.4%
Outpatient							
<18	467	437	376	608	718	785	68.1%
18–34	5443	4666	3995	6532	8048	9027	65.9%
35–49	2043	2090	1621	2304	3169	3983	95.0%
50–64	825	879	606	944	1135	1219	47.8%
≥65	48	53	49	45	69	59	22.9%

Abbreviation: ACL, anterior cruciate ligament.

TABLE 3 Incidence for age groups in Germany for surgically treated inpatient and outpatient ACL ruptures per 100,000 inhabitants per year with growth rate.

Age	2019	2020	2021	2022	2023	2024	Growth rate for incidence between 2019 and 2024
Inpatient							
<18	24.78	17.43	13.71	21.65	20.62	19.7	−20.5%
18–29	142.4	103.74	89.56	128.71	115.12	108.61	−23.7%
30–39	75.6	59.3	50.2	68.88	67.02	65.71	−13.1%
40–49	54.72	44.72	33.78	46.41	43.13	42.24	−22.8%
50–64	19.18	16.89	12.96	18.1	11.57	15.56	−18.9%
≥65	0.7	0.65	0.5	0.68	0.65	0.68	−2.9%
Outpatient							
<18	3.42	3.18	2.71	4.27	5.14	5.62	64.3%
18–34	32.34	28.02	24.16	39.04	49.44	55.72	72.3%
35–49	13.2	13.61	10.57	14.68	19.98	24.78	87.7%
50–64	4.32	4.6	3.18	4.96	6.09	6.66	54.2%
≥65	0.27	0.29	0.27	0.24	0.37	0.31	14.8%

Abbreviation: ACL, anterior cruciate ligament.

**FIGURE 3** Days of inpatient treatment of patients after ACL injury between 2019 and 2024. ACL, anterior cruciate ligament.

procedures accounting for the vast majority of ACL surgeries in many high-income healthcare systems, supported by advances in minimally invasive techniques and optimized perioperative care [8].

Concerning outcome parameters after the surgical treatment, Valkering et al. found no difference in post-operative pain or functional outcome within a 1-year

TABLE 4 Rate ratio (RR) for treatment sector and different age groups for ACL surgeries in Germany between 2019 and 2024.

	RR
Year 2019 inpatient vs. outpatient	4.99
Year 2024 inpatient vs. outpatient	2.35
Cumulative 2019–2024 inpatient vs. outpatient	3.45
Outpatient cases 2024 vs. 2019	1.72
Inpatient cases 2024 vs. 2019	0.81
Outpatient cases <35 vs. >35 years in 2019	3.01
Outpatient cases <35 vs. >35 years in 2024	2.90
Inpatient cases <39 vs. >40 years in 2019	3.26
Inpatient cases <39 vs. >40 years in 2024	2.76
Younger patients outpatient vs. inpatient in 2019 ^a	0.22
Younger patients outpatient vs. inpatient in 2024 ^a	0.48
Elderly patients outpatient vs. inpatient in 2019 ^a	0.24
Elderly patients outpatient vs. inpatient in 2024 ^a	0.54

Abbreviation: ACL, anterior cruciate ligament.

^aYounger patients = outpatient <35 years; inpatient <40 years; elderly patients = outpatient >35 years; inpatient >40 years.

follow-up between inpatient and outpatient treatment [28]. Further investigations identified a significant reduction in pain on the first and third days after surgery in outpatients, while in the long-term follow-up, no differences were reported [8]. Strength and knee

function were similar between inpatient and outpatient treatment, as well as similar rates of complications [8]. Patient selection is an important aspect in decision-making between inpatient and outpatient treatment. In a short-term period, an increased rate of post-operative complications was reported for inpatient treated patients [16]. However, the selection of patients needs to be considered here: Mainly, patients with higher risk for complications are treated as inpatients.

Between inpatient and outpatient ACL reconstructions, a difference of €4043.53 was reported in a previous analysis [27]. In outpatient treatment Ferrari et al. demonstrated in their meta-analysis cost savings of \$1371–\$7390, which represents relevant cost savings for the healthcare system with similar or better pain and functional outcomes [8]. In a further systematic review on economic analysis of ACL reconstructions, Saltzmann et al. reported a significant reduction in outpatient treatment. Additionally, the use of hamstring or bone patellar tendon bone graft in a single-bundle technique was identified as cost-effective with similar outcomes [23]. From a health-system perspective, the observed shift towards outpatient management has important implications for resource allocation, quality assurance and training in sports orthopaedics. As outpatient ACL reconstruction becomes increasingly dominant, ensuring standardized care pathways, outcome monitoring, and appropriate case selection will be essential to maintain treatment quality and patient safety across healthcare settings.

From a clinical perspective, the shift towards outpatient ACL reconstruction has important implications for patient care and healthcare organization. As ambulatory surgery becomes more common, careful patient selection remains crucial to ensure safety, especially in individuals with higher surgical complexity or more health issues. Standardized perioperative protocols, including optimized pain management, early mobilization and structured rehab plans, are vital to maintaining treatment quality in an outpatient setting. Additionally, the growing reliance on ambulatory care underscores the need for effective postoperative monitoring and clear follow-up strategies to quickly detect potential complications.

Although this study benefits from a large nationwide data set, several limitations must be acknowledged. First, the use of administrative billing data does not allow for the assessment of the true incidence of ACL injuries, as only surgically treated cases were captured. Conservative management could not be reliably identified due to limitations in diagnostic coding without associated procedural codes; therefore, the reported incidence reflects treatment patterns rather than the actual epidemiology of ACL injuries.

Second, the validity of the findings depends on the accuracy and consistency of coding within the underlying databases. Differences between inpatient and

outpatient data sets (InEK and ZI) were addressed by combining both sources; however, variations in coding practices and data structure may still introduce bias. In addition, surgically treated re-ruptures could not be reliably distinguished from primary procedures due to similar procedural coding.

Third, the administrative nature of the data sets does not permit assessment of relevant clinical outcomes such as early postoperative complications, infection rates, hospital readmissions or opioid consumption. These parameters are essential to evaluate the safety and appropriateness of the observed shift towards outpatient ACL reconstruction. Consequently, while our results demonstrate a clear structural change in treatment pathways, no direct conclusions can be drawn regarding the comparative safety or clinical effectiveness of inpatient versus outpatient care.

Furthermore, age group definitions differed between the inpatient and outpatient data sets due to variations in data structure, which may limit direct comparability. In addition, the analysis included only patients covered by statutory health insurance, representing approximately 90% of the German population; thus, the findings may not be fully generalizable to privately insured patients or the entire population.

Finally, cost analyses were not performed within the present study, as these have been addressed in previous work [27]. Future prospective studies and registry-based analyses incorporating detailed clinical outcomes and comprehensive patient-level data are required to better understand the true epidemiology of ACL injuries and the clinical impact of the ongoing shift towards outpatient care.

CONCLUSION

A marked nationwide shift from inpatient to outpatient ACL reconstruction occurred in Germany between 2019 and 2024, characterized by a substantial increase in outpatient procedures and a decline in inpatient care across all age groups. This transition reflects a fundamental change in healthcare delivery, suggesting improved efficiency while emphasizing the importance of appropriate patient selection and standardized perioperative management to maintain clinical safety and effectiveness.

AUTHOR CONTRIBUTIONS

Dominik Szyski: Conceptualization; data curation; formal analysis; investigation; methodology; visualization; writing—original draft. **Werner Kruttsch:** Data curation; supervision; writing—original draft. **Johannes Weber:** Resources. **Gero Knapp:** Methodology; resources. **Lorenz Huber:** Formal analysis, methodology, visualization. **Nike Walter:** Data curation; methodology; writing—original draft. **Christian Heiss:**

Project administration; supervision. **Volker Alt:** Project administration; supervision. **Markus Rupp:** Conceptualization; investigation; project administration; supervision; writing—original draft.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

ETHICS STATEMENT

The authors have nothing to report.

ORCID

Dominik Szymiski  <https://orcid.org/0000-0002-1739-8524>

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