Journal of Anesthesia (2025) 39:719–730
https://doi.org/10.1007/s00540-025-03522-w

ORIGINAL ARTICLE

A new acute pain service fee addition in Japan: a nationwide study based on a reimbursement claims database

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Received: 8 September 2024 / Accepted: 21 May 2025 / Published online: 7 June 2025

Abstract

Purpose Postoperative pain management is critical for psychological and physical patient outcomes. In April 2022, the Japanese government introduced a new Acute Pain Service (APS) fee addition into the health care reimbursement system to promote structured APS implementation. This study aims to describe the current status of APS addition and explore its association with patient and hospital outcomes.

Methods We conducted a retrospective study using a nationwide claims database. Patients who underwent surgery with general anesthesia from April 2022 to June 2023 were included. Surgical procedures were categorized into 15 departments or classified as "mixed," and APS addition claim frequency was summarized. Propensity score matching and multivariable regression analyses were performed.

Results A total of 14,022 patients with APS addition and 551,315 without were included. The relative frequency of APS addition was 2.48%, with the highest in esophageal surgery (11.8%). APS addition claims gradually increased over time. Propensity score matching showed no apparent differences in total hospitalization costs or length of stay between groups. However, significant interactions were observed between APS addition and patient age. Among 90-year-old patients, the estimated mean cost reduction [95% confidence interval (CI)] was 4.6% [2.1%, 7.0%] for males and 4.7% [2.4%, 6.9%] for females, while the estimated mean [95% CI] reduction in length of stay was 6.7% [3.0%, 10.3%] and 8.9% [5.6%, 12.1%], respectively.

Conclusion Although the overall effects of APS addition were minimal, age-stratified analyses suggest that it may be associated with improved outcomes among older patients. These exploratory findings warrant further investigation.

Keywords Acute pain service · Postoperative pain · Nationwide claims database

Introduction

Postoperative pain is a common complication experienced by surgical patients, and its appropriate management improves not only psychological but also physical patient outcomes [1–3]. Acute Pain Service (APS) is a multidisciplinary approach to postoperative pain management, typically led by anesthesiologists in collaboration with other healthcare professionals [4]. APS was first introduced in the United States [4] and Germany [5] in 1985. Since then, many health-related organizations have called for the introduction of APS, which has since spread globally [6–14]. Although APS was also introduced in Japan in 1996 [15], it had been left to the discretion of individual medical institutions [16]. No nationwide surveys have been conducted to assess the status of APS implementation [16].

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In April 2022, the Japanese government revised medical service fees. At that time, an additional fee for APS (hereafter referred to as 'APS addition') was introduced. The additional fee of approximately 6.5 US dollars per day can be claimed for up to three days post-surgery, provided the eligible patients receive postoperative analgesia meeting the following conditions. The eligible patients must undergo surgery involving closed-circuit general anesthesia by mask or endotracheal intubation and receive continuous pain relief through epidural local anesthetic infusion, continuous nerve block anesthetic infusion, or continuous intravenous opioid infusion postoperatively. The facility must be an insured medical institution that has been notified as complying with the facility standards specified by the Minister of Health, Labour, and Welfare and have a designated postoperative pain management team consisting of a full-time anesthesiologist, a trained nurse, and a trained pharmacist.

Under the Japanese reimbursement system for inpatient care in acute care hospitals, known as the Diagnosis Procedure Combination (DPC) system, hospitals are generally not reimbursed for individual treatments or examinations, except for high-cost procedures or equipment. Instead, reimbursement is based on a bundled payment that includes a basic hospitalization fee and various additional fees. The fee schedule is revised every two years, and changes in these fees function as economic incentives for healthcare providers, serving as an indirect policy tool to guide clinical practice. According to the notification issued by the Ministry of Health, Labour and Welfare on February 9 th, 2022, the primary purpose of introducing the APS addition is to promote high-quality postoperative pain management. This is expected to reduce pain scores, improve patients' quality of life, and prevent complications. Given this policy framework, the introduction of the APS addition is expected to encourage hospitals to enhance their APS operations in alignment with these goals. To date, there has been no publicly available descriptive or comprehensive evaluation of the APS addition in Japan.

In this study, we describe the current status of the APS addition using a nationwide claims database from acute care hospitals in Japan. We also explore its associations with selected patient and hospital management outcomes, including in-hospital death, length of stay, total hospitalization costs, and analgesic drug use. This study intends to generate hypotheses and provide preliminary insights into the implementation of the APS system in the Japanese healthcare context.

Methods

Data source and population

A retrospective study was conducted using a nationwide claims database provided by Medical Data Vision Co. Ltd. (MDV; Tokyo, Japan). According to the corporate website, the MDV database includes administrative data from approximately one-fourth of acute care hospitals in Japan, covering more than 40 million patients at the time of this study (https://www.mdv.co.jp/press/2023/detail_2079.html). The database provides information on patients' diagnoses and medical procedures based on claims submitted by healthcare institutions to insurers. Each procedure is associated with reimbursement point values, enabling the calculation of the total medical costs charged to insurers and patients. Individual applications to MDV were required to access the database, as the data were not publicly available.

We first extracted patients who were hospitalized between April 2022 and June 2023 (based on the admitting date) and received general anesthesia (receipt category L008) during hospitalization. Among them, we included those who underwent any of the surgical procedures defined in the next section and had summary data available at discharge. Patients who underwent multiple surgeries on separate days during a single admission were excluded (Fig. 1), as the postoperative period could not be clearly defined. In all analyses, each hospital admission was treated as an independent case, even if a patient appeared multiple times in the database.

Ethics approval and informed consent

According to Japanese guidelines, informed consent or institutional review board approval to conduct the study was unnecessary because the database was anonymized before the initiation of this study.

Surgeries

Because information on the actual surgical department was not available in the database, we manually assigned departments for all surgeries requiring general anesthesia based on the surgical procedures recorded. The classification included the following departments: head and neck surgery (including otorhinolaryngology), orthopedics, neurosurgery, spine surgery, thoracic surgery, cardiovascular surgery, breast surgery, esophageal surgery, gastroenterological surgery, hepatobiliary pancreatic surgery, urology, gynecology, obstetrics, plastic surgery (including dermatology), and others (Online Resource 1a). These surgical claim records were extracted from the procedure database. To simplify patterns of surgical combinations and reduce noise introduced by minor textual variations in procedure names, we disregarded the content in parentheses found in the receipt names of surgeries (Online Resource 1b). Surgical procedures recorded on the same day were treated as a single surgical episode and subsequently grouped into one of 15 surgical departments or into a 'mixed' category if they involved procedures across multiple departments (Online Resource 1c). Because it was

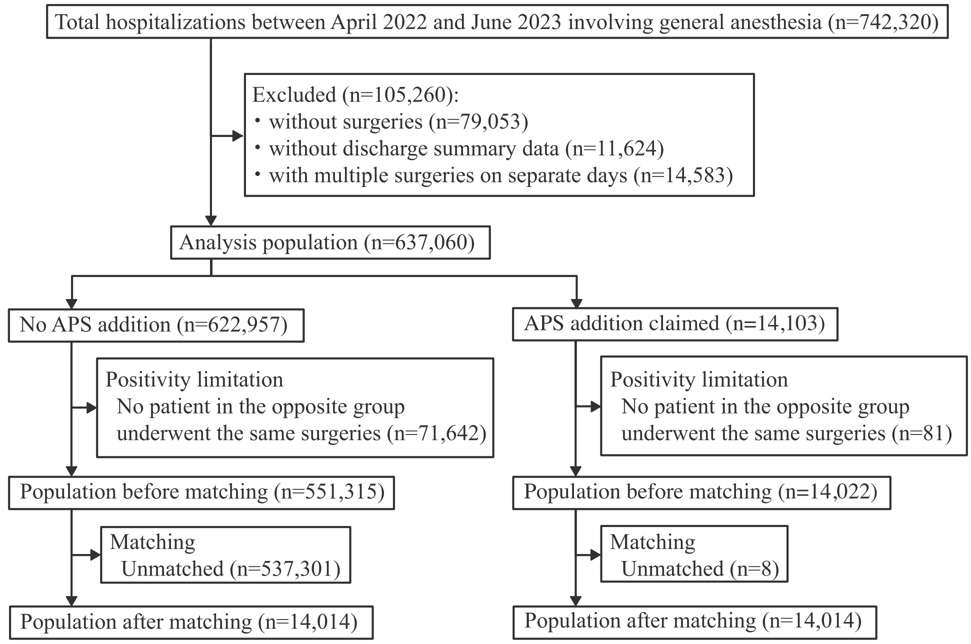

Fig. 1 Flow diagram

not feasible to manually review and label thousands of possible combinations of surgeries, we accepted a coarser classification granularity and automatically determined the department of each surgical combination based on the departments assigned to individual surgeries. Only surgical combinations that included at least one patient with an APS addition were retained for analysis.

APS addition

We defined APS addition as being claimed for a patient when a record of category A242-2 was found within three days after the surgery. For the purposes of outcome comparison, APS addition was treated as a dichotomous variable to facilitate interpretation in this initial evaluation. Additionally, in descriptive analyses of APS addition frequency, we also considered the number of days for which the addition was claimed.

Covariates

We collected covariates across three categories: patient demographics, hospital characteristics, and surgical information. Patient demographics included sex and age. Hospital characteristics comprised hospital size, defined by the number of beds (< 200, 200–499, and ≥ 500) and certification as a designated cancer hospital. Surgical information included surgical combination and the calendar month of hospitalization. We considered non-linearity for age and calendar month in all multivariable regression analyses.

Outcomes

Primary outcomes were total hospitalization costs and length of hospital stay. Total hospitalization costs were calculated as the sum of reimbursed charges recorded in the claims data during hospitalization. Secondary outcomes included length of postoperative hospital stay, in-hospital death, and number of oral analgesic prescriptions. For oral analgesics, we assessed the number of days for regular prescriptions after surgery, the number of as-needed prescriptions after surgery, and the number of different types of oral analgesics prescribed. We defined oral analgesics as drugs with anatomical therapeutic chemical (ATC) classification codes beginning with M01 A (excluding anti-rheumatic drugs), N02 A, or N02B.

Statistical analysis

We counted the frequency of APS addition grouped by surgical department and the calendar month of admission. Background characteristics were described using the median and interquartile range for continuous variables, and counts and percentages for categorical variables.

To assess differences between patients for whom APS addition was or was not claimed, we conducted propensity score matching [17]. Propensity scores were estimated using a logistic regression model based on variables available in the database, including sex, age, calendar month, department, number of beds category, and designated cancer hospital. Non-linearity for age and calendar month was addressed using restricted cubic splines with three knots [18]. Matching was performed using greedy nearest-neighbor matching without calipers. To ensure that patients were compared within clinically similar surgical contexts—at a minimum, those who may have undergone the same surgical procedures—we first restricted matching to patients within the same surgical combination group by applying exact matching on this variable. Within each surgical combination group, patients were then matched based on the propensity score. The balance of baseline characteristics before and after matching was assessed using standardized mean differences (SMDs), with |SMD|< 0.2 considered to indicate acceptable balance. After matching, we visually compared the distributions of each outcome between groups with and without APS addition.

Additionally, we conducted subgroup analyses using the full unmatched sample to assess whether the effects of APS addition on total hospital costs and length of stay vary across patient subgroups. We initially selected age and sex as subgroup variables because these are commonly considered potential effect modifiers in clinical outcomes. The multivariable regression models included two- and three-way interaction terms among APS addition, age, and sex, and were adjusted for hospital scale, designated cancer hospital, and surgical combination. Because of skewed distributions, we used log-transformed outcome variables. As post-hoc analyses, we additionally evaluated models considering other variables instead of sex as an effect modifier. Similar analyses were repeated separately for each department. For these analyses, we reported *p*-values for the overall effect of APS addition as well as for its effects within selected age subgroups. A *p*-value < 0.05 was considered statistically significant. All statistical analyses were conducted using R Statistical Software (v4.3.2; R Core Team 2023).

Results

Population

A total of 742,320 patients were hospitalized between April 2022 and June 2023 and underwent surgeries requiring general anesthesia. Among them, APS addition was claimed for 14,103 patients. Due to a violation of the positivity assumption in certain surgical combinations, 14,022 patients with APS addition and 551,315 patients without APS addition were included in the analyses (Fig. 1). Among all included cases, 1,407 patients (0.25%) were discharged on the same day as surgery. The background characteristics of these patients are shown in Table 1.

Frequency of APS addition

APS addition was claimed in 2.48% of all patients throughout the study period. The highest percentage was found in esophageal surgery (11.8%). The percentage for all departments has been increasing since October 2022. Especially for esophageal surgery, it reached 34.5% in June 2023 (Fig. 2). APS addition was more frequently claimed in larger hospitals: 2.85% of patients in hospitals with ≥ 500 beds and 2.53% in those with 200–499 beds received APS addition, whereas only 0.15% of patients in smaller hospitals (< 200 beds) did. Similarly, the proportion of claims was higher in designated cancer hospitals than in non-designated hospitals (2.94% vs. 1.22%).

Regarding the number of days for which APS addition was claimed, 491,967 patients (87.0%) were hospitalized for at least three days postoperatively, meaning they were eligible for a maximum of three APS addition claims. Among these patients, when limited to those with at least one APS addition claim, 9,526 (69.0%) had claims submitted for all three possible days. The number of days for which APS addition was claimed varied across surgical departments (Table 2). Among patients with at least one claim, the proportion with claims on all three eligible days was higher in esophageal surgery (83.7%), head and neck surgery (83.5%), and hepatobiliary pancreatic surgery (73.8%). In contrast, this proportion was lower in cardiovascular surgery (56.4%), and orthopedics (59.0%).

Propensity score matching

After propensity score matching, the overall covariate balance was maintained (Table 3). However, when stratified by surgical department, balance was not achieved in those with a small number of matched pairs (Online Resource 2). In particular, covariates such as calendar month, hospital scale, and designated cancer hospital remained imbalanced in some strata. No evidence suggested that APS addition was associated with total hospitalization costs, overall hospital stay (Fig. 3), or postoperative hospital stay (Online Resource 3). Additionally, there were no apparent differences in the variety of oral analgesics, the number of days with regular prescriptions, or the frequency of as-needed prescriptions between patients with and without APS addition (Fig. 4). In gastroenterological surgery, in-hospital deaths occurred in 38 patients (0.9%) with APS addition and 60 (1.4%) without it; in orthopedics, the numbers were 3 (0.1%) and 14 (0.7%), respectively. In other departments, 10 or fewer in-hospital deaths were observed, with minimal differences between the two groups (Table 4).

Subgroup analyses

Significant overall effects of APS addition were observed for total hospitalization costs ($p < 0.001$) (Fig. 5a) and length of stay ($p < 0.001$) (Fig. 5b). APS addition was associated with higher total hospitalization costs and longer stays

Table 1 Baseline characteristics before propensity score matching

Variables	APS addition Claimed (n = 14,022)	APS addition None (n = 551,315)	SMD
Female sex	49.4% (6,921)	54.0% (297,926)	−0.094
Age (year), median [IQR]	70.0 [57.0, 77.0]	68.0 [52.0, 77.0]	0.180
Calendar month			
2022/04 to 2022/06	1.1% (161)	21.1% (116,551)	1.104
2022/07 to 2022/09	2.8% (396)	20.4% (112,429)	
2022/10 to 2022/12	19.0% (2,661)	20.4% (112,301)	
2023/01 to 2023/03	31.9% (4,478)	20.4% (112,473)	
2023/04 to 2023/06	45.1% (6,326)	17.7% (97,561)	
Hospital scale			
< 200 beds	0.4% (59)	7.3% (40,318)	0.368
200–499 beds	55.3% (7,756)	54.3% (299,184)	
≧ 500 beds	44.3% (6,207)	38.4% (211,813)	
Designated cancer hospital	86.9% (12,184)	73.0% (402,470)	0.352
Department			
Gastroenterological surgery	30.4% (4,267)	22.6% (124,732)	0.647
Orthopedics	15.1% (2,121)	25.6% (141,022)	
Gynecology	10.5% (1,470)	8.6% (47,316)	
Thoracic surgery	10.4% (1,459)	4.7% (26,177)	
HBP surgery	10.3% (1,441)	8.4% (46,513)	
Spine surgery	7.9% (1,112)	7.6% (41,835)	
Urology	7.2% (1,004)	3.9% (21,472)	
Cardiovascular surgery	1.9% (267)	3.3% (18,144)	
Esophageal surgery	1.6% (227)	0.3% (1,704)	
Head and neck surgery	0.7% (97)	4.0% (22,296)	
Breast surgery	0.4% (56)	5.4% (29,519)	
Obstetrics	0.2% (33)	0.8% (4,318)	
Plastic surgery	0.1% (12)	0.7% (4,128)	
Neurosurgery	0.1% (12)	1.9% (10,688)	
Mixed	2.8% (395)	1.0% (5,497)	
Others	0.3% (49)	1.1% (5,954)	

SMD, standardized mean difference; IQR, interquartile range; HBP, hepatobiliary pancreatic

Data were presented as percentage (number) of patients unless otherwise indicated

among younger patients, whereas the opposite trend—lower total hospitalization costs and shorter stays—was observed among older patients. In particular, among 90-year-old patients, the estimated mean cost reduction [95% confidence interval (CI)] was 4.6% [2.1%, 7.0%] in men and 4.7% [2.4%, 6.9%] in women (Fig. 5a) and the mean reduction in overall hospital stay [95% CI] was 6.7% [3.0%, 10.3%] in men and 8.9% [5.6%, 12.1%] in women (Fig. 5b). This age-related tendency was confirmed for all the variables for which the interaction was considered, except for surgical department (Online Resource 4, 5). In multivariable regression analyses performed for each department separately, incorporating the interaction between age and APS addition, the same trend was observed in certain surgical departments such as spine surgery, orthopedic surgery, and hepatobiliary pancreatic surgery (Online Resource 6, 7).

Discussion

We conducted the first large-scale study of a new reimbursement fee within the Japanese medical payment system, known as APS addition, using a nationwide claims database. The overall proportion of APS addition claims was 2.48%, with the highest observed in esophageal surgery (11.8%). The claiming percentage began to rise in October 2022, approximately six months after the introduction of APS addition. This temporal increase may reflect institutional adaptation to the new reimbursement policy over time. For instance, Hascilowicz reported that hospitals with pre-existing APS-like systems responded more readily to the introduction of APS addition, followed by hospitals with newly installed APS [16]. In Japan, the second half of the fiscal year typically begins in October,

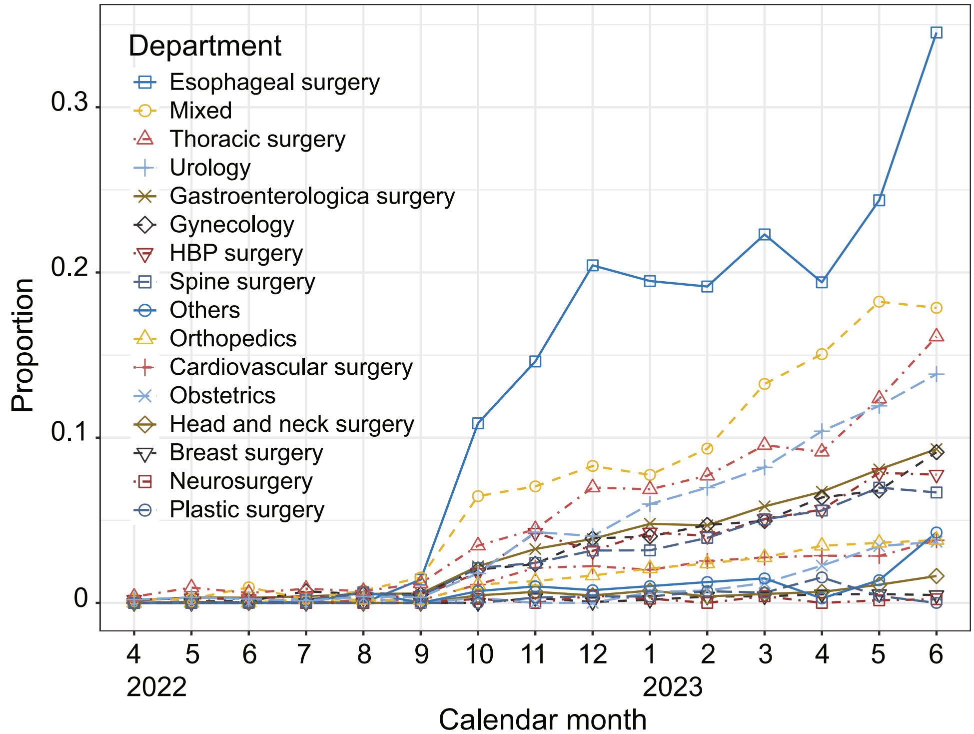

Fig. 2 Time series of APS addition claim rate for each department. The y-axis indicates the proportion of admissions for which APS addition was claimed relative to the total number of admissions. After the first six months, there is an increasing trend in all departments

Table 2 APS addition claim frequency by number of days and department

Department	1 day	2 days	3 days	Total
Obstetrics	12.1% (4)	3.0% (1)	84.8% (28)	33
Esophageal surgery	6.2% (14)	10.1% (23)	83.7% (190)	227
Others	10.2% (5)	6.1% (3)	83.7% (41)	49
Head and neck surgery	6.2% (6)	10.3% (10)	83.5% (81)	97
Mixed	15.0% (59)	11.2% (44)	73.9% (291)	394
HBP surgery	13.1% (187)	13.0% (186)	73.8% (1053)	1426
Breast surgery	17.0% (9)	11.3% (6)	71.7% (38)	53
Gynecology	20.4% (299)	8.5% (124)	71.2% (1044)	1467
Thoracic surgery	22.1% (318)	7.0% (101)	70.8% (1018)	1437
Gastroenterological surgery	16.7% (705)	13.3% (560)	70.0% (2955)	4220
Spine surgery	15.2% (169)	15.5% (172)	69.3% (769)	1110
Urology	20.1% (202)	12.3% (123)	67.6% (678)	1003
Orthopedics	25.3% (506)	15.7% (315)	59.0% (1181)	2002
Cardiovascular surgery	28.2% (75)	15.4% (41)	56.4% (150)	266
Plastic surgery	27.3% (3)	27.3% (3)	45.5% (5)	11
Neurosurgery	25.0% (3)	41.7% (5)	33.3% (4)	12

HBP, hepatobiliary pancreatic

Data were presented as percentage (number) of patients for days and number of patients for Total

Table 3 Baseline characteristics after propensity score matching

Variables	APS addition Claimed (n = 14,014)	None (n = 14,014)	SMD
Female sex	49.3% (6,915)	50.7% (7,109)	−0.028
Age (year), median [IQR]	70.0 [57.0, 77.0]	71.0 [59.0, 77.0]	−0.050
Calendar month			
2022/04 to 2022/06	1.1% (161)	1.3% (177)	0.084
2022/07 to 2022/09	2.8% (396)	3.4% (478)	
2022/10 to 2022/12	19.0% (2,659)	18.2% (2,548)	
2023/01 to 2023/03	31.9% (4,475)	34.4% (4,823)	
2023/04 to 2023/06	45.1% (6,323)	42.7% (5,988)	
Hospital scale			
< 200 beds	0.4% (59)	0.3% (45)	0.070
200–499 beds	55.3% (7,753)	52.0% (7,285)	
≥ 500 beds	44.3% (6,202)	47.7% (6,684)	
Designated cancer hospital	86.9% (12,176)	87.1% (12,202)	−0.006
Department			
Gastroenterological surgery	30.4% (4,266)	30.4% (4,266)	0[a]
Orthopedics	15.1% (2,121)	15.1% (2,121)	
Gynecology	10.5% (1,470)	10.5% (1,470)	
Thoracic surgery	10.4% (1,459)	10.4% (1,459)	
HBP surgery	10.3% (1,441)	10.3% (1,441)	
Spine surgery	7.9% (1,112)	7.9% (1,112)	
Urology	7.2% (1,003)	7.2% (1,003)	
Cardiovascular surgery	1.9% (267)	1.9% (267)	
Esophageal surgery	1.6% (227)	1.6% (227)	
Head and neck surgery	0.7% (96)	0.7% (96)	
Breast surgery	0.4% (56)	0.4% (56)	
Obstetrics	0.2% (33)	0.2% (33)	
Plastic surgery	0.1% (12)	0.1% (12)	
Neurosurgery	0.1% (11)	0.1% (11)	
Mixed	2.8% (391)	2.8% (391)	
Others	0.3% (49)	0.3% (49)	

SMD, standardized mean difference; IQR, interquartile range; HBP, hepatobiliary pancreatic

Data were presented as percentage (number) of patients unless otherwise indicated

[a]Surgical combinations are exactly matched, and consequently, departments are

which may have prompted many hospitals to revise their internal systems accordingly.

Apart from temporal trends, institutional and departmental characteristics also appeared to influence APS addition claims. APS addition was more frequently claimed by higher-functioning hospitals. 2.85% of patients in hospitals with ≥ 500 beds and 2.53% in those with 200–499 beds received APS addition, whereas only 0.15% of patients in smaller hospitals (< 200 beds) did. Similarly, the proportion of claims was higher in designated cancer hospitals than in non-designated hospitals (2.94% vs. 1.22%). This is likely because institutions with greater medical resources met the requirements for APS addition more easily. Previous studies in other countries showed that the percentage of APS implementation was higher in larger hospitals [11–14], with which our work is consistent. Although previous studies did not specify which surgical departments were most involved in APS implementation, our study found that the claiming rate of APS addition was particularly high in esophageal and thoracic surgery. On the other hand, in cardiovascular

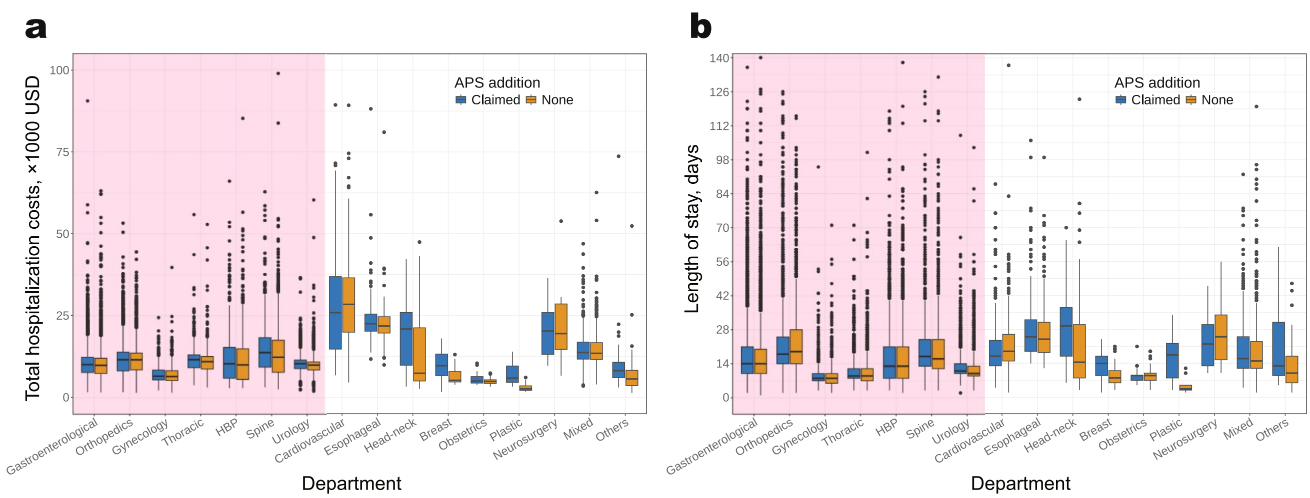

Fig. 3 Boxplots of total hospitalization costs and length of stay for each department. Boxplots of **a** total hospitalization costs and **b** length of stay are shown. In each figure, blue boxes indicate the group with APS addition, and yellow boxes indicate the group without APS addition. A red background indicates matched populations with acceptable balance, i.e., the absolute standardized mean differences for all variables under 0.2

surgery, even though open chest surgeries were performed, claiming APS addition was relatively infrequent. In addition, we observed notable variation in the number of days APS addition was claimed across departments. The proportion of patients for whom APS addition was claimed on all three eligible days was higher in esophageal and head and neck surgery. In contrast, departments such as cardiovascular surgery and orthopedics showed lower proportions of three-day claims. These differences highlight the potential influence of department-specific factors on the operationalization of APS.

However, it is important to note that the absence of an APS addition claim does not necessarily imply the absence of APS implementation. Some institutions may have provided APS or similar services without fulfilling all the formal requirements for claiming the reimbursement. Furthermore, the surgical department assignments were manually conducted based on procedure records and automatically combined, and they may not fully reflect the actual clinical department structures.

We applied propensity score matching to construct a matched cohort resembling patients who received APS addition and compared outcome distributions between the groups. Although covariate balance was generally achieved, some imbalance remained within certain departments, particularly in variables such as calendar month, hospital scale and designated cancer hospital. While no meaningful differences were observed in total hospitalization costs or length of stay between the matched groups, these residual imbalances may limit the interpretability of the findings. By contrast, analyses incorporating interaction terms between age and APS addition revealed reductions in both medical expenses and length of hospital stay, particularly among older patients. One possible explanation is that the benefits of enhanced postoperative pain management through APS may have contributed to earlier discharge in older patients, who may be more sensitive to pain-related complications. Conversely, APS addition may be associated with increased resource use in younger or low-risk patients, possibly due to additional monitoring or interventions. Though no direct causal conclusions can be drawn, previous studies have reported that inadequate postoperative analgesia can delay recovery and prolong hospital stay [3], supporting the plausibility of the observed associations. These findings may indicate that APS addition has contributed to shorter

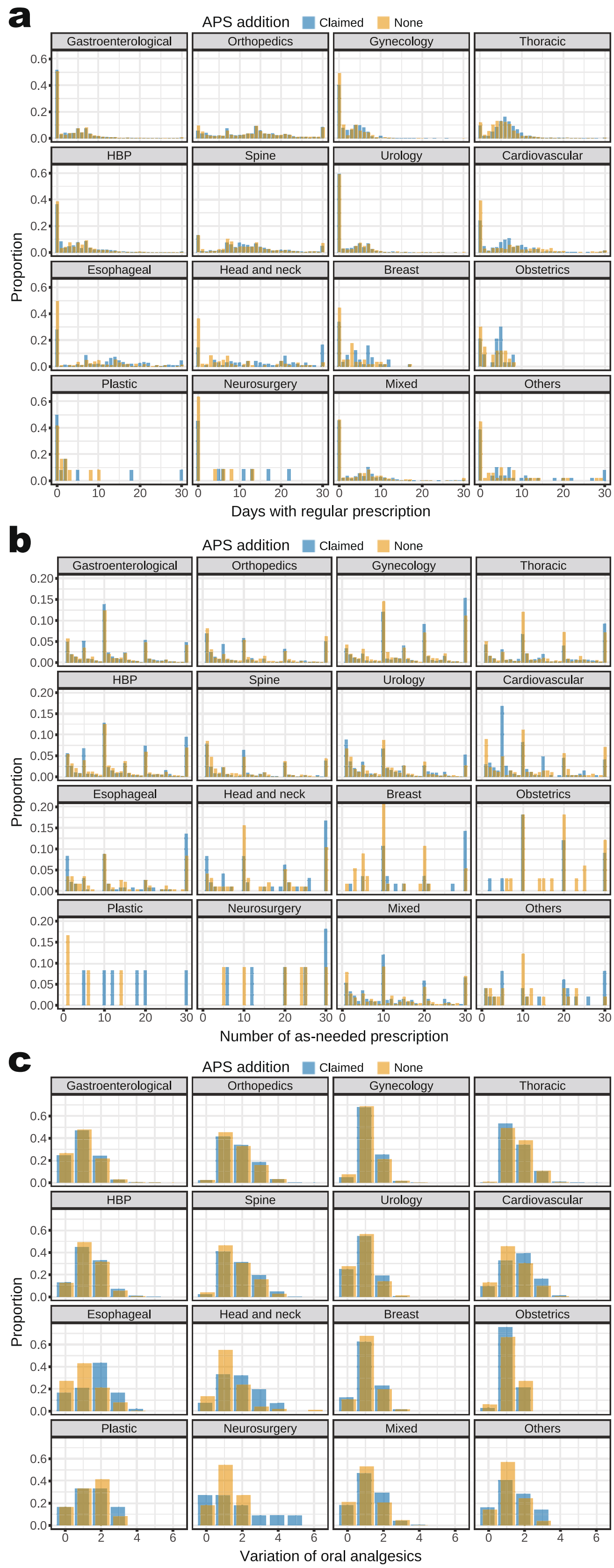

Fig. 4 Distributions about oral analgesic use. Frequency distributions of **a** the days with regular analgesic prescriptions, **b** the number of as-needed analgesic prescriptions, and **c** the number of oral analgesic variations are shown. In each figure, blue bars indicate the group with APS addition, and yellow bars indicate the group without APS addition. Frequencies were standardized in each department and group

Table 4 In-hospital mortality for each department after propensity score matching

Department	Dead % (n/number of pairs)	
	Claimed	None
Gastroenterological surgery	0.9% (38/4,266)	1.4% (60/4,266)
Orthopedics	0.1% (3/2,121)	0.7% (14/2,121)
Gynecology	0.0% (0/1,470)	0.0% (0/1,470)
Thoracic surgery	0.5% (7/1,459)	0.7% (10/1,459)
HBP surgery	0.5% (7/1,441)	0.7% (10/1,441)
Spine surgery	0.4% (4/1,112)	0.4% (4/1,112)
Urology	0.0% (0/1,003)	0.3% (3/1,003)
Cardiovascular surgery	1.9% (5/267)	3.4% (9/267)
Esophageal surgery	1.8% (4/227)	1.3% (3/227)
Head and neck surgery	0.0% (0/96)	0.0% (0/96)
Breast surgery	0.0% (0/56)	0.0% (0/56)
Obstetrics	0.0% (0/33)	0.0% (0/33)
Plastic surgery	0.0% (0/12)	0.0% (0/12)
Neurosurgery	0.0% (0/11)	0.0% (0/11)
Mixed	0.0% (0/391)	1.0% (4/391)
Others	0.0% (0/49)	0.0% (0/49)

HBP, hepatobiliary pancreatic

hospital stays and lower total hospitalization costs among older patients.

While we have discussed potential age-related differences in the effects of APS addition, we cannot disregard the possibility of unmeasured confounding. Due to the nature of the claims database, we were unable to obtain information on certain important factors—such as the severity of diseases, patient comorbidities, inter-hospital transfer policies and availability of receiving institutions, hospital specialization, funding policies, the specific content of postoperative management, rehabilitation practices, and the APS model—that may influence clinical outcomes. Because these factors were not accounted for in our analyses, the observed associations may reflect residual confounding or bias due to unmeasured factors. Therefore, we present our findings as preliminary and exploratory, and we suggest only the possibility that age-related variation in the effect of APS addition may exist.

Additionally, no apparent differences were observed in postoperative oral analgesic use between groups, including the number of regular and as-needed prescriptions, or the variety of drugs administered. Regarding patient-centered outcomes, we were only able to examine in-hospital death, which was infrequent and thus not amenable to formal statistical evaluation. While a slight trend toward fewer deaths in the APS addition group was observed in some departments, the numbers were too small to draw meaningful conclusions. Adequate postoperative pain management is known to improve both physical and psychological outcomes [1–3]. However, this study only discussed in-hospital death. Other important outcomes, such as pain severity, functional recovery, comorbidities, and quality of life, were not available in the database. To comprehensively evaluate the effect of APS addition, it is essential to go beyond administrative data and incorporate more patient-oriented outcomes.

The limitations of this study, some of which have been discussed above, are summarized below. First, the data we used were not originally collected for research purposes but derived from administrative claims. While the presence of an APS addition claim indicates that APS was likely provided to some extent, the absence of such a claim does not necessarily imply that APS was not implemented. Furthermore, the definitions of surgical procedures also might have differed from the actual procedures. Some degree of misclassification is unavoidable when using the nationwide claims database. However, it was reported that it is highly sensitive and specific for some procedures [19]. Thus, we can presume some accuracy for our setting. Second, the sample size for some departments was relatively small, which may have limited the statistical power to detect differences within those subgroups. Further evaluation of such departments requires more patients. Third, despite adjusting for several covariates, the analysis did not account for several potential unmeasured confounders. These unmeasured factors may have influenced the outcomes and should be considered when interpreting the results. Finally, this study mainly focused on hospital management outcomes. Patient-oriented measures were not assessed, underscoring the need for future studies incorporating more granular clinical data. Such outcomes are particularly important when evaluating pain management interventions, as administrative data alone cannot capture subjective pain experiences or patient satisfaction.

In conclusion, we used a nationwide claims database to describe the early status of APS addition implementation in Japan and explored its association with selected clinical and hospital management outcomes. While matched comparisons showed no clear differences, subgroup analyses indicated that APS addition was associated with lower hospitalization costs and shorter stays among older patients. These exploratory findings may inform future research on postoperative pain management and reimbursement strategies.

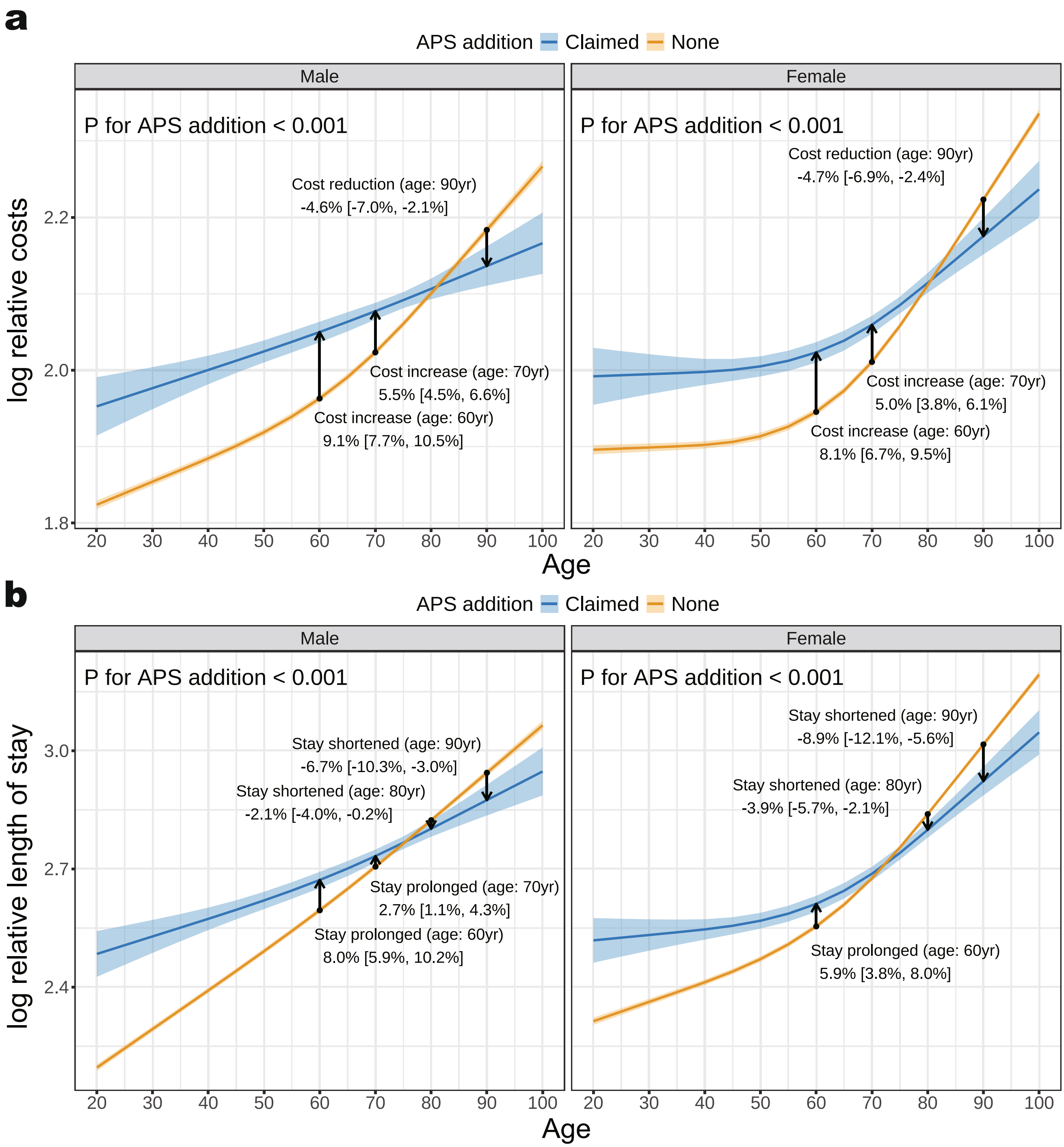

Fig. 5 Predictive means of the age- and sex-specific population. Predictive means of **a** total hospitalization costs and **b** length of hospital stay are shown. *P* for APS addition is shown on the top left in each plot. If the overall effect was significant, the effects in some specific-age populations were plotted. Blue and yellow lines indicate the group with APS addition and without APS addition, respectively. Each line was plotted with its 95% confidence interval, which was drawn as a colored area. These results were adjusted by hospital scale, designated cancer hospital, calendar month, and surgical category

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s00540-025-03522-w.

Acknowledgements The authors used ChatGPT-4o (OpenAI) to assist in structuring and refining parts of the manuscript.

Author contributions Conceptualization: Yuta Nonomiya, Hiroshi Morimatsu, Daijiro Kabata, Ayumi Shintani; Methodology: Yuta Nonomiya, Daijiro Kabata, Ayumi Shintani; Formal analysis and investigation: Yuta Nonomiya, Kaori Kuriu; Writing—original draft preparation: Yuta Nonomiya; Writing—review and editing: Yuta Nonomiya, Hiroshi Morimatsu, Kaori Kuriu, Daijiro Kabata, Ayumi Shintani; Resources: Ayumi Shintani; Supervision: Daijiro Kabata, Ayumi Shintani.

Data availability The data used in this study cannot be shared with external researchers according to the contract with MDV.

Declarations

Conflict of interest Yuta Nonomiya is receiving a fellowship for the Next Generation AI Human Resource Development Project of Osaka Metropolitan University; Hiroshi Morimatsu has no conflict of interest; Kaori Kuriu has no conflict of interest; Daijiro Kabata has no conflict of interest; Ayumi Shintani is receiving personal fees from AbbVie, Asahi Kasei Corporation, AstraZeneca plc, Astellas Pharma, Bayer Yakuhin, Bristol Myers Squibb, Chugai Pharmaceutical, Daiichi Sankyo, Eisai, Janssen Pharmaceutical, Kissei Pharmaceutical, Kyowa Kirin, Mallinckrodt Pharmaceuticals, Merck Biopharma, Maruho, Mitsubishi Tanabe Pharma Corporation, Nipro Corporation, Novo Nordisk Pharma, Nippon Shinyaku, Ono Pharmaceutical, Pfizer, Shionogi Pharma, Takeda Pharmaceutical Company Limited, Taisho Pharmaceutical, Torii Pharmaceutical, Sanofi K.K., Nippon Kayaku, JCR Pharmaceuticals Co., and MSD.

References

1. Breivik H. Postoperative pain management: why is it difficult to show that it improves outcome? Eur J Anaesthesiol. 1998;15:748–51.
2. Joshi GP, Ogunnaike BO. Consequences of inadequate postoperative pain relief and chronic persistent postoperative pain. Anesthesiol Clin North America. 2005;23:21–36.
3. Rawal N. Current issues in postoperative pain management. Eur J Anaesthesiol. 2016;33:160–71.
4. Ready LB, Oden R, Chadwick HS, Benedetti C, Rooke GA, Caplan R, Wild LM. Development of an anesthesiology-based postoperative pain management service. Anesthesiology. 1988;68:100–6.
5. Maier C, Kibbel K, Mercker S, Wulf H. Postoperative pain therapy at general nursing stations. An analysis of eight year's experience at an anesthesiological acute pain service. Anaesthesist. 1994;43:385–97.
6. Zimmermann DL, Stewart J. Postoperative pain management and acute pain service activity in Canada. Can J Anaesth. 1993;40:568–75.
7. Goucke CR, Owen H. Acute pain management in Australia and New Zealand. Anaesth Intensive Care. 1995;23:715–7.
8. Merry A, Judge MA, Ready B. Acute pain services in New Zealand hospitals; a survey. N Z Med J. 1997;110:233–5.
9. Rawal N, Allvin R. Acute pain services in Europe: a 17-nation survey of 105 hospitals. Eur J Anaesthesiol. 1998;15:354–63.
10. Harmer M, Davies KA. The effect of education, assessment and a standardised prescription on postoperative pain management. The value of clinical audit in the establishment of acute pain services. Anaesthesia. 1998;53:424–30.
11. Nasir D, Howard JE, Joshi GP, Hill GE. A survey of acute pain service structure and function in United States hospitals. Pain Res Treat. 2011;2011:934932.
12. van Boekel RLM, Steegers MAH, Verbeek-van Noord I, van der Sande R, Vissers KCP. Acute pain services and postsurgical pain management in the Netherlands: a survey. Pain Pract. 2015;15:447–54.
13. Erlenwein J, Koschwitz R, Pauli-Magnus D, Quintel M, Meißner W, Petzke F, Stamer UM. A follow-up on Acute Pain Services in Germany compared to international survey data. Eur J Pain. 2016;20:874–83.
14. Lovasi O, Lám J, Schutzmann R, Gaál P. Acute Pain Service in Hungarian hospitals. PLoS ONE. 2021;16: e0257585.
15. Nakatsuka H. [Postoperative pain management in Okayama University] Okayama daigaku ni okeru jutsugo toutsu kanri (in Japanese). J Jpn Soc Clin Anesth. 2003;23:212–7.
16. Hascilowicz T. Acute Pain Service: An overview of the present status in Japan and abroad (in Japanese). Pein Kurinikku (Pain Clinic). 2023;44:241–9.
17. Rosenbaum PR, Rubin DB. Constructing a control group using multivariate matched sampling methods that incorporate the propensity score. Am Stat. 1985;39:33–8.
18. Harrell FE Jr, Lee KL, Pollock BG. Regression models in clinical studies: determining relationships between predictors and response. J Natl Cancer Inst. 1988;80:1198–202.
19. Yamana H, Moriwaki M, Horiguchi H, Kodan M, Fushimi K, Yasunaga H. Validity of diagnoses, procedures, and laboratory data in Japanese administrative data. J Epidemiol. 2017;27:476–82.