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Original Article

Weekday Variation in Fee-for-Service Reimbursement for Hip Fracture Surgery in Japan: A Multicenter Retrospective Cohort Study Using DPC Administrative Data

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Abstract

Background: Temporal variation in healthcare delivery is well documented, yet its implications for financing under hybrid payment systems remain unclear. Weekday differences in care processes may generate payment variation without corresponding outcome differences, raising efficiency and equity concerns. We examined weekday variation in per-diem reimbursement after hip fracture surgery under Japan's Diagnosis Procedure Combination (DPC) system and whether it was accompanied by clinical-outcome differences.

Methods: We conducted a multicenter retrospective cohort study using nationwide DPC data from 185 acute care hospitals in Japan (April 2014–July 2025), including patients undergoing open reduction and internal fixation (ORIF) or hemiarthroplasty for proximal femoral fracture. The exposure was day of surgery (Monday–Friday); the primary outcome was per-diem fee-for-service (FFS) reimbursement (an FFS equivalent valuation of services, not realized revenue). Multivariable linear regression with cluster-robust standard errors, clustered at the hospital level, was fitted separately by procedure, adjusting for patient and admission characteristics. We assessed weekday patterns and a prespecified Monday–Friday comparison.

Results: Of 41 362 patients analyzed (ORIF, n = 25 779; hemiarthroplasty, n = 15 583), per-diem reimbursement showed a consistent weekday pattern, highest on Friday in both groups. Compared with Friday, Monday surgery was associated with lower adjusted per-diem reimbursement in both ORIF (β = −578.1 JPY; 95% CI, −1021.7 to −134.6; $P = .010$) and hemiarthroplasty (β = −736.4 JPY; 95% CI, −1389.5 to −83.2; $P = .027$). Surgery- and anesthesia-related services showed the largest Friday–Monday differences, whereas diagnostic testing differed minimally. Length of stay and recorded clinical indicators (discharge functional status and 7- and 28-day readmission) were broadly similar across weekdays.

Conclusion: Weekday variation in reimbursement was observed alongside broadly similar measured clinical indicators, suggesting that routine differences in care processes may be associated with reimbursement differences under hybrid financing systems. Routine monitoring of temporal payment patterns may help align reimbursement design more closely with observed care delivery.

Keywords: Hip Fractures, Fee-for-Service, Healthcare Costs, Delivery of Healthcare, Hospital Administration, Administrative Claims Data

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Background

Hip fracture is one of the most common and serious injuries among older adults and represents a major public health and health system challenge in aging societies. Patients with hip fracture typically require urgent surgical intervention, prolonged hospitalization, and intensive multidisciplinary care, resulting in substantial healthcare expenditures and consumption of medical resources. In addition to its impact on mortality and functional decline, hip fracture care imposes a considerable burden on healthcare systems because of its high incidence, prolonged length of stay, and frequent need for postoperative rehabilitation and long-term care services.[1,2]

Accordingly, improving the quality of care for patients with hip fracture should be considered not only in terms of clinical outcomes but also with respect to healthcare efficiency and resource allocation. From a health systems perspective, quality of care encompasses outcomes, patient experience, and costs, and unwarranted variation in care delivery that is not explained by patient severity or clinical need may indicate inefficiencies and opportunities for quality improvement.[3-5]

Previous studies have examined temporal variations in healthcare delivery, including weekend and day-of-week

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Key Messages

Implications for policy makers

- Hybrid payment systems can generate systematic reimbursement differences by day of surgery even when measured clinical indicators—functional status at discharge and 7- and 28-day readmission—are similar, a pattern that may reflect differences in care processes rather than differences in patient need.
- Monitoring "process-sensitive" indicators (eg, perioperative service intensity and scheduling around weekends) alongside outcomes may help regulators and payers identify sources of variation that are not apparent when evaluation focuses on mortality or complications alone.
- Hospitals and payers should review peri-weekend operating room and anesthesia workflows (eg, staffing configurations, timing of billable services, and cross-weekend coordination) to better understand variation in fee-for-service (FFS) billing patterns.
- Standardized perioperative pathways across weekdays—including clear protocols for peri-weekend service delivery—may improve efficiency and benchmarking fairness without compromising patient safety.
- Administrative claims data can be leveraged for routine surveillance of temporal variation to support targeted quality-improvement and payment-policy refinements in aging societies.

Implications for the public

When someone breaks a hip, the timing of surgery can influence not only care processes but also how hospitals are paid. Using a large Japanese hospital claims database, we found that operations performed on Fridays tended to generate higher daily fee-for-service (FFS) payments than those performed on Mondays, even though the measured clinical indicators were broadly similar. This suggests that hospitals may deliver and bill for certain perioperative services differently depending on the day of the week, especially around the weekend period. Understanding and reducing these timing-related differences may help hospitals provide more consistent care and use resources more efficiently. Ultimately, improving consistency in perioperative routines across weekdays could contribute to more sustainable healthcare financing while maintaining safe care for older patients.

effects, suggesting that organizational factors such as staffing levels, availability of diagnostic services, and care coordination may influence patient outcomes and processes of care.[6-8] However, findings regarding clinical outcomes have been inconsistent, and most existing studies have focused primarily on endpoints such as mortality and complications, with relatively limited attention paid to healthcare resource utilization or reimbursement-related outcomes. Moreover, studies from other healthcare systems have demonstrated substantial variation in hospital costs for hip fracture surgery that is not fully explained by patient outcomes, underscoring the importance of examining system-level drivers of resource utilization and financing.[9]

Despite growing interest in temporal variation in healthcare delivery, important gaps remain. Few studies have investigated whether the day of surgery is associated with differences in healthcare resource utilization or reimbursement structure among patients undergoing similar procedures. Understanding such differences is critical, as variations in resource use that are not explained by patient characteristics may reflect system-level processes rather than differences in clinical need.[10,11] This gap is particularly evident in healthcare systems operating under diagnosis-related group–based reimbursement schemes. In Japan, the Diagnosis Procedure Combination (DPC) system combines bundled payments with fee-for-service (FFS) components, enabling detailed assessment of daily healthcare utilization and reimbursement.[12,13] However, empirical evaluation of weekday differences—such as Monday versus Friday surgery—in per-diem FFS reimbursement and the composition of billable medical services remains limited, especially for high-burden conditions such as hip fracture. These questions are particularly relevant for policy-makers seeking to align payment systems with efficient and equitable care delivery in aging health systems.

Therefore, this study aimed to examine weekday variation in per-diem FFS reimbursement and healthcare resource utilization among patients with hip fracture, using nationwide DPC administrative data. Analyses were stratified by surgical procedure (open reduction and internal fixation [ORIF] and hemiarthroplasty). We hypothesized that end-of-week surgery would be associated with higher per-diem FFS reimbursement than early-week surgery, not because of worse clinical outcomes, but because of differences in care processes and healthcare delivery structures across the peri-weekend period. By clarifying the contribution of specific categories of FFS billable medical services, this study was expected to provide insights into system-level factors influencing healthcare efficiency and to inform strategies for optimizing resource allocation without compromising quality of care.

Methods

Study Design and Setting

This was a nationwide retrospective observational study using administrative hospital data from acute care hospitals in Japan.

This study characterized weekday variation in healthcare resource utilization and reimbursement across all weekday (Monday–Friday) surgeries. Throughout, "weekday cohort" denotes all patients whose surgery was performed on a weekday, analyzed together within each procedure group, and "weekday pattern" refers to the trend in the outcome across the five weekdays. After describing this across-weekday pattern, we conducted a prespecified contrast between Monday and Friday—the days anchoring the workweek—rather than restricting the cohort to those two days.

The analytic framework focused on healthcare resource utilization and reimbursement structure rather than clinical outcomes. This study followed a prespecified analytic protocol using routinely collected administrative data. The study period spanned from April 2014 to July 2025.

Data Sources

We used a nationwide administrative database based on the DPC system, applied in acute care hospitals in Japan. The DPC system combines per-diem bundled payments with itemized FFS components and captures diagnoses, procedures, daily services, and reimbursement information. Under the DPC system, a case-mix–based per-diem bundled payment covers hospitalization, basic nursing, and most laboratory tests, imaging, and drugs, whereas designated high-cost and procedural services—principally surgery, anesthesia, certain materials and devices, and specified drugs—are reimbursed separately on an FFS basis outside the bundle. For hip fracture surgery, the main FFS components are surgical procedures, anesthesia, materials and devices, medications, and selected procedures, imaging, and laboratory tests billed outside the bundle. Because these FFS services are billed on the day they are delivered, differences across weekdays in the timing, staffing, and content of perioperative care can shift the FFS billable amount even when the bundled per-diem payment is unchanged.

The database has been widely used in health services research, and prior validation studies have demonstrated acceptable accuracy for diagnoses, procedures, and healthcare utilization variables.[12,13] Although DPC data are primarily collected for reimbursement purposes, standardized national coding rules and periodic reimbursement audits support data consistency across hospitals. The structure of the DPC system provides a unique opportunity to evaluate how financing mechanisms interact with routine care delivery.

In this study, additional screening procedures were applied to exclude records with missing or inconsistent key variables to further enhance analytic validity.

Study Population and Selection Criteria

The study population consisted of patients admitted for proximal femoral fracture who underwent surgical treatment during the study period. Eligible cases were identified from the DPC Major Diagnostic Category diagnosis code 160800 (fracture of the hip and proximal femur) recorded in the Form 1 file, combined with the principal surgical procedure recorded in the Form 1 and EF files: Japanese K-procedure code K0461 (ORIF of the femur), or K0811 (prosthetic head replacement [hemiarthroplasty]). Only the first eligible operation per admission was analyzed. Patients aged under 18 years and same-day (day-case) discharges were excluded. To ensure data quality and comparability, analyses were restricted to acute care hospitals that continuously submitted DPC data and met predefined data completeness criteria.

Cases were excluded if they did not meet the diagnostic or procedural definitions of interest, had missing or inconsistent key variables, or could not be reliably classified with respect to the day of surgery or per-diem FFS reimbursement. These selection criteria were applied uniformly across hospitals to minimize misclassification and ensure consistency of case identification. Records with missing or logically inconsistent values in the fields required to define the analytic cohort—day of surgery, diagnostic and procedural codes, and per-diem FFS reimbursement—were excluded rather than imputed, and no value imputation was performed. The 2865 weekday records excluded for this reason (6.5% of eligible weekday surgeries) comprised cases with missing or logically inconsistent values in one or more of these cohort-defining fields; residual missingness in individual patient-level covariates within the analytic cohort was limited and is reported in Table 1; the number of records excluded at each stage is shown in the study flow diagram (Supplementary file 1, Figure S1).

The analytic cohort included all eligible weekday surgeries (Monday–Friday), enabling evaluation of temporal patterns across the workweek.

After applying all inclusion and exclusion criteria, the final analytic cohort comprised patients treated in 185 hospitals. The analytic cohort represented a census of all eligible patients treated at participating hospitals during the study period; therefore, no formal sample size calculation was performed. The detailed case selection process is presented in a supplementary flow diagram.

Exposure

The primary exposure was day of surgery within the weekday cohort (Monday–Friday).

Surgery day was defined based on the calendar day on which the definitive operative procedure for proximal femoral fracture was performed.

A prespecified comparison between Monday and Friday was conducted following assessment of weekday patterns.

Outcomes

Primary outcome. The primary outcome was per-diem FFS reimbursement, defined as the total FFS reimbursement for the index hospitalization (the FFS equivalent valuation of the entire admission recorded in the DPC data, corresponding to the total FFS reimbursement row in Table 2) divided by the length of stay in days (Japanese yen per day). It was analyzed as a continuous variable. Throughout this study, per-diem FFS reimbursement denotes the FFS equivalent monetary valuation of the services provided during the admission, as scored under Japan's national FFS fee schedule; it is used in this sense throughout the manuscript and does not represent realized net hospital revenue, which also depends on the bundled per-diem component and on hospital-specific adjustment coefficients. Secondary outcome. The secondary outcome was the composition of FFS reimbursement, disaggregated into major service components (surgical procedures, anesthesia-related services, imaging, laboratory testing, medications, materials, and other billable medical services); each component was expressed as a FFS billable amount (yen), that is, the itemized amount reimbursed outside the DPC per-diem bundle; the sum of these component billable amounts (the FFS billable amount row in Table 2) is a distinct and smaller quantity than the total FFS reimbursement used as the numerator of the primary outcome, and each component was compared between Monday and Friday. Descriptive clinical indicators. Clinical indicators available in the database—length of stay, discharge functional status (Barthel Index and Japan Coma Scale [JCS] at discharge), and readmission within 7 and 28 days—were

Table 1. Patient Characteristics by Day of Surgery

Variable	Category	ORIF Monday (N = 5266)	ORIF Friday (N = 5580)	ORIF *P*[a]	ORIF *P*[b]	Hemi Monday (N = 3056)	Hemi Friday (N = 3328)	Hemi *P*[a]	Hemi *P*[b]	Missing, n (ORIF/Hemi)
Sex	Male	1255 (23.8%)	1324 (23.7%)	.910	.839	785 (25.7%)	866 (26.0%)	.760	.716	0/0
	Female	4011 (76.2%)	4256 (76.3%)			2271 (74.3%)	2462 (74.0%)			
Admission source	Home	4055 (77.0%)	4240 (76.0%)	.235	.098	2434 (79.7%)	2568 (77.2%)	.068	.246	0/0
	Referred from another hospital	346 (6.6%)	423 (7.6%)			225 (7.4%)	297 (8.9%)			
	Nursing/long-term care facility	851 (16.2%)	907 (16.2%)			391 (12.8%)	457 (13.7%)			
	Other	14 (0.2%)	10 (0.2%)			6 (0.2%)	6 (0.2%)			
Admission type	Elective	146 (2.8%)	207 (3.7%)	.006*	.007	160 (5.2%)	196 (5.9%)	.256	.281	4/3
	Emergency	5120 (97.2%)	5373 (96.3%)			2896 (94.8%)	3132 (94.1%)			
Consciousness at admission (JCS)	I	494 (9.4%)	458 (8.2%)	.016*	.007	257 (8.4%)	286 (8.6%)	.987	.822	7/5
	II	364 (6.9%)	456 (8.2%)			200 (6.5%)	213 (6.4%)			
	III	287 (5.5%)	290 (5.2%)			121 (4.0%)	134 (4.0%)			
	Alert	4121 (78.3%)	4376 (78.4%)			2478 (81.1%)	2695 (81.0%)			
Pressure injury at admission	Present	12 (0.23%)	3 (0.05%)	.015*	—	1 (0.03%)	1 (0.03%)	.986	—	—
Malnutrition at admission	Present	413 (7.8%)	463 (8.3%)	.033*	.037	236 (7.7%)	275 (8.3%)	.541	.543	8747/4912
Eating or swallowing dysfunction at admission	Present	56 (1.1%)	79 (1.4%)	.126	.143	38 (1.2%)	37 (1.1%)	.874	.172	8263/4682
Long-term care need level	Care level I–II	915 (17.4%)	955 (17.1%)	.282	.415	520 (17.0%)	504 (15.1%)	.126	.432	8397/4698
	Care level III–V	708 (13.4%)	683 (12.2%)			313 (10.2%)	355 (10.7%)			
Dementia-related independence level	Level I–II	1360 (25.8%)	1463 (26.2%)	.713	.545	782 (25.6%)	873 (26.2%)	.350	.240	652/175
	Level III–V	1234 (23.4%)	1299 (23.3%)			609 (19.9%)	632 (19.0%)			
Consciousness at discharge (JCS)	I	385 (7.3%)	378 (6.8%)	.333	.199	218 (7.1%)	233 (7.0%)	.992	.672	283/156
	II	393 (7.5%)	457 (8.2%)			215 (7.0%)	229 (6.9%)			
	III	208 (3.9%)	210 (3.8%)			96 (3.1%)	104 (3.1%)			
	Alert	4280 (81.3%)	4535 (81.3%)			2527 (82.8%)	2764 (83.0%)			
Home medical care at discharge	Own institution	29 (0.6%)	48 (0.9%)	.202	.375	9 (0.3%)	14 (0.4%)	.199	.409	3/4
	Other institution	360 (6.8%)	388 (6.9%)			214 (7.0%)	232 (7.0%)			
	None	4830 (91.7%)	5086 (91.2%)			2807 (91.9%)	3052 (91.7%)			
	Unknown	47 (0.9%)	58 (1.0%)			26 (0.8%)	30 (0.9%)			

Table 1. Continued

Variable	Category	ORIF Monday (N = 5266)	ORIF Friday (N = 5580)	ORIF P^a	ORIF P^b	Hemi Monday (N = 3056)	Hemi Friday (N = 3328)	Hemi P^a	Hemi P^b	Missing, n (ORIF/Hemi)
Pressure injury at discharge	Present	16 (0.30%)	15 (0.27%)	.550	—	3 (0.10%)	8 (0.24%)	.135	—	—
Malnutrition at end of reimbursement period	Present	467 (8.9%)	488 (8.7%)	.231	.180	307 (10.0%)	394 (11.8%)	.001*	.045	8769/4934
Eating or swallowing dysfunction at end of period	Present	91 (1.7%)	107 (1.9%)	.298	.872	61 (2.0%)	51 (1.5%)	.157	.050	8267/4690
Readmission within 7 days	Yes	4 (0.08%)	12 (0.22%)	.078	.311	3 (0.10%)	5 (0.15%)	.728	.272	0/0
Readmission within 28 days	Yes	12 (0.23%)	27 (0.48%)	.035*	.043	11 (0.36%)	12 (0.36%)	.999	.028	0/0
Age, years		86.0 [79.0–91.0]	86.0 [78.0–90.0]	.366	.788	83.0 [77.0–88.0]	86.0 [76.3–88.0]	.754	.323	26/23
Height, cm		150.0 [143.0–156.0]	150.0 [143.0–156.0]	.357	.043	152.0 [145.0–158.0]	152.0 [145.0–158.0]	.635	.057	0/0
Body weight, kg		45.4 [39.0–53.6]	45.4 [39.0–53.6]	.678	.963	47.0 [40.0–55.0]	47.0 [40.0–55.0]	.511	.050	0/0
ADL at admission		5 [0–15]	5 [0–20]	.098	.599	5 [0–20]	5 [0–25]	.721	.582	929/518
ADL at discharge		45 [15–75]	45 [15–75]	.607	.410	50 [20–80]	50 [20–85]	.942	.933	1245/708
Length of hospital stay, days		23 [18–33]	23 [18–34]	.714	.007	26 [19–36]	25 [19–34]	.009*	.022	0/0
Length of stay in general ward, days		23 [18–32]	23 [17–33]	.671	—	25 [19–34]	24 [18–33]	.051	—	—
DPC-covered length of stay, days		22 [17–29]	22 [17–29]	.524	.060	23 [19–31]	23 [18–30]	.102	.011	0/0
Days before primary surgery		3 [1–4]	2 [1–3]	<.001*	<.001	4 [2–6]	3 [1–6]	<.001*	<.001	0/0
Days after final surgery		18 [14–28]	19 [15–28]	.015*	.001	18 [15–28]	19 [14–27]	.954	.388	0/0
Emergency medical management add-on, claims		1 [1–1]	1 [1–1]	.193	.045	1 [1–1]	1 [1–1]	.710	.893	3108/1744
Emergency medical management add-on, eligible claims		1 [1–1]	1 [1–1]	.008*	.017	1 [1–1]	1 [1–1]	.076	.284	3108/1744
Comprehensive rehabilitation plan fee, claims		1 [0–2]	1 [0–2]	.072	.187	1 [0–2]	1 [0–2]	.522	.263	3108/1744
Comprehensive rehabilitation plan fee, eligible claims		2 [1–2]	2 [1–2]	.002*	<.001	2 [1–2]	2 [1–2]	.035*	.227	3108/1744

Abbreviations: ADL, activities of daily living; DPC, Diagnosis Procedure Combination; JCS, Japan Coma Scale; ORIF, open reduction and internal fixation.

Categorical variables are shown as n (column %); continuous variables as median [interquartile range]. Percentages are based on the total number of patients in each group. P^a, Monday vs. Friday (χ^2 test or Fisher's exact test for categorical variables, as appropriate; Wilcoxon rank-sum test for continuous variables). P^b, test for difference across weekdays Monday–Friday (χ^2 test or Fisher's exact test for categorical variables, as appropriate; Kruskal–Wallis test for continuous variables). Missing, number of records with no recorded value for the variable. —, not applicable. Values were aggregated from the source DPC data.

Table 2. Healthcare Resource Utilization and Reimbursement by Day of Surgery

Characteristic	ORIF Monday	ORIF Friday	*P* Value	Hemiarthroplasty Monday	Hemiarthroplasty Friday	*P* Value
Daily FFS reimbursement	59 397.1 [49 454.2–71 136.2]	60 038.7 [49 231.2–72 075.0]	.017*	72 318.9 [59 191.2–86 653.3]	73 273.0 [60 930.8–89 264.0]	.003*
FFS billable amount	717 362.0 [621 221.5–883 088.0]	729 875.0 [625 237.0–911 600.5]	.007*	1 110 389.0 [1 024 555.5–1 291 834.0]	1 109 200.0 [1 018 957.5–1 272 095.0]	.224
Resource use index (0991)	1.7805 [1.405–2.107]	1.7735 [1.385–2.115]	.752	1.882 [1.50425–2.16]	1.882 [1.471–2.147]	.211
Surgery and anesthesia (subtotal)	485 485.0 [433 790.0–549 962.5]	494 410.0 [435 797.5–557 330.0]	<.001*	870 400.0 [851 972.5–921 197.5]	874 280.0 [821 602.5–924 920.0]	.109
Total FFS reimbursement	1 403 210.0 [1 215 209.5–1 732 230.0]	1 422 116.0 [1 220 451.5–1 754 318.5]	.195	1 843 352.0 [1 652 235.0–2 177 104.0]	1 829 017.0 [163 5052.5–2 146 247.5]	.031*

Abbreviations: ORIF, Open reduction and internal fixation; FFS, fee-for-service.
Note: Values are presented as median [interquartile range].
Comparisons between Monday and Friday were performed using the Mann–Whitney U test.
Asterisks indicate statistical significance ($P < .05$).
Total FFS reimbursement denotes the FFS equivalent valuation of the entire index hospitalization and is the numerator of the per-diem primary outcome. FFS billable amount denotes the itemized services reimbursed outside the DPC per-diem bundle (for example, surgery, anesthesia, and high-cost drugs and materials); it is a distinct, smaller quantity and is not the numerator of the per-diem outcome.

examined descriptively to confirm that reimbursement differences were not driven by adverse patient outcomes; these indicators were not entered as dependent variables in the regression models.

Variables

Patient-level variables comprised age (years, continuous), sex (female/male), fracture type, admission type (emergency vs. elective), level of consciousness at admission graded with the JCS (alert, I, II, or III), functional status at admission measured with the Barthel Index (0–100, continuous), and surgical procedure (ORIF or hemiarthroplasty), which defined the analytic strata rather than serving as a covariate within the procedure-specific models. Hospital-level clustering was captured through a unique institutional identifier assigned to each of the 185 hospitals and was used to account for within-hospital correlation in the analyses.

Analytical Strategy

Analyses first evaluated weekday patterns in per-diem FFS reimbursement across the full Monday–Friday cohort. Descriptive statistics were used to summarize patient and hospital characteristics. Adjusted differences in per-diem FFS reimbursement were estimated using ordinary least squares linear regression with cluster-robust (sandwich) standard errors clustered at the hospital level; separate models were fitted for each procedure group and for the primary outcome. Covariates were selected a priori based on clinical relevance and data availability and included age, admission type, level of consciousness at admission (JCS categories), and functional status at admission (Barthel Index); because separate models were fitted within each procedure group, surgical procedure defined the analytic strata and was not entered as a covariate. Linear regression was chosen because the aim was to estimate absolute adjusted differences in reimbursement, expressed in yen, that are directly interpretable for budgeting and policy; cluster-robust standard errors accommodated within-hospital correlation and heteroscedasticity of reimbursement. Covariates were prespecified on clinical grounds rather than selected by stepwise procedures, to avoid overfitting and data-driven bias. Because reimbursement has many unmeasured determinants, the models were expected to explain only a small share of total variance; adjusted R^2 values are reported in the Results and Table S2 of Supplementary file 1. The prespecified primary contrast was Monday versus Friday—the days anchoring the working week—chosen a priori to capture early- versus late-week operational differences; unadjusted per-diem FFS reimbursement is displayed descriptively for all five weekdays to show the gradient (Supplementary file 1, Figure S2), whereas the multivariable models estimated the adjusted Monday-versus-Friday difference; no formal linear-trend test was prespecified.

Because surgical procedure is a major determinant of perioperative care processes and resource utilization, analyses were prespecified according to procedure type. ORIF was treated as the primary analytic group, reflecting its predominance and clinical comparability across hospitals. Hemiarthroplasty was analyzed as a secondary group to assess the robustness and generalizability of the findings. Procedure-specific multivariable models were constructed accordingly.

Age and Barthel Index were treated as continuous variables, while admission type and JCS were modeled as categorical variables. Hospital-level clustering was accounted for in all multivariable analyses. The Monday–Friday regression models were fitted to complete cases with respect to these covariates (ORIF, n = 10 440; hemiarthroplasty, n = 6145).

Adjusted Monday–Friday contrasts were then estimated to quantify the magnitude of weekday differences.

To describe which service components differed by day of surgery, we compared the Friday-minus-Monday difference in median per-admission FFS billable amount for each component. For each component, the Friday-minus-Monday difference in the median billable amount was calculated (Table 3); the component-level differences (in yen) are

displayed, ranked by magnitude, in Figure, in which positive values indicate higher billable amounts on Friday. The service components (surgery and anesthesia, procedures, inpatient care, drugs, materials, consultation, and other) are author-defined aggregations of EF-file billing items grouped into clinically meaningful categories rather than predefined DPC billing headings; the classification is exhaustive at the level of billed items, so that the items sum to the total FFS billable amount, although the medians of components need not sum exactly to the median total. All analyses were conducted using JMP Pro 18 (SAS Institute Inc., Cary, NC, USA).

Reporting Guidelines

This manuscript adheres to the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) guidelines for observational research.[14]

Results

Study Population

During the study period, 46 210 patients with proximal femoral fracture were identified across 185 hospitals (Supplementary file 1, Figure S1). After excluding surgeries performed on weekends (n = 1983), 44 227 patients who

Table 3. Breakdown of Fee-for-Service Billable Amounts by Component and Day of Surgery

Characteristic	ORIF Monday	ORIF Friday	*P* Value	Hemiarthroplasty Monday	Hemiarthroplasty Friday	*P* Value
FFS billable amount: Procedures	468 641.0 [390 018.0–612 662.5]	476 895.0 [395 182.5–634 525.0]	.016*	495 018.0 [417 475.0–638 933.0]	492 055.0 [418 682.5–627 737.5]	.235
FFS billable amount: Drugs	18 840.0 [4277.5–37 662.5]	19 575.0 [5 770.0–38 392.5]	<.001*	17 365.0 [6110.0–29 635.0]	18 440.0 [6540.0–32 627.5]	.009*
FFS billable amount: Materials	215 020.0 [200 060.0–236 692.5]	215 400.0 [200 110.0–238 847.5]	.137	593 720.0 [552 177.5–624 005.0]	594 090.0 [552 155.0–624 050.0]	.589
FFS billable amount: Consultations	19 190.0 [12 800.0–26 332.5]	17 550.0 [11 550.0–24 450.0]	<.001*	19 245.0 [12 640.0–26 230.0]	18 190.0 [12 210.0–25 422.5]	.001*
FFS billable amount: Surgery and anesthesia	485 485.0 [433 790.0–549 962.5]	494 410.0 [435 797.5–557 330.0]	<.001*	870 400.0 [851 972.5–921 197.5]	874 280.0 [821 602.5–924 920.0]	.109
FFS billable amount: Other	61 000.0 [39 750.0–95 450.0]	61 450.0 [39 000.0–98 537.5]	.896	66 150.0 [44 662.5–102 037.5]	67 500.0 [44 162.5–102 900.0]	.988
FFS billable amount: Hospitalization-related items/add-ons	118 134.0 [82 066.5–182 235.0]	119 160.0 [81 041.5–188 388.5]	.784	122 646.0 [85 220.0–189 207.5]	118 872.0 [83 170.0–180 630.0]	.006*
Injections (subtotal)	7220.0 [4357.5–15 482.5]	7420.0 [4432.5–15 490.0]	.174	8835.0 [4 732.5–18 837.5]	8785.0 [5040.0–17 950.0]	.745
Procedures (subtotal)	3780.0 [1920.0–7325.0]	3910.0 [1960.0–7737.5]	.111	4430.0 [2312.5–8150.0]	4370.0 [2220.0–8267.5]	.566
Surgery and anesthesia (subtotal)	485 485.0 [433 790.0–549 962.5]	494 410.0 [435 797.5–557 330.0]	<.001*	870 400.0 [851 972.5–921 197.5]	874 280.0 [821 602.5–924 920.0]	.109
Surgery (subtotal)	433 610.0 [389 990.0–488 865.0]	436 955.0 [390 210.0–493 305.0]	.108	803 450.0 [760 355.0–843 702.5]	804 005.0 [760 732.5–842 847.5]	.903
Anesthesia (subtotal)	64 000.0 [9100.0–86 760.0]	70 885.0 [10 160.0–90 415.0]	<.001*	82 100.0 [11 140.0–100 892.5]	83 825.0 [11 582.5–103 407.5]	<.001*
Laboratory tests (subtotal)	54 310.0 [40 300.0–71 605.0]	53 795.0 [40 260.0–72 500.0]	.964	58 480.0 [47 622.5–78 360.0]	58 355.0 [44 337.5–77 275.0]	.917
Imaging (subtotal)	37 410.0 [31 080.0–48 362.5]	37 300.0 [30 640.0–48 070.0]	.122	35 805.0 [28 925.0–45 615.0]	35 830.0 [28 872.5–46 690.0]	.682

Abbreviations: ORIF, Open reduction and internal fixation; FFS, fee-for-service.
Note: Values are presented as median [interquartile range].
Comparisons between Monday and Friday were performed using the Mann–Whitney U test.
Asterisks indicate statistical significance (*P* < .05).
Hospitalization-related items/add-ons denotes inpatient-care FFS items billed outside the DPC per-diem bundle, not the bundled per-diem payment itself. materials); it is a distinct, smaller quantity and is not the numerator of the per-diem outcome.

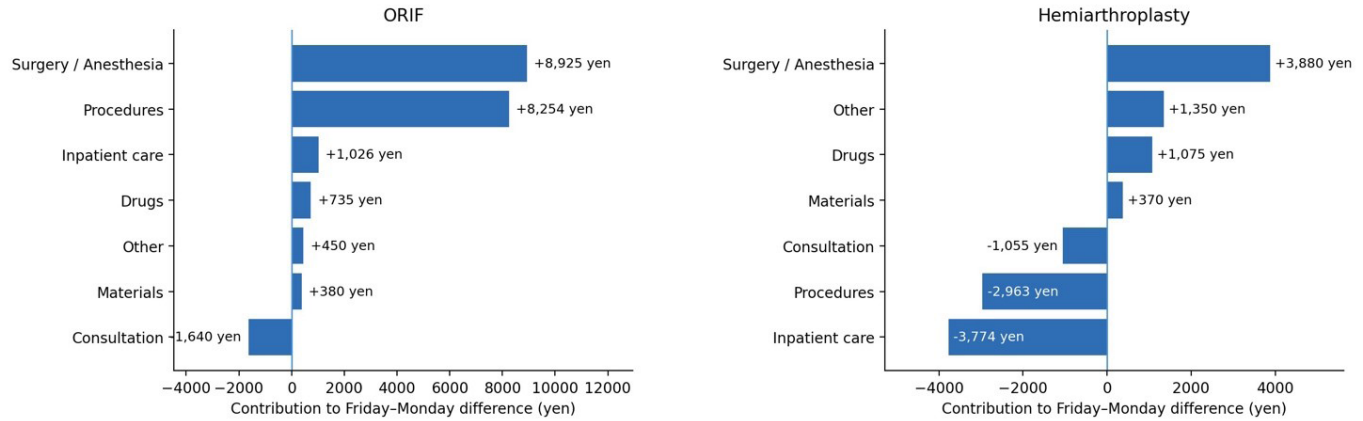


Figure. Descriptive Friday–Monday differences in median per-admission fee-for-service billable amount, by service component. Bars indicate the Friday-minus-Monday difference (yen) in the median per-admission FFS billable amount for each component; positive values indicate higher billable amounts for Friday surgeries and negative values indicate higher billable amounts for Monday surgeries. Results are shown separately for ORIF and hemiarthroplasty. Abbreviations: ORIF, Open reduction and internal fixation; FFS, fee-for-service.

underwent weekday surgery were eligible for analysis. A further 2865 patients were excluded because of missing or incomplete data, resulting in a final analytic cohort of 41 362 patients.

Of these, 25 779 patients underwent ORIF and 15 583 patients underwent hemiarthroplasty. Surgeries performed from Monday through Friday were included to characterize weekday patterns in healthcare resource utilization. This cohort allowed evaluation of temporal variation across the full workweek before prespecified contrasts were examined. Monday–Friday comparisons were then examined within each procedure group, with Monday versus Friday specified as the primary contrast.

Weekday Pattern of Reimbursement

Figure S2 of Supplementary file 1 shows a consistent weekday pattern in unadjusted (raw) per-diem FFS reimbursement. Unadjusted median reimbursement increased toward the end of the workweek in both procedure groups. For ORIF, the unadjusted median reimbursement was 59 397 JPY on Monday and increased to its highest value on Friday (60 038 JPY). A similar pattern was observed for hemiarthroplasty, with median reimbursement rising from 72 319 JPY on Monday to a peak of 73 273 JPY on Friday. Although interquartile ranges overlapped across weekdays, the distribution on Friday was shifted upward in both procedure groups, indicating a systematic elevation rather than isolated extreme values. These weekday patterns supported the prespecified comparison between Monday and Friday.

Patient Characteristics

Baseline patient characteristics stratified by day of surgery and surgical procedure are shown in Table 1.

Across both surgical procedures, patient demographics were generally comparable between Monday and Friday surgeries. Median age, sex distribution, body size measures, admission source, and functional status at admission did not differ materially between the two groups.

In the ORIF group, small but statistically significant differences were observed for admission type and level of consciousness at admission. Emergency admissions were slightly more frequent among Monday surgeries than Friday surgeries, and distributions of the JCS differed modestly between groups. Minor differences were also observed in the prevalence of pressure injury and malnutrition at admission. Differences in discharge functional status and most postoperative clinical indicators were small.

In the hemiarthroplasty group, most baseline characteristics were similar between Monday and Friday surgeries, although small differences were observed in selected perioperative and utilization-related variables.

Healthcare Resource Utilization and Reimbursement

Comparisons of healthcare resource utilization and reimbursement by day of surgery are summarized in Table 2.

In both surgical procedures, per-diem FFS reimbursement was higher for Friday surgeries than for Monday surgeries. The adjusted magnitude of this per-diem difference is quantified in the regression analysis (Table 4). In the ORIF group, median daily FFS reimbursement was significantly higher for Friday surgeries than for Monday surgeries. A similar pattern was observed in the hemiarthroplasty group.

Total FFS billable amounts per admission were higher for Friday surgeries in the ORIF group, whereas in the hemiarthroplasty group, total billable amounts were modestly higher for Monday surgeries. Resource use indices did not differ substantially between Monday and Friday surgeries in either procedure group.

Breakdown of Fee-For-Service Components

The detailed breakdown of FFS billable amounts by component is presented in Table 3.

In the ORIF group, Friday surgeries were associated with higher billable amounts for procedures, drugs, and surgery- and anesthesia-related components compared with Monday surgeries. Anesthesia-related billable amounts were notably higher for Friday surgeries, whereas laboratory testing and imaging fees showed minimal variation by day of surgery.

In the hemiarthroplasty group, Friday surgeries were associated with higher drug-related and anesthesia-related billable amounts. Most other components, including materials and imaging, did not differ significantly between Monday and Friday surgeries. Hospitalization-related fees showed a small but statistically significant difference favoring Monday surgeries.

Multivariable Analysis

Results of multivariable linear regression analyses for per-diem FFS reimbursement are shown in Table 4.

After adjustment for patient characteristics, admission type, level of consciousness at admission, and functional status, Friday surgery remained independently associated with higher per-diem FFS reimbursement in both surgical procedures. Adjusted contrasts indicated persistent weekday differences after accounting for measured confounders. Compared with Friday surgeries, Monday surgeries were associated with significantly lower per-diem FFS reimbursement in both the ORIF and hemiarthroplasty models.

Age, emergency admission, level of consciousness, and functional status at admission were also significantly associated with per-diem FFS reimbursement, although the direction and magnitude of associations differed between surgical procedures. Model fit statistics are presented in Table S2 of Supplementary file 1. Explanatory power was modest, with adjusted R^2 values of 0.015 for ORIF and 0.007 for hemiarthroplasty.

Supplementary Analyses

Additional analyses of length of stay and selected utilization measures are presented in Table S1 of Supplementary file 1. Differences in length of stay and utilization indicators between Monday and Friday surgeries were small and inconsistent.

Service Component Differences by Day of Surgery

Figure shows the descriptive Friday–Monday differences in median per-admission FFS billable amount for major service components. Surgery- and anesthesia-related services showed the largest differences, whereas laboratory testing and imaging differed minimally. Because medians are not additive, these component differences are descriptive and do not sum exactly to the overall per-admission difference.

Discussion

Principal Findings and Health System Significance

In this nationwide analysis of Japanese DPC administrative data, we identified systematic weekday variation in per-diem FFS reimbursement among patients undergoing surgery for proximal femoral fracture. Unadjusted per-diem reimbursement varied across weekdays and was highest on Friday in both procedure groups; in the adjusted primary analysis, Monday surgery was associated with lower per-diem reimbursement than Friday surgery. These differences persisted after adjustment for patient characteristics and admission-related factors and were not accompanied by meaningful differences in length of stay or the measured clinical indicators.

From a health policy perspective, these findings are important because they suggest that temporal variation in healthcare delivery can translate into measurable financial variation under hybrid payment systems, even when clinical outcomes remain stable. While prior studies have examined weekday and weekend effects primarily in relation to mortality and complications,[6-8] our findings demonstrate that variation may be embedded within financing mechanisms themselves. This expands the understanding of temporal variation beyond clinical performance to include reimbursement dynamics and system-level operational structures.

To contextualize the magnitude of these differences, the adjusted per-diem contrast corresponds to approximately 578 JPY per day for ORIF and 736 JPY per day for hemiarthroplasty—about 1% of daily FFS reimbursement (roughly US $3.9 and US $4.9 per day at recent exchange rates of about 150 JPY per US dollar). As an illustrative extrapolation—multiplying the per-diem estimate by a typical length of stay rather than directly estimating a per-admission effect—accumulating this contrast over a median hospital stay of 23–25 days corresponds to roughly 13 000–18 000 JPY per admission. On the same illustrative basis, for a hospital performing 100 ORIF procedures annually the aggregate Friday-versus-Monday difference would be on the order of

Table 4. Multivariable Linear Regression Analyses for Per-Diem Fee-for-Service Reimbursement by Surgical Procedure (Yen)

Variable	ORIF β (Yen)	ORIF 95% CI	ORIF *P* Value	Hemiarthroplasty β (Yen)	Hemiarthroplasty 95% CI	Hemiarthroplasty *P* Value
Day of surgery (Monday vs. Friday)	-578.1	-1021.7 to -134.6	.010*	-736.4	-1389.5 to -83.2	.027*
Age, years (per 1-year increase)	-171.6	-209.1 to -134.1	<.001*	24.5	-53.1 to 102.1	.536
Emergency admission (vs. elective)	-1663.9	-2922.8 to -405.0	.009*	-3097.3	-4583.6 to -1611.0	<.001*
JCS I (vs. alert)	-801.7	-2,090.7 to 487.3	.222	-1494.0	-3494.4 to 506.4	.143
JCS II (vs. alert)	2000.8	644.1 to 3357.5	.003*	337.8	-1835.4 to 2510.9	.760
JCS III (vs. alert)	2004.1	431.7 to 3576.6	.012*	3854.2	1291.0 to 6417.4	.003*
ADL (Barthel Index) at admission (per 1-point increase)	-26.6	-42.8 to -10.4	.001*	-14.8	-38.3 to 8.6	.214

Abbreviations: CI, confidence interval; JCS, Japan Coma Scale; ADL, activities of daily living; ORIF, open reduction and internal fixation.

Note: Outcome was per-diem FFS total reimbursement (yen). Values are regression coefficients (β) with 95% CIs. Reference categories were Friday for day of surgery, elective for admission type, and alert for the JCS. Models were adjusted for age, admission type, JCS category, and Barthel Index at admission. Hospital-level clustering was accounted for using robust variance estimation.

1.3 million JPY per year (approximately US $8900). Because length of stay differs across weekdays and between procedures, these extrapolated figures are illustrative only: multiplying the per-diem contrast by a typical length of stay does not equal the adjusted per-admission or annual difference and should not be interpreted as a formal estimate of per-admission or facility-level financial impact. These sums are non-trivial in aggregate at high surgical volumes but small relative to total institutional revenue; at the individual-admission level the difference is modest, and for hemiarthroplasty the direction can even reverse when total per-admission billing is considered, because Friday stays were slightly shorter (Table 2). We therefore interpret the weekday gradient as an indicator of operational variation rather than as evidence of financially material inefficiency.

The observed pattern may therefore not be fully explained by measured differences in patient severity or surgical indication, and may instead be consistent with organizational features of care around the peri-weekend period that interact with payment design to produce financial variation.

Financing Design as a Driver of Temporal Variation

Healthcare financing structures shape provider behavior and organizational processes. In systems that combine bundled payments with FFS components, as in Japan's DPC model, reimbursement is partially sensitive to the timing and composition of billable services.[12,13] This design allows detailed tracking of healthcare utilization but may also amplify routine operational differences.

The present study shows that weekday timing is associated with systematic differences in reimbursement. Under the DPC framework, small shifts in the sequencing or intensity of perioperative services across weekdays can result in differences in daily FFS reimbursement. Such variation is not necessarily problematic; however, when it is unrelated to patient need or outcomes, it may reflect variation embedded in routine workflow.

This observation is relevant for countries operating under diagnosis-related group–based or hybrid payment models, including many OECD (Organisation for Economic Co-operation and Development) health systems. In any setting where bundled payments coexist with itemized service components, financing design may be associated with organizational timing effects. Our findings therefore highlight the importance of auditing not only clinical outcomes but also payment-sensitive process indicators when evaluating system performance.

Temporal Variation and System Performance

Variation in care that is not explained by patient need is increasingly recognized as unwarranted variation and a potential target for system improvement.[15] Within the Triple Aim framework and its subsequent extensions, high-performing health systems are expected to optimize outcomes, patient experience, and costs simultaneously.[3-5]

Most weekday or weekend-effect studies have focused on adverse clinical outcomes.[6-8] However, stable outcomes do not necessarily imply stable resource use. Our findings suggest that financing and service-delivery mechanisms may be associated with systematic variation in recorded resource allocation even in the absence of measured clinical deterioration.

This has important implications for health system governance. If outcome metrics alone are used to evaluate quality, payment-related inefficiencies may remain undetected.[16,17] Incorporating reimbursement-sensitive indicators into performance monitoring may therefore provide a more comprehensive assessment of system efficiency.

Organizational Mechanisms and Operational Structure

The descriptive component analysis indicates which service groups differed most by day of surgery. Surgery- and anesthesia-related services showed the largest Friday–Monday differences in per-admission FFS billable amount, whereas diagnostic testing differed minimally; these component comparisons are descriptive and are reported separately from the per-diem primary outcome. These findings are consistent with differences in perioperative workflows, staffing configurations, scheduling practices, and cross-weekend coordination. Because staffing, scheduling, anesthesia practice, and operating-room workflows were not directly measured in the administrative data, these interpretations should be regarded as hypotheses consistent with the observed associations rather than confirmed mechanisms.

Organizational and staffing factors have repeatedly been implicated in temporal variation in hospital care.[18,19] Our results suggest that such organizational dynamics may carry downstream financial implications under hybrid payment systems. In effect, reimbursement patterns may serve as indirect markers of operational structure.

Importantly, these financial differences were not accompanied by differences in the measured clinical indicators. This suggests that the health system is absorbing routine operational variability without compromising safety; whether this carries any cost in allocative efficiency cannot be determined from these data and remains uncertain.

Policy Implications and International Relevance

Several policy implications emerge.

First, policy-makers should recognize that hybrid payment systems may be sensitive to routine temporal variation in care delivery. Even small operational differences can produce measurable financial consequences. Regular auditing of weekday reimbursement patterns may help identify payment variation that is not clinically visible.

Second, payment models should be evaluated not only for their incentive structures at the macro level but also for their interaction with micro-level organizational processes. Payment-sensitive variation may reflect structural timing effects rather than deliberate clinical decision-making. Policy-makers in other countries operating DRG-based or mixed reimbursement systems should consider assessing intra-week financial variation as part of routine health system performance evaluation.

Third, standardization of perioperative pathways across weekdays may reduce potentially avoidable financial variation

without affecting clinical outcomes. Approaches such as harmonized staffing models, cross-weekend coordination protocols, and consistent scheduling frameworks may enhance allocative efficiency.[20,21] Aligning reimbursement mechanisms with stable care delivery structures could improve financial sustainability while maintaining quality.

More broadly, this study illustrates how financing architecture can function as a lens through which latent organizational variation becomes visible. For international audiences, the Japanese DPC system provides a case study of how hybrid payment design interacts with real-world hospital operations. The findings may therefore inform comparative health policy discussions regarding bundled payments, mixed reimbursement models, and performance auditing.

Strengths and Limitations

This study benefits from the use of a large nationwide administrative database covering 185 acute care hospitals and enabling detailed examination of daily reimbursement components. Stratification by surgical procedure improved interpretability and enhanced the robustness of findings.

However, several limitations should be acknowledged. As an observational study, residual confounding cannot be fully excluded. Although key patient-level factors were adjusted for, administrative data lack granular clinical details such as intraoperative complexity and provider-level decision-making. Coding variability and unmeasured organizational characteristics may also contribute to residual bias.[11,13,22] In addition, because the study period spanned April 2014 to July 2025, temporal factors such as seasonality, fiscal-year effects, and the COVID-19 pandemic were not explicitly modeled; residual temporal confounding therefore cannot be excluded. Because the DPC fee schedule is revised biennially and the COVID-19 pandemic period may have affected both the weekday distribution of surgeries and the composition of billed services, we cannot rule out that these temporal factors contributed to the observed weekday pattern; calendar-year and fiscal-year fixed effects, DPC-revision periods, and seasonal terms were not incorporated into the models. Finally, although hospital-level clustering was addressed through cluster-robust (sandwich) standard errors, this approach corrects the precision of estimates for within-hospital correlation but does not adjust for hospital-specific reimbursement levels or coding practices as potential confounders; hospital fixed-effects or multilevel models and alternative distributional specifications (eg, generalized linear models for skewed costs) were not applied, so residual confounding by hospital characteristics correlated with weekday composition cannot be excluded. In particular, competition for shared operating-room and anesthesia capacity from elective procedures in other surgical specialties may vary systematically across the week and was not measured; such hospital-wide resource competition could contribute to the observed weekday differences and represents a further potential unmeasured confounder. The adjusted models also explained only a small fraction of the overall variation in per-diem reimbursement (adjusted $R^2 = 0.015$ for ORIF and 0.007 for hemiarthroplasty), indicating that day of surgery is not a major determinant of reimbursement; the weekday coefficients should therefore be interpreted as small average adjusted contrasts rather than as evidence that timing drives most of the variation in payment.

Furthermore, while Monday–Friday contrasts were prespecified, the analysis cannot fully capture underlying organizational mechanisms. Future mixed-methods research integrating quantitative reimbursement analysis with qualitative examination of hospital workflow may provide deeper insight into causal pathways. Lastly, the primary outcome reflects an FFS equivalent valuation of the services recorded in the DPC data rather than realized net hospital revenue, which also depends on the bundled per-diem component and hospital-specific adjustment coefficients; the weekday contrasts therefore describe variation in the valuation of billed services rather than differences in actual institutional income.

Conclusion

Weekday variation in per-diem FFS reimbursement was observed alongside broadly similar measured clinical indicators (functional status at discharge and 7- and 28-day readmission) in a nationwide cohort of hip fracture surgeries in Japan. These findings suggest that hybrid payment systems may translate routine organizational timing differences into measurable financial variation.

For policy-makers and health system leaders, the results underscore the need to evaluate financing structures alongside clinical performance indicators. Aligning reimbursement mechanisms with consistent care delivery processes may enhance allocative efficiency without compromising patient safety. In aging societies facing increasing fiscal pressure, understanding how payment design interacts with operational structure is essential for sustainable health system management.

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Disclosure of artificial intelligence (AI) use

During manuscript preparation, the authors used ChatGPT (OpenAI, San Francisco, CA, USA) to improve language clarity and refine manuscript structure. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the final version of the manuscript.

Ethical issues

This multicenter retrospective observational study was approved by the Ethics Committee of Chiba University Hospital (approval number: 3309). The requirement for informed consent was waived by the Ethics Committee of Chiba University Hospital, as the study used only publicly available, anonymized aggregate data. This study adhered to the Strengthening of the Reporting of Observational Studies in Epidemiology guidelines. A statistical plan was established before the data were accessed, collected, and analyzed. The study complied with the principles of the Declaration of Helsinki (2013).

Conflicts of interest

Authors declare that they have no conflicts of interest.

Data Availability statement

The datasets generated and analyzed during the current study are available in the Zenodo repository.[23]

Authors' contributions

Conceptualization: Kentaro Hara.
Data curation: Masato Kanda.
Formal analysis: Kentaro Hara and Takahiro Inoue.
Methodology: Kentaro Hara.
Project administration: Takahiro Inoue.
Resources: Masato Kanda and Takahiro Inoue.
Supervision: Takahiro Inoue.
Validation: Misa Tomooka, Hiroyo Kuwabara, and Yoshio Kobayashi.
Writing–original draft: Kentaro Hara.
Writing–review & editing: Misa Tomooka, Hiroyo Kuwabara, Yoshio Kobayashi, and Takahiro Inoue.

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Supplementary files

Supplementary file 1 contains Tables S1-S2 and Figures S1-S2.

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