Research Square

Preprints are preliminary reports that have not undergone peer review.
They should not be considered conclusive, used to inform clinical practice,
or referenced by the media as validated information.

Prefecture-Level Uptake of Robot-Assisted Colectomy in Japan: Association With Prior Robotic Rectal Surgery Activity in NDB Open Data

Masanori Sato

msnrsato@hama-med.ac.jp

Hamamatsu University School of Medicine

Kyota Tatsuta

Hamamatsu University School of Medicine

Mikihiro Shimizu

Hamamatsu University School of Medicine

Kosuke Sugiyama

Hamamatsu University School of Medicine

Mayu Sakata

Hamamatsu University School of Medicine

Toshiya Akai

Hamamatsu University School of Medicine

Hiroya Takeuchi

Hamamatsu University School of Medicine

Research Article

Keywords: Robotic surgery, Colectomy, Rectal surgery, Technology diffusion, Regional variation, National Database of Health Insurance Claims

Posted Date: November 24th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-11711626/v1

License: This work is licensed under a Creative Commons Attribution 4.0 International License.
Read Full License

Additional Declarations: No competing interests reported.

Abstract

Background

Robot-assisted colectomy was covered by national health insurance in Japan in 2022, four years after robot-assisted rectal surgery. We examined the association between prior robotic rectal surgery activity and subsequent colectomy uptake across prefectures.

Methods

We conducted a nationwide longitudinal ecological study using National Database (NDB) Open Data and Hospital Function Reports from 47 prefectures. Prior rectal activity was defined as the cumulative number of robotic rectal procedures per 100,000 population during 2018–2021. We used generalized estimating equations to examine its association with the proportion of robotic colectomies among minimally invasive colectomies during 2022–2024. We adjusted for fiscal year, robotic system density, prior robotic gastrectomy and robot-assisted radical prostatectomy volumes, and the proportion of residents aged ≥ 65 years.

Results

The number of robotic colectomies in Japan increased from 1,653 (3.4%) in 2022 to 10,674 (19.5%) in 2024. A 1-standard-deviation increase in prior rectal activity was associated with a 2.75-percentage-point higher robotic colectomy proportion (95% CI, 0.60–4.89; $p = 0.012$). Robotic system density and prior gastric and prostate robotic activity showed no significant associations. The association remained significant in analyses using different values for suppressed counts and in the weighted analysis, but was no longer significant after excluding Shizuoka Prefecture.

Conclusions

Prefectures with more prior robotic rectal surgery activity had higher subsequent uptake of robotic colectomy, even after adjustment for robotic system density and prior robotic activity in other fields. Robotic colectomy increased rapidly after 2022, although the association was sensitive to the inclusion of Shizuoka Prefecture.

Introduction

In Japan, robot-assisted rectal surgery was covered by national health insurance in April 2018 and has since become widely used [1–3]. Robot-assisted colectomy was covered four years later, in April 2022 [4, 5]. Introducing robotic surgery requires robotic systems, trained surgeons, surgical teams, and proctoring

[6]. Thus, prior experience with robotic rectal surgery may be related to the subsequent uptake of robotic colectomy.

Robot-assisted gastrectomy and rectal surgery were both covered by national health insurance in 2018 and expanded during the same period. Prior robotic gastrectomy activity may reflect the ability of gastrointestinal surgery departments to introduce robotic procedures. In contrast, prior robotic rectal surgery may be more closely related to the experience of colorectal surgeons and their teams. Robot-assisted radical prostatectomy (RARP) was already widely performed in Japan before robotic gastrointestinal surgery became common [7, 8]. A high RARP caseload per robotic system might reduce the operating time available for gastrointestinal surgery. However, the associations of prior robotic procedures and system availability with subsequent robotic colectomy uptake remain unclear.

This study aimed to describe national trends and prefecture-level variation in the adoption of robot-assisted colectomy and rectal surgery in Japan between fiscal years 2018 and 2024 using the National Database of Health Insurance Claims and Specific Health Checkups of Japan (NDB) Open Data and publicly available Hospital Function Reports. We further investigated whether prefecture-level experience with robot-assisted rectal surgery during 2018–2021 was associated with the adoption of robot-assisted colectomy following its insurance coverage in 2022. To assess this association while accounting for general robotic capacity and broader gastrointestinal robotic readiness, we accounted for regional robotic system density and the uptake of robot-assisted gastrectomy. In an exploratory analysis, we also evaluated the relationship between the RARP caseload per robotic system and the adoption of robot-assisted gastrointestinal surgery.

Methods

Study design and data sources

This nationwide longitudinal ecological study included all 47 Japanese prefectures from fiscal years 2018 to 2024. We obtained annual numbers of laparoscopic and robotic colon, rectal, and gastric procedures and radical prostatectomies from NDB Open Data [9]. Numbers of robotic systems were obtained from Hospital Function Reports for 2016–2024 [10], and prefecture populations from official statistics [11]. The primary analysis included 141 prefecture-year observations (47 prefectures × 3 years, 2022–2024).

Identification of robotic procedures

We identified procedures using reimbursement codes (Table 1 and Supplementary Table S1 in Online Resource 1). Colectomy and gastrectomy were limited to malignant tumors. Open colectomy and procedures performed for intestinal obstruction were excluded. Rectal surgery included rectal resection, low anterior resection, and abdominoperineal resection, with additional procedures included when new

codes became available. Benign rectal disease could not be excluded because diagnosis codes were unavailable.

For colon, rectal, and gastric surgery, the robotic proportion was the number of robotic procedures divided by the total number of robotic and conventional laparoscopic procedures. RARP was assessed as a proportion of all radical prostatectomies and as the number of procedures per robotic system.

Table 1
Definitions of surgical procedures included in the analysis

Organ	Robotic procedures	Comparator procedures	Definition and key considerations
Colon	Colectomy	Laparoscopic colectomy	Malignant tumors
Rectum	Rectal resection	Laparoscopic rectal resection	Benign and malignant diseases
Stomach	Robot-assisted laparoscopic gastrectomy, proximal gastrectomy, and total gastrectomy for malignant tumors	Corresponding conventional laparoscopic gastric procedures for malignant tumors	Malignant tumors
Prostate	Radical prostatectomy	Open, laparoscopic, and minimum-incision endoscopic prostatectomy	

Robotic and comparator procedures were defined using corresponding reimbursement codes. Robotic proportions for colon, rectum, and stomach were calculated among minimally invasive procedures. Additional rectal procedures were included from 2024. Detailed procedure codes, exclusions, and year-specific definitions are provided in Supplementary Table S1.

Robotic system availability

We reviewed facility-level robotic systems counts for unlikely changes over time. Missing values were distinguished from reported zeros. Suspected errors were corrected based on trends over time and available external information (Supplementary Methods). We used the corrected counts to calculate robotic systems per 100,000 population and procedures per system.

Outcomes and exposure variables

The primary outcome was the prefecture-level proportion of robotic colectomies during 2022–2024. The primary exposure was the cumulative number of robotic rectal procedures during 2018–2021 per 100,000 population in 2021. Covariates were fiscal year, robotic system density in the corresponding

year, prior robotic gastrectomy and RARP volumes during 2018–2021, and the proportion of residents aged ≥ 65 years.

Handling of suppressed values

In NDB Open Data, suppressed cells represented 0–9 procedures during 2018–2021 and 1–9 procedures from 2022 onward. We replaced suppressed counts with 5 in the primary analysis. Sensitivity analyses used the lower and upper bounds (0 or 9 before 2022; 1 or 9 from 2022). Reported zeros were unchanged.

Statistical analysis

Continuous variables are presented as means and standard deviations. We used Spearman correlation coefficients to examine the association between prior robotic rectal surgery activity and the robotic colectomy proportion in each year from 2022 to 2024.

For the primary longitudinal analysis, we used generalized estimating equations (GEE) with a Gaussian distribution, identity link, independence working correlation, and robust standard errors to account for repeated observations within prefectures [12]. Continuous predictors were standardized. Coefficients are presented as adjusted percentage-point differences per 1-standard-deviation increase, with 95% confidence intervals. For prior robotic rectal surgery activity, 1 SD was 7.37 procedures per 100,000 population.

We selected covariates based on their clinical relevance rather than univariable *p*-values. Model 1 included prior robotic rectal surgery activity and fiscal year. Model 2 additionally included robotic system density. Model 3 further included prior robotic gastrectomy, prior RARP, and the proportion of residents aged ≥ 65 years. We repeated Model 3 after excluding each prefecture in turn.

In secondary analysis, we examined prior robotic gastrectomy activity and RARP procedures per robotic system. An exploratory GEE model replaced prior RARP volume with the annual number of RARP procedures per robotic system, while keeping the other covariates unchanged.

We repeated Model 3 using the lower and upper bounds for suppressed counts. We also performed a weighted GEE analysis using the number of eligible minimally invasive colectomies in each prefecture-year as the weight. All tests were two-sided, and $p < 0.05$ was considered statistically significant. Analyses were performed using R version 4.5.2 (R Foundation for Statistical Computing, Vienna, Austria) and the *geepack* package (version 1.3.13). ChatGPT (OpenAI) was used to assist in generating R code for the statistical analyses. The authors reviewed and executed the code and verified the analytical results.

Ethical considerations

We used only publicly available aggregate data without personal identifiers. Institutional review board approval and informed consent were not required.

Results

National trends in robotic surgery

The number of robotic surgical systems in Japan increased from 284 in 2018 to 427 in 2021, 497 in 2022, and 754 in 2024 (Fig. 1a). The proportion of robotic rectal procedures among minimally invasive rectal procedures increased from 6.3% in 2018 to 21.0% in 2021 and 44.2% in 2024. The corresponding proportions for gastric surgery were 7.2%, 18.2%, and 39.9% (Fig. 1b). Prefecture-level characteristics are shown in Table 2.

Table 2
Prefecture-level characteristics of the analytic dataset

Variable	Prior experience (2018–2021)	FY2022	FY2023	FY2024
Prior robotic experience				
Robotic rectal surgery, per 100,000 population	12.5 (7.4)	—	—	—
Robotic gastrectomy, per 100,000 population	10.0 (6.3)	—	—	—
RARP, per 100,000 population	58.0 (21.9)	—	—	—
Variables during the analytic period				
Eligible minimally invasive colectomies, n	—	1038.9 (1066.4)	1143.8 (1182.0)	1162.0 (1185.6)
Robot-assisted colectomy proportion, %	—	2.4 (3.0)	9.4 (6.8)	16.3 (9.6)
Robotic system density, per 100,000 population	—	0.40 (0.16)	0.51 (0.21)	0.63 (0.21)
Population aged ≥ 65 years, %	—	31.4 (3.3)	31.6 (3.3)	31.8 (3.4)

Values are mean (SD) across 47 prefectures. Prior experience was defined as the cumulative number of robotic procedures during fiscal years 2018–2021 per 100,000 population in 2021. Continuous predictors were standardized across the 141 prefecture-year observations; 1 SD of prior robotic rectal surgery experience corresponded to 7.37 procedures per 100,000 population. Procedure counts use the primary replacement of 5 for suppressed cells. Eligible minimally invasive colectomies were the sum of

robot-assisted and conventional laparoscopic colectomies. FY, fiscal year; RARP, robot-assisted radical prostatectomy; SD, standard deviation.

Association between prior robotic rectal surgery activity and robotic colectomy uptake

Prior robotic rectal surgery activity was positively correlated with the robotic colectomy proportion in 2022, 2023, and 2024 (Spearman's ρ = 0.482, 0.482, and 0.443; p < 0.001, p < 0.001, and *p* = 0.002, respectively; Fig. 2). The longitudinal analysis included 141 observations. The association was positive in all three models (Table 3). In Model 3, a 1-standard-deviation increase in prior activity (7.37 procedures per 100,000 population) was associated with a 2.75-percentage-point higher robotic colectomy proportion (95% CI, 0.60–4.89; *p* = 0.012). A higher proportion of residents aged ≥ 65 years was also associated with a lower robotic colectomy proportion in Model 3 (adjusted difference, − 2.48 percentage points; *p* < 0.001).

When Model 3 was repeated using robotic system density in 2021 or without adjustment for system density, the adjusted differences were 3.26 percentage points (95% CI, 1.08–5.43; *p* = 0.003) and 3.11 percentage points (95% CI, 1.01–5.20; *p* = 0.004), respectively.

In leave-one-prefecture-out analyses, the association remained positive in all 47 analyses and significant in 46. After excluding Shizuoka Prefecture, the association was no longer statistically significant (adjusted difference, 1.59 percentage points; 95% CI, − 0.20–3.38; *p* = 0.082; data not shown).

Table 3
Multivariable associations with the prefecture-level proportion of robotic colectomy, 2022–2024

Variable	Model 1		Model 2		Model 3	
	Coefficient (95% CI)	*p* value	Coefficient (95% CI)	*p* value	Coefficient (95% CI)	*p* value
Prior robotic rectal experience	3.26 (1.33 to 5.19)	< 0.001	2.55 (0.38 to 4.71)	0.021	2.75 (0.60 to 4.89)	0.012
Robotic-system density	-	-	1.25 (-1.22 to 3.71)	0.332	1.08 (-1.98 to 4.14)	0.489
Prior robotic gastrectomy experience	-	-	-	-	0.17 (-2.31 to 2.65)	0.893
Prior RARP experience	-	-	-	-	-0.15 (-1.74 to 1.45)	0.857
Population aged 65 years or older	-	-	-	-	-2.48 (-3.91 to -1.05)	< 0.001
Calendar year (reference: 2022)						
2023	6.97 (5.58 to 8.35)	< 0.001	6.34 (4.45 to 8.24)	< 0.001	6.60 (4.49 to 8.71)	< 0.001
2024	13.87 (11.60 to 16.14)	< 0.001	12.53 (8.70 to 16.35)	< 0.001	13.07 (8.84 to 17.30)	< 0.001

Values are regression coefficients expressed as percentage-point differences in the robotic colectomy proportion per 1-SD increase in each continuous predictor, with 95% confidence intervals. The analysis included 141 prefecture-year observations (47 prefectures, 2022–2024). Model 1 included prior robotic rectal experience and calendar year; Model 2 additionally included robotic-system density; and Model 3 additionally included prior robotic gastrectomy experience, prior RARP experience, and the proportion of the population aged 65 years or older. Continuous predictors were standardized before regression. Suppressed counts were assigned a value of 5 in the primary analysis. CI, confidence interval; RARP, robot-assisted radical prostatectomy; SD, standard deviation.

Comparison with robotic gastrectomy experience

We examined prior robotic gastrectomy activity because gastrectomy and rectal surgery were both covered by insurance in 2018. Prior robotic rectal and gastric activity were correlated across prefectures (Spearman's ρ = 0.693; $p < 0.001$; Supplementary Fig. S1a). Both were positively correlated with the robotic colectomy proportion (Supplementary Fig. S1b, c). However, after adjustment for both measures, prior robotic gastrectomy activity was not significantly associated with robotic colectomy uptake (0.17

percentage points; 95% CI, − 2.31–2.65; p = 0.893), whereas the association with prior rectal activity remained significant (Table 3).

Relationship with RARP utilization

We examined prior RARP activity and the number of RARP procedures per robotic system. In 2024, RARP procedures per system were not significantly correlated with the robotic proportions of colectomy, rectal surgery, or gastrectomy (Supplementary Fig. S2). Prior RARP activity was not significantly associated with the robotic colectomy proportion in Model 3 (− 0.15 percentage points; 95% CI, − 1.74–1.45; p = 0.857; Table 3). Similarly, in the exploratory model using annual RARP procedures per system, the association was not significant (0.17 percentage points; 95% CI, − 0.73–1.06; p = 0.713). The association with prior robotic rectal activity remained significant (2.76 percentage points; 95% CI, 0.63–4.88; p = 0.011).

Sensitivity analyses

We performed two sensitivity analyses (Supplementary Table S2). First, replacing suppressed counts with their lower or upper bounds gave similar results (2.73 percentage points; 95% CI, 0.75–4.71; p = 0.007, and 2.79 percentage points; 95% CI, 0.42–5.17; p = 0.021, respectively). Second, the association remained significant when observations were weighted by the number of eligible minimally invasive colectomies (3.17 percentage points; 95% CI, 0.88–5.46; p = 0.007).

Discussion

In this nationwide study, the proportion of robotic colectomies increased from 3.4% in 2022 to 19.5% in 2024. Prefectures with more prior robotic rectal surgery activity had higher robotic colectomy proportions during 2022–2024, even after adjustment for robotic system density, prior robotic activity in other fields, and population characteristics. This was consistent with our hypothesis. Our study quantified this association using nationwide data and showed that it remained significant after adjustment for robotic system density and prior robotic activity in other surgical fields. Few previous studies have examined this association at the prefecture level.

Prior robotic rectal surgery may have helped surgeons and hospitals prepare for robotic colectomy. In Japan, robotic rectal surgery was covered by insurance in 2018, four years before robotic colectomy [1, 5]. Previous studies have reported the importance of surgeon training, experienced surgical teams, and proctoring when introducing robotic colorectal surgery [13–16]. However, we could not determine whether the observed association was related to colorectal-specific experience or general experience with robotic surgery.

We also evaluated prior robotic gastrectomy activity to explore whether the observed association reflected broader gastrointestinal robotic activity. Although prior rectal and gastric activity were correlated, the association with prior rectal activity persisted when both were included in the model. Neither prior gastric activity nor robotic system density was significantly associated with colectomy

uptake, but their confidence intervals did not exclude potentially meaningful associations. A higher proportion of residents aged ≥ 65 years was associated with lower robotic colectomy uptake, possibly reflecting regional differences in healthcare resources and access to robotic surgery.

We also examined whether greater use of robotic systems for prostate surgery was associated with lower use of robotic surgery in gastrointestinal surgery. We found no significant negative correlation between RARP procedures per robotic system and the proportions of robotic gastrointestinal procedures. RARP utilization was also not significantly associated with robotic colectomy uptake in the adjusted analysis. These results suggest that prior surgical experience may be important for the adoption of robotic colectomy, in addition to the availability of robotic systems. Further hospital- and surgeon-level studies are needed to examine whether prior robotic rectal surgery experience contributes to the introduction of robotic colectomy.

The leave-one-prefecture-out analyses showed that the estimated association was sensitive to the inclusion of Shizuoka Prefecture. Excluding Shizuoka attenuated the association, which was no longer statistically significant in either the unweighted or volume-weighted analysis. One possible explanation is the concentration of robotic colorectal surgery in high-volume centers within the prefecture, rather than uniformly greater uptake across its hospitals. This possibility could not be examined using the available aggregate data.

This study has several limitations. First, this was a prefecture-level study, and we could not determine whether experience with robotic rectal surgery was used to introduce robotic colectomy within the same hospitals or surgical teams. Therefore, the observed association does not establish a causal relationship. Second, aggregate data limited adjustment for patient, hospital, and regional characteristics. Concentration of procedures in high-volume centers and cross-prefectural referrals may influence prefecture-level estimates, particularly procedure counts per population. Prior robotic activity may also have increased system availability and thereby facilitated colectomy uptake. Adjusting contemporaneous system density could therefore remove part of this relationship. Third, small procedure counts were suppressed in the NDB Open Data, and the Hospital Function Reports provided limited information on robotic systems and their use. However, sensitivity analyses using different assumptions for suppressed counts showed consistent results.

Conclusion

Robot-assisted colectomy increased rapidly in Japan after national insurance coverage began in 2022. Greater prior robotic rectal surgery activity was associated with higher subsequent robotic colectomy uptake at the prefecture level, even after adjustment for robotic system availability and prior robotic activity in other surgical fields. The magnitude of this association was sensitive to the inclusion of Shizuoka Prefecture.

Declarations

Author Contribution

Masanori Sato contributed to the study conception and design, methodology, data curation, formal analysis, visualization, and preparation of the first draft. Mikihiro Shimizu provided statistical advice and critically reviewed and revised the manuscript. Kyota Tatsuta, Kosuke Sugiyama, Mayu Sakata, Toshiya Akai, and Hiroya Takeuchi critically reviewed and revised the manuscript. All authors read and approved the final manuscript.

Data Availability

The source data are publicly available from the Ministry of Health, Labour and Welfare's NDB Open Data and Hospital Function Reports, and the Statistics Bureau of Japan's Population Estimates. Detailed procedure definitions are provided in Supplementary Table S1.

References

1. Matsuyama T, Endo H, Yamamoto H, Takemasa I, Uehara K, Hanai T et al (2021) Outcomes of robot-assisted versus conventional laparoscopic low anterior resection in patients with rectal cancer: propensity-matched analysis of the National Clinical Database in Japan. BJS Open 5:zrab083. https://doi.org/10.1093/bjsopen/zrab083
2. Nishigori T, Ichihara N, Obama K, Uyama I, Miyata H, Inomata M et al (2022) Prevalence and safety of robotic surgery for gastrointestinal malignant tumors in Japan. Ann Gastroenterol Surg 6:746–752. https://doi.org/10.1002/ags3.12579
3. Takemasa I, Yamamoto H, Nishigori T, Fujita T, Makino T, Taniyama Y et al (2026) First Annual Report for Robot-Assisted Surgery Based on the National Clinical Database 2019 in Japan: Report on Three Major Gastrointestinal Fields. Asian J Endosc Surg 19:e70220. https://doi.org/10.1111/ases.70220
4. Omura T, Kamihara T, Omura T (2026) Early Diffusion and Regional Variation in Robot-Assisted Laparoscopic Resection for Malignant Colon Tumors in Japan: An. Asian J Endosc Surg 19:e70343. https://doi.org/10.1111/ases.70343. Analysis of National Database Open Data From Fiscal Years 2022 and 2023
5. Yamauchi S, Shiomi A, Matsuda C, Takemasa I, Hanai T, Uemura M et al (2023) Robotic-assisted colectomy for right-sided colon cancer: Short-term surgical outcomes of a multi-institutional prospective cohort study in Japan. Ann Gastroenterol Surg 7:932–939. https://doi.org/10.1002/ags3.12694
6. Minamimura K, Hara K, Matsumoto S, Yasuda T, Arai H, Kakinuma D et al (2023) Current Status of Robotic Gastrointestinal Surgery. J Nippon Med Sch 90:308–315. https://doi.org/10.1272/jnms.JNMS.2023_90-404
7. Nakamura M, Suzuki M, Izumi T, Tsuru I, Muraki Y, Kume H (2023) Trends in surgical treatment for prostate cancer: Analysis of National Database Open Data in Japan. GHM 5:62–63.

https://doi.org/10.35772/ghm.2022.01065

8. Nishimura K (2015) Current status of robotic surgery in Japan. Korean J Urol 56:170. https://doi.org/10.4111/kju.2015.56.3.170
9. Ministry of Health Labour and Welfare NDB Open Data. In: Ministry of Health, Labour and Welfare. https://www.mhlw.go.jp/stf/seisakunitsuite/bunya/0000177182.html. Accessed 10 Sept 2026
10. Ministry of Health Labour and Welfare Hospital Function Reports. In: Ministry of Health, Labour and Welfare. https://www.mhlw.go.jp/stf/seisakunitsuite/bunya/0000055891.html. Accessed 11 Sept 2026
11. Statistics Bureau of Japan, Ministry of Internal Affairs and Communications (2025) Population Estimates. In: Population Estimates. https://www.stat.go.jp/english/data/jinsui/index.html. Accessed 4 Jan 2026
12. Liang K-Y, Zeger SL (1986) Longitudinal data analysis using generalized linear models. Biometrika 73:13–22. https://doi.org/10.1093/biomet/73.1.13
13. Panteleimonitis S, Popeskou S, Aradaib M, Harper M, Ahmed J, Ahmad M et al (2018) Implementation of robotic rectal surgery training programme: importance of standardisation and structured training. Langenbecks Arch Surg 403:749–760. https://doi.org/10.1007/s00423-018-1690-1
14. Wong NW, Teo NZ, Ngu JC-Y (2024) Learning Curve for Robotic Colorectal Surgery. Cancers 16:3420. https://doi.org/10.3390/cancers16193420
15. Suda K, Yamamoto H, Nishigori T, Obama K, Yoda Y, Hikage M et al (2022) Safe implementation of robotic gastrectomy for gastric cancer under the requirements for universal health insurance coverage: a retrospective cohort study using a nationwide registry database in Japan. Gastric Cancer 25:438–449. https://doi.org/10.1007/s10120-021-01257-7
16. Vining CC, Skowron KB, Hogg ME (2021) Robotic gastrointestinal surgery: learning curve, educational programs and outcomes. Updates Surg 73:799–814. https://doi.org/10.1007/s13304-021-00973-0

Figures

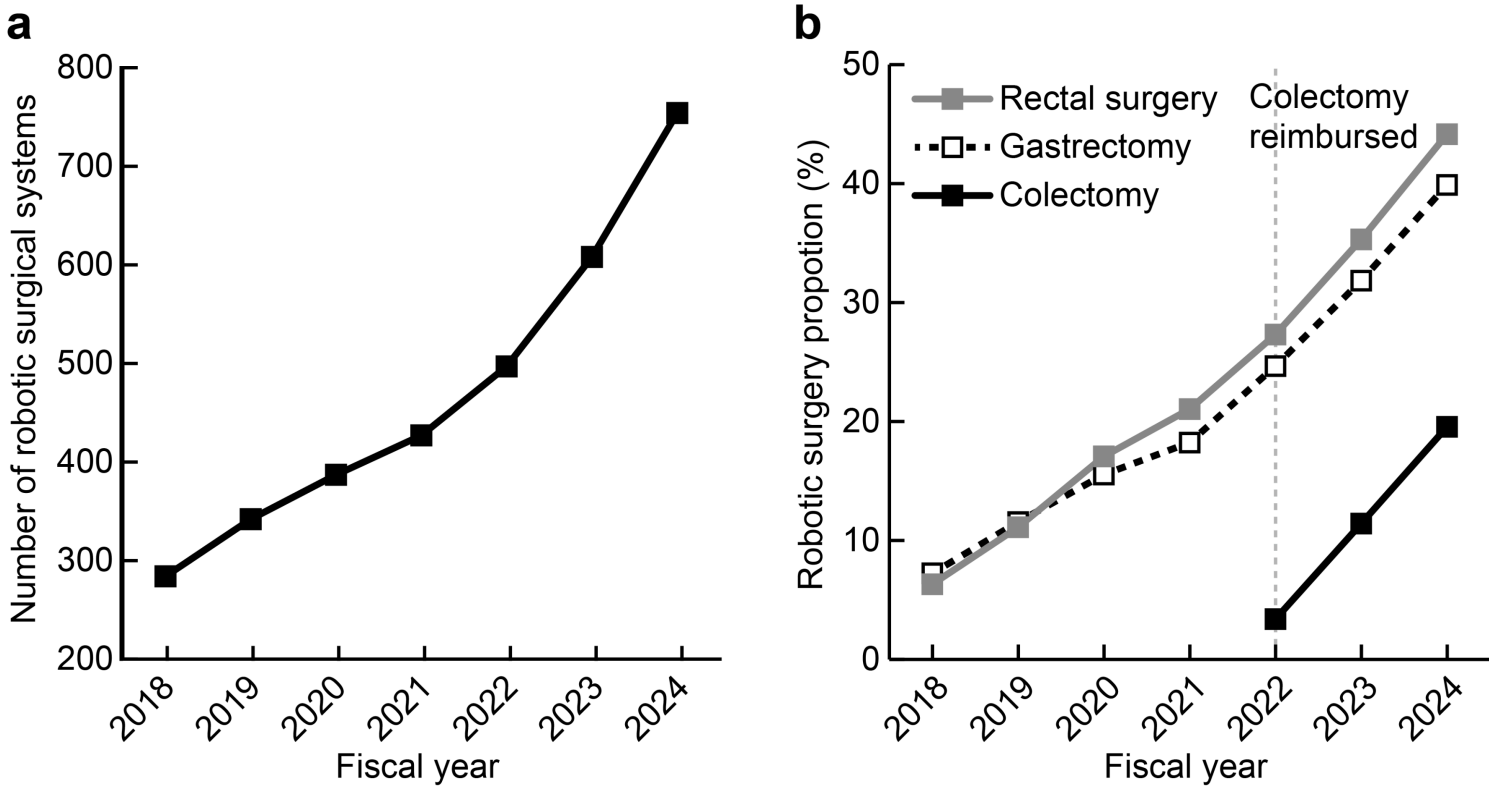

Figure 1

National trends in robotic surgery in Japan, 2018–2024. (a) Annual number of robotic surgical systems reported in Hospital Function Reports. (b) National proportions of robotic rectal surgery and gastrectomy among the corresponding minimally invasive procedures during 2018–2024, and robotic colectomy during 2022–2024. The vertical dotted line marks the start of national health insurance coverage for robotic colectomy in 2022.

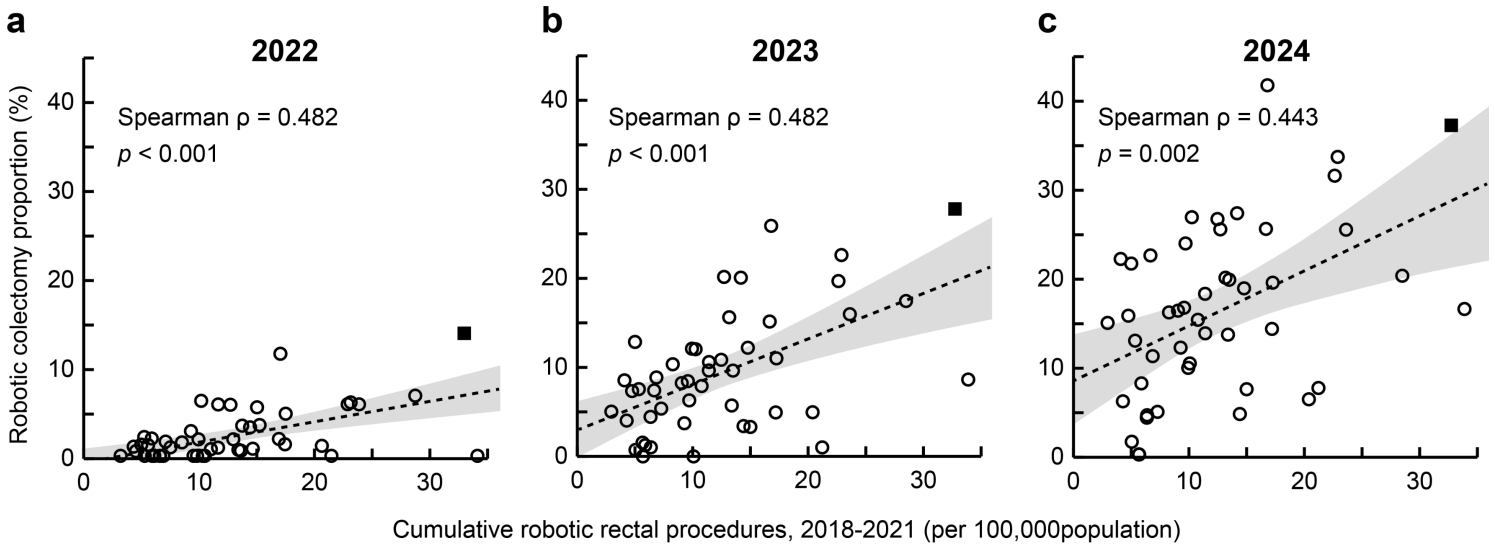

Figure 2

Association between prior robotic rectal surgery activity and subsequent robotic colectomy uptake. Scatterplots show the association between cumulative robotic rectal procedures during 2018–2021 per 100,000 population and the robotic colectomy proportion in (a) 2022, (b) 2023, and (c) 2024. Each point represents a prefecture. Shizuoka Prefecture is indicated by a filled square. Lines show fitted linear regressions, and shaded areas indicate 95% confidence intervals. Spearman correlation coefficients (ρ) and *p*-values are shown in each panel.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- ESM1.pdf