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ORIGINAL ARTICLE

Inter-prefectural regional disparities in gastric cancer surgery: A Japanese nationwide population-based cohort study from 2014 to 2019

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Abstract

Aim: This study aimed to investigate the regional disparities in gastric cancer surgery in Japan.

Methods: The annual incidence of gastric cancer and number of gastrectomies, board-certified surgeons in gastroenterology by the Japanese Society of Gastroenterological Surgery, and board-certified surgeons by the Japan Society for Endoscopic Surgery were evaluated by prefecture in Japan during 2014–2019. Medium-sized regional disparities were assessed using the Gini coefficient. Gastrectomies were further broken down by site (distal; proximal; total) and approach (open vs laparoscopic). Moreover, we compared the urban and rural regional disparities in all study variables.

Results: The annual national average incidence of gastric cancer was 127 466 and the number of gastrectomies was 49 128. Gini coefficients for almost all variables, except for board-certified surgeons by the Japan Society of Endoscopic Surgery, were <0.2, indicating low inequality. The incidence of gastric cancer, the number of gastrectomies, and the aging rate were significantly higher in rural prefectures than in urban prefectures.

Conclusion: Inter-prefectural regional disparities in gastric cancer surgery were generally small; however, both the incidence of gastric cancer and number of gastrectomies were higher in rural prefectures, where the aging rate was also increased. This study provides an overview of the landscape of gastric cancer care in Japan.

KEYWORDS
database, epidemiology, gastrectomy, gastric cancer, surgeon

1 | INTRODUCTION

Gastric cancer (GC) is a major public health issue, particularly in Asian countries.[1,2] Although there has been a decline in the incidence of GC worldwide,[2] its incidence in Japan has increased yearly due to the aging population.[3] In 2020, Japan had the second-highest incidence of GC (138 470) after China (478 508).[1] Additionally, GC is ranked as the third most common cause of cancer mortality in Japan after lung and colorectal malignancies, causing 42 319 deaths.[3]

Japan has 47 prefectures, some of which have urban areas, while others are predominantly rural. The concentration of physicians in urban as opposed to rural areas has long been a problem in Japan, as well as many other countries.[4–6] The disparities caused by the urban concentration of physicians are likely magnified by advancements in the diagnosis and surgical management of GC. One such advancement is laparoscopic resections, which have already been shown to improve short-term outcomes for early and advanced GC.[7–11] In fact, it has been shown that board-certified surgeons by the Japan Society for Endoscopic Surgery (BS-JSES) contribute to reducing postoperative complications.[12] Concurrently, gastrectomy (GR) participation rates for board-certified surgeons in gastroenterology by the Japanese Society of Gastroenterological Surgery (BS-JSGS) have been increasing annually.[13] While prior studies have elucidated nationwide trends related to gastric cancer, few have examined regional disparities in GC, GR, BS-JSGS, and BS-JSES.

The purpose of this study was to clarify recent trends in the prevalence of GC, GR, BS-JSGS, and BS-JSES in Japan using the National Database of Health Insurance Claims and Specific Health Checkups of Japan (NDB),[14–16] which contains over 95% of the data on medical insurance claims in the country. We also aimed to quantify regional disparities in GC, GR, BS-JSGS, and BS-JSES at the prefectural level.

2 | METHODS

2.1 | Study design and data sampling technique

This study did not require Institutional Board approval or informed consent because of its retrospective nature and the use of legally anonymized public data. To fully protect the anonymity of the patients, the NDB Open Data did not report data for procedures that occurred fewer than 10 times in a year.

We investigated the total number of gastrectomies (all sites and approaches) stratified by age and trends in the annual number of gastrectomies during 2014–2019, using the NDB Open Data Japan.[17] We also calculated the incidence of GC and the number of GR and BS-JSGS in 47 prefectures of Japan from 2014 to 2019 using data from the Cancer Information Database,[18] the NDB Open Data Japan,[17] and the Ministry of Internal Affairs and Communications population statistics (MIAC).[19] We chose to focus on the pre-Coronavirus Disease 2019 trends, so data after 2020 was excluded. The Cancer Information Database for the period 2016–2019, encompassing data from 47 prefectures, was employed due to its provision of accurate and reliable data on the incidence of GC. The rate per 100000 people was calculated from MIAC demographic data.[19] We quantified aging as the number of people aged ≥65 years, calculated from MIAC demographic data.[19]

We used the ICD-10 code C16 (Malignant neoplasm of stomach) to identify cases of GC. The number of BS-JSGS was also calculated from the MIAC data,[19] using biennial data (2014, 2016, and 2018) on specialist physicians by prefecture. The biennial data were collected through a questionnaire, and the response rate was reported as 87%–90%,[20] capturing the majority of physicians in Japan. In accordance with the provisions of Japanese law, doctors are required to report their specialty to the government every 2 years. The number of BS-JSES was calculated from the MIAC data[19] and publicly available data on the JSES homepage (https://www.jses.or.jp/). The website lists the names, work locations, years of certifications, and subspecialities (esophagus, stomach, colon, etc.) of BS-JSES by prefecture. We specifically targeted BS-JSES with a subspecialty focus on the stomach. The breakdown of GR was examined by site: distal (DGR), proximal (PGR), and total (TGR). We classified surgical approaches as open, laparoscopic, or both (meaning both approaches were used). We included GR with the following surgical codes:

1. K655 2 Open distal gastrectomy for malignant tumor.
2. K655-2 2 Laparoscopic distal gastrectomy for malignant tumor.
3. K655-4 2 Open proximal gastrectomy for malignant tumor.
4. K655-5 2 Laparoscopic proximal gastrectomy for malignant tumor.
5. K657 2 Open total gastrectomy for malignant tumor.
6. K657-2 2 Laparoscopic total gastrectomy for malignant tumor.

To examine disparities in the incidence/number of GC, GR, BS-JSGS, and BS-JSES between prefectures, we calculated Gini coefficients, as done in previous studies.[15,21,22] Traditionally, Gini coefficients were employed for assessing income and wealth distribution, offering a standardized metric to gauge the degree of distribution inequality. They were classified as low (<0.2), moderate (≥0.2, <0.3), high (≥0.3, <0.4), or extreme (≥0.4) inequality, with 0 representing complete equality and 1 indicating complete inequality.

2.2 | Definition of urban and rural prefectures

In accordance with previous reports,[15,21,23] we also investigated differences between urban and rural prefectures with definitions for each as follows: a densely populated (urban) group consisting of seven prefectures with a population density of more than 1000 persons per unit area (Saitama, Tokyo, Chiba, Kanagawa, Aichi, Osaka, and Fukuoka, accounting for approximately half of the total population in Japan) vs a sparsely populated (rural) group consisting of the remaining 40 prefectures.

2.3 | Statistical analyses

The Jonckheere-Terpstra trend test was used to examine whether the values changed over the 6-year study period. Data comparisons between urban and rural groups were performed using the unpaired *t*-test.

All statistical analyses were performed using EZR (Saitama Medical Center, Jichi Medical University, Saitama, Japan),[24] a graphical user interface for R (The R Foundation for Statistical Computing, Vienna, Austria). Statistical significance was set at a two-sided *P*-value of <0.05.

3 | RESULTS

3.1 | Total number of gastrectomies (all sites and approaches) stratified by age during 2014–2019

Regarding the total number of gastrectomies (all sites and approaches) during 2014–2019 stratified by age, a unimodal distribution was observed, with a peak at 70–79 years (Figure 1). 77.9% of all GR occurred in people aged ≥65 years.

3.2 | Trends in the annual number of gastrectomies during 2014–2019

Over 6 years, the incidence of all GR and GR (open) significantly decreased ($P < 0.01$), whereas the incidence of GR (laparoscopic) significantly increased ($P < 0.01$) (Figure 2A). In the breakdown of GR approaches, the incidence of DGR (both), TGR (both), DGR (open), PGR (open), and TGR (open) significantly decreased ($P < 0.01$, except for PGR [open], which had $P < 0.05$), whereas PGR (both), DGR (laparoscopic) and PGR (laparoscopic) significantly increased ($P < 0.01$) (Figure 2B). The incidence/number of TGR (laparoscopic), GC, BS-JSGS, and BS-JSES remained approximately constant over the study period.

3.3 | Basic statistics and Gini coefficients for GC, GR, BS-JSGS, and BS-JSES

Table 1 shows the basic statistics and Gini coefficients for GC, GR, BS-JSGS, and BS-JSES, using 47 prefectures as the unit of analysis. The annual national average incidence/number of GC and GR was 127 466 cases and 49 128 surgeries, respectively. The heat maps show the latest data for the incidence/number of all GR, GR (open), GR (laparoscopic), BS-JSGS, and BS-JSES per 100 000 person-years (Figure 3A–E). The Gini coefficients were low (<0.2) for GC, all GR, DGR (both), DGR (laparoscopic), TGR (both), BS-JSGS, and BS-JSES. Gini coefficients were not calculated for the PGR (both), PGR (open), PGR (laparoscopic), and TGR (laparoscopic) due to missing data (fewer than 10 procedures occurred during the year, so the NDB did not report the information).

3.4 | Comparison of differences in the incidence/number of GC, GR, BS-JSGS, and BS-JSES, as well as the aging rate, between urban and rural prefectures

Table 2 shows a comparison of differences in the incidence/number of GC, GR, BS-JSGS, and BS-JSES, and the aging rate, between urban and rural prefectures. In particular, the incidence/number of GC and GR, as well as the aging rate, were significantly higher in sparsely populated prefectures than in densely populated prefectures.

4 | DISCUSSION

We used publicly available medical datasets from Japan to investigate the uptake of laparoscopic GR and relationships among the incidence/number of GC, GR, BS-JSGS, and BS-JSES by prefecture. Our study confirmed that the number of all GR decreased, as previously reported.[25] Additionally, we found that, over time, the number of open GR decreased, while the number of laparoscopic GR increased, suggesting that the laparoscopic approach is replacing the open approach (Figure 2A). Furthermore, all GR, both DGR, and both TGR decreased in frequency, while the utilization of both PGR increased (Figure 2A,B). We suspect that this finding indicates an increasing trend in proximal GC. While we did not delve into the different types of gastric cancer in this study, the incidence of adenocarcinoma of the gastric cardia was found to be on the rise in some European countries.[2,26,27]

In this study, we used Gini coefficients to examine inter-prefectural regional disparities in GC surgery. The Gini coefficients for GC and GR were generally less than 0.2, indicating low regional disparities. However, the Gini coefficients were slightly higher for DGR (open)

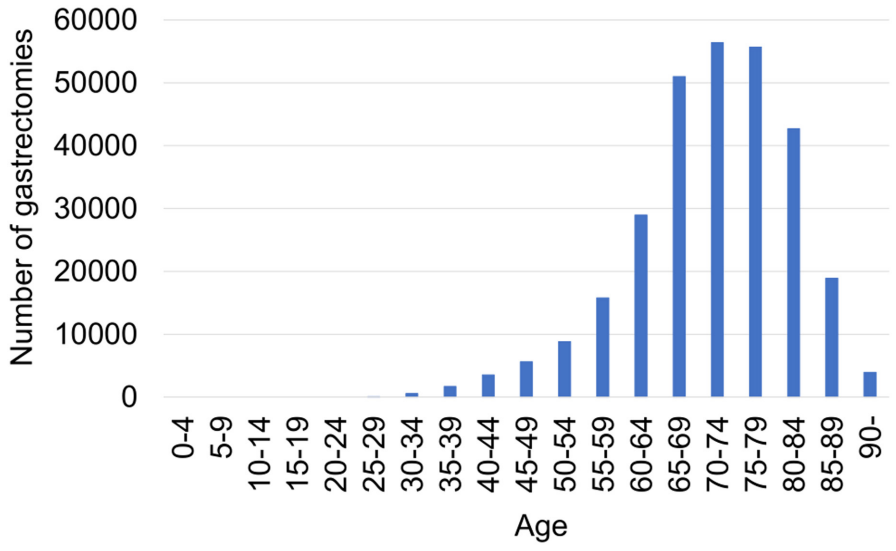

FIGURE 1 Total number of gastrectomies (all sites and approaches) stratified by age during 2014–2019.

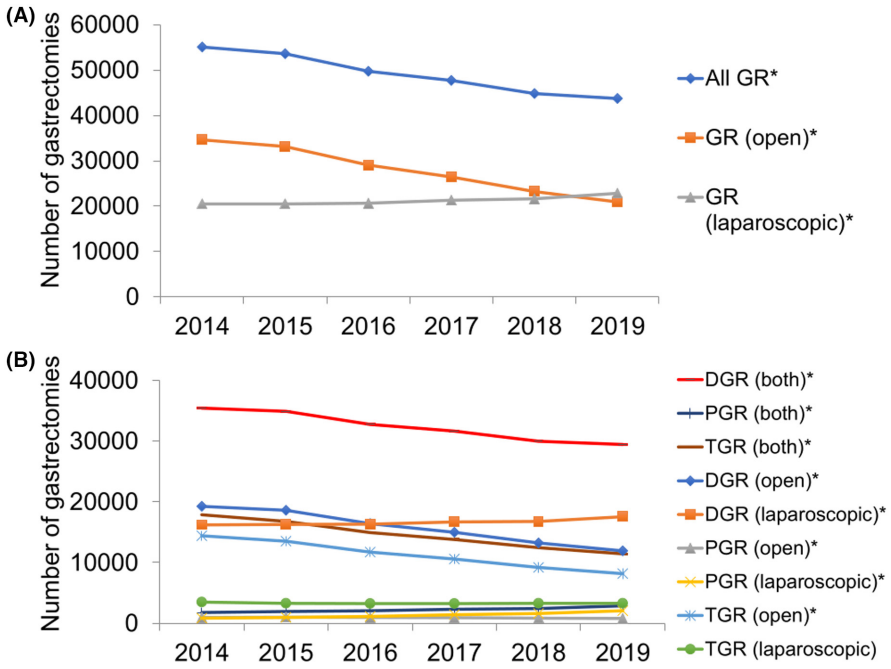

FIGURE 2 Trends in the annual number of gastrectomies in Japan during 2014–2019. (A) (upper): Trends in the annual number of gastrectomies by approach. (B) (lower): Trends in the annual number of gastrectomies by site and approach. GR, gastrectomies; DGR, distal gastrectomies; PGR, proximal gastrectomies; TGR, total gastrectomies. *Indicates a statistically significant trend ($P < 0.05$).

and TGR (laparoscopic). In 2018, the Gini coefficient for TGR (laparoscopic) was 0.26 (Table 1), suggesting possible issues with access in certain prefectures. Additionally, the Gini coefficient for BS-JSES was moderate-high, while it was low for BS-JSGS. This finding is likely due to the recent introduction of BS-JSES in 2005, resulting in a lower absolute number of such surgeons (1/10 the number of BS-JSGS) (Table 1). Since BS-JSES specialize in endoscopic surgical skills, it may be difficult to acquire the advanced skills in facilities without BS-JSES surgeons. However, the Gini coefficient for BS-JSES has shown a decreasing trend over the years (Table 1), suggesting that laparoscopic management is becoming more widespread. Overall, the results suggest that access to necessary and urgent surgical procedures for GC is generally equal across different regions of Japan, with some small variabilities based on type of procedure or surgeon.

Contrary to our expectations, the incidence/number of GC and GR per 100000 person-years was generally higher in rural prefectures than in urban prefectures, although the number of BS-JSGS, BS-JSES, and DGR (laparoscopy) per 100000-person years was not. We posit that the aging rate of the local population had a significant effect on these regional differences. More specifically, a high percentage of the rural population in Japan were elderly, and therefore more likely to develop GC. This is supported by our findings that 77.9% of all GR occurred in people aged ≥65 (Figure 1). Considering the high incidence of GC in rural areas, the burden on rural BS-JSGS or BS-JSES was greater than that on urban BS-JSGS or BS-JSES. Although this may provide a good environment for training inexperienced surgeons, many trainees do not remain in rural areas. The aging and subsequent retirement of rural surgeons is expected, so early countermeasures are desirable. Given the older age composition of patients with typical cancers, our findings may be applicable to other types of cancer.

As mentioned repeatedly, the number of all gastrectomies (GR) has been decreasing in recent years. Hence, there has been concern about the quality of GR due to the decreasing opportunities for surgeons to gain exposure to such procedures. In 2023, an accreditation system for GC treatment facilities was established to ensure the quality of treatment.[28] Our findings that minimally invasive and useful laparoscopic surgery is differently provided in urban/rural regions and correlates with the number of BS-JSGS and BS-JSES, as well as the abovementioned accredited GC treatment facilities, may be useful information for patients when making decisions about where to seek treatment.

There were several major limitations of this study. First, this study did not encompass endoscopic treatment or chemotherapy and instead focuses on open and laparoscopic surgery, Second, our investigation was unable to process any data regarding patient background, such as cancer staging. Differences in patient background may influence regional disparities. Therefore, further research in this area is warranted. Third, some of the BS-JSGS no longer perform surgery, and are rather family physicians. Therefore, the number of BS-JSGS may be overcalculated. Fourth, to ensure anonymization of the data, the NDB Open Data excluded information for any procedures occurring fewer than 10 times a year. These omissions may have resulted in slightly lower than accurate values for GR. We also were unable to conduct inter-prefectural analysis for PGR and TGR due to missing data from this anonymization process. Lastly, medical care and social systems vary significantly from country to country, making it difficult to generalize our findings to other countries.

This study is the first observational epidemiological study on the localized regional disparities in gastric cancer surgery using a nationwide database. Regional disparities in the three factors (GC, GR, and BS-JSGS) were small at the prefectural level. However, the prevalence of open surgery remains higher in prefectures with lower BS-JSGS or BS-JSES scores, which contributes to the observable widening of regional disparities over the study period. Additionally, both the incidence/number of GC and GR were higher in rural prefectures compared to urban prefectures, where the aging rate was higher. This study offers a comprehensive overview of the landscape of GC care in Japan.

TABLE 1 The annual national incidence/number, rate per 100 000 person-years and Gini coefficient for gastric cancer, gastrectomies, board-certified surgeons in gastroenterology by the Japanese Society of Gastroenterological Surgery, and board-certified surgeons by the Japan Society for Endoscopic Surgery during 2014–2019, using 47 prefectures as the unit of analysis.

	Annual national incidence/number	Rate per 100 000 person-years			Gini coefficient
		Average (95% CI)	Maximum	Minimum	
GC					
2014	126 149	Not available	Not available	Not available	Not available
2015	124 194	Not available	Not available	Not available	Not available
2016	134 650	115.8 (108.1 to 123.5)	195.1	36.2	0.12
2017	129 476	111.0 (103.9 to 118.1)	173.9	39.3	0.12
2018	126 009	108.7 (101.8 to 115.7)	172.4	36.9	0.12
2019	124 319	108.0 (100.9 to 115.1)	170.7	38.5	0.13
All GR					
2014	55 112	43.6 (40.7 to 46.5)	70.9	16.2	0.12
2015	53 620	42.7 (39.8 to 45.6)	75.0	16.9	0.12
2016	49 728	41.5 (38.9 to 44.2)	64.8	12.6	0.12
2017	47 745	37.4 (35.0 to 39.8)	58.8	14.7	0.12
2018	44 833	37.6 (35.1 to 40.0)	62.7	13.5	0.12
2019	43 730	37.0 (34.7 to 39.3)	55.9	13.2	0.12
GR (open)					
2014	34 636	29.5 (27.1 to 31.9)	57.0	11.8	0.15
2015	33 125	28.4 (26.0 to 30.7)	53.0	11.0	0.15
2016	29 059	24.6 (22.4 to 26.7)	47.6	8.0	0.17
2017	26 452	22.6 (20.7 to 24.6)	43.2	10.5	0.16
2018	23 187	20.0 (18.1 to 22.0)	44.2	8.3	0.18
2019	20 892	18.2 (16.2 to 20.2)	38.0	6.4	0.21
GR (laparoscopic)					
2014	20 476	14.1 (12.8 to 15.4)	28.9	4.3	0.17
2015	20 495	14.3 (12.9 to 15.7)	34.9	5.3	0.17
2016	20 669	17.0 (15.4 to 18.5)	36.5	4.7	0.17
2017	21 293	14.8 (13.5 to 16.0)	27.8	4.2	0.16
2018	21 646	17.5 (15.9 to 19.2)	35.9	5.2	0.17
2019	22 838	18.8 (17.0 to 20.5)	37.8	5.3	0.17
DGR (both)					
2014	35 453	30.2 (28.2 to 32.2)	46.4	10.1	0.13
2015	34 899	29.9 (27.9 to 31.9)	52.9	12.8	0.12
2016	32 745	27.7 (25.9 to 29.5)	44.7	8.9	0.12
2017	31 651	26.8 (25.2 to 28.4)	40.2	11.6	0.11
2018	29 979	25.4 (23.6 to 27.1)	45.4	8.8	0.12
2019	29 449	25.3 (23.6 to 26.9)	40.3	8.2	0.12
DGR (open)					
2014	19 269	16.6 (15.1 to 18.0)	29.0	5.6	0.17
2015	18 608	16.2 (14.7 to 17.7)	30.7	6.8	0.17
2016	16 408	14.1 (12.8 to 15.4)	27.2	5.2	0.18
2017	14 973	13.1 (11.9 to 14.2)	24.3	6.3	0.17
2018	13 206	11.5 (10.3 to 12.7)	24.4	4.8	0.19
2019	11 927	10.6 (9.4 to 11.8)	20.8	3.2	0.22

(Continues)

TABLE 1 (Continued)

	Annual national incidence/ number	Rate per 100 000 person-years			Gini coefficient
		Average (95% CI)	Maximum	Minimum	
DGR (laparoscopic)					
2014	16 184	13.6 (12.4 to 14.7)	26.5	4.3	0.16
2015	16 291	13.7 (12.4 to 15.0)	31.4	5.3	0.17
2016	16 337	13.6 (12.4 to 14.8)	28.6	3.7	0.16
2017	16 678	13.8 (12.7 to 14.8)	24.8	4.2	0.15
2018	16 773	13.9 (12.7 to 15.1)	27.9	4.1	0.16
2019	17 522	14.7 (13.4 to 16.0)	28.1	3.5	0.16
PGR (both)					
2014	1783	Not available	4.8	Not available	Not available
2015	1937	Not available	3.8	Not available	Not available
2016	2057	Not available	4.2	Not available	Not available
2017	2304	Not available	4.5	Not available	Not available
2018	2415	Not available	3.5	Not available	Not available
2019	2846	Not available	4.7	Not available	Not available
PGR (open)					
2014	969	Not available	2.4	Not available	Not available
2015	1005	Not available	1.9	Not available	Not available
2016	954	Not available	3.1	Not available	Not available
2017	918	Not available	2.0	Not available	Not available
2018	814	Not available	1.8	Not available	Not available
2019	797	Not available	2.0	Not available	Not available
PGR (laparoscopic)					
2014	814	Not available	2.4	Not available	Not available
2015	932	Not available	3.5	Not available	Not available
2016	1103	Not available	2.5	Not available	Not available
2017	1386	Not available	3.0	Not available	Not available
2018	1601	Not available	2.4	Not available	Not available
2019	2049	Not available	3.9	Not available	Not available
TGR (both)					
2014	17 876	12.3 (11.3 to 13.3)	26.7	6.1	0.15
2015	16 784	11.5 (10.6 to 12.4)	20.9	4.2	0.14
2016	14 926	12.4 (11.6 to 13.3)	22.4	3.8	0.13
2017	13 790	9.0 (8.2 to 9.9)	17.3	3.0	0.17
2018	12 439	10.6 (9.8 to 11.4)	21.4	4.6	0.14
2019	11 435	9.6 (8.9 to 10.4)	17.8	4.3	0.14
TGR (open)					
2014	14 398	12.3 (11.3 to 13.3)	26.7	6.1	0.15
2015	13 512	11.5 (10.6 to 12.4)	20.9	4.2	0.14
2016	11 697	9.8 (9.0 to 10.7)	19.2	2.8	0.15
2017	10 561	9.0 (8.2 to 9.9)	17.3	3.0	0.17
2018	9167	8.0 (7.2 to 8.8)	18.6	3.5	0.17
2019	8168	7.1 (6.3 to 7.9)	16.0	3.2	0.2
TGR (laparoscopic)					
2014	3478	Not available	Not available	Not available	Not available
2015	3272	Not available	Not available	Not available	Not available
2016	3229	Not available	5.6	Not available	Not available
2017	3229	Not available	Not available	Not available	Not available
2018	3272	2.6 (2.2 to 3.0)	8.2	0.9	0.26
2019	3267	Not available	7.8	Not available	Not available
BS-JSGS					
2014	–	5.1 (4.7 to 5.4)	8.5	3.0	0.13
2016	–	5.2 (4.9 to 5.6)	8.9	3.1	0.12

TABLE 1 (Continued)

	Annual national incidence/ number	Rate per 100 000 person-years			Gini coefficient
		Average (95% CI)	Maximum	Minimum	
2018	–	5.8 (5.4 to 6.2)	9.6	3.2	0.13
BS-JSES					
2014	–	0.24 (0.20 to 0.29)	0.70	0	0.33
2015	–	0.27 (0.23 to 0.32)	0.70	0	0.31
2016	–	0.32 (0.26 to 0.37)	0.88	0	0.30
2017	–	0.36 (0.30 to 0.41)	0.88	0	0.30
2018	–	0.41 (0.35 to 0.47)	1.07	0	0.27
2019	–	0.44 (0.37 to 0.51)	1.26	0	0.28

Note: The Gini coefficients ranged from 0 (completely equality) and 1 (complete inequality), according to the degree of variation in the incidence/ number rate among 47 prefectures.

Abbreviations: BS-JSES, board-certified surgeons by the Japan Society for Endoscopic Surgery; BS-JSGS, board-certified surgeons in gastroenterology by the Japanese Society of Gastroenterological Surgery; CI, confidence interval; DGR, distal gastrectomies; GC, gastric cancer; GR, gastrectomies; PGR, proximal gastrectomies; TGR, total gastrectomies.

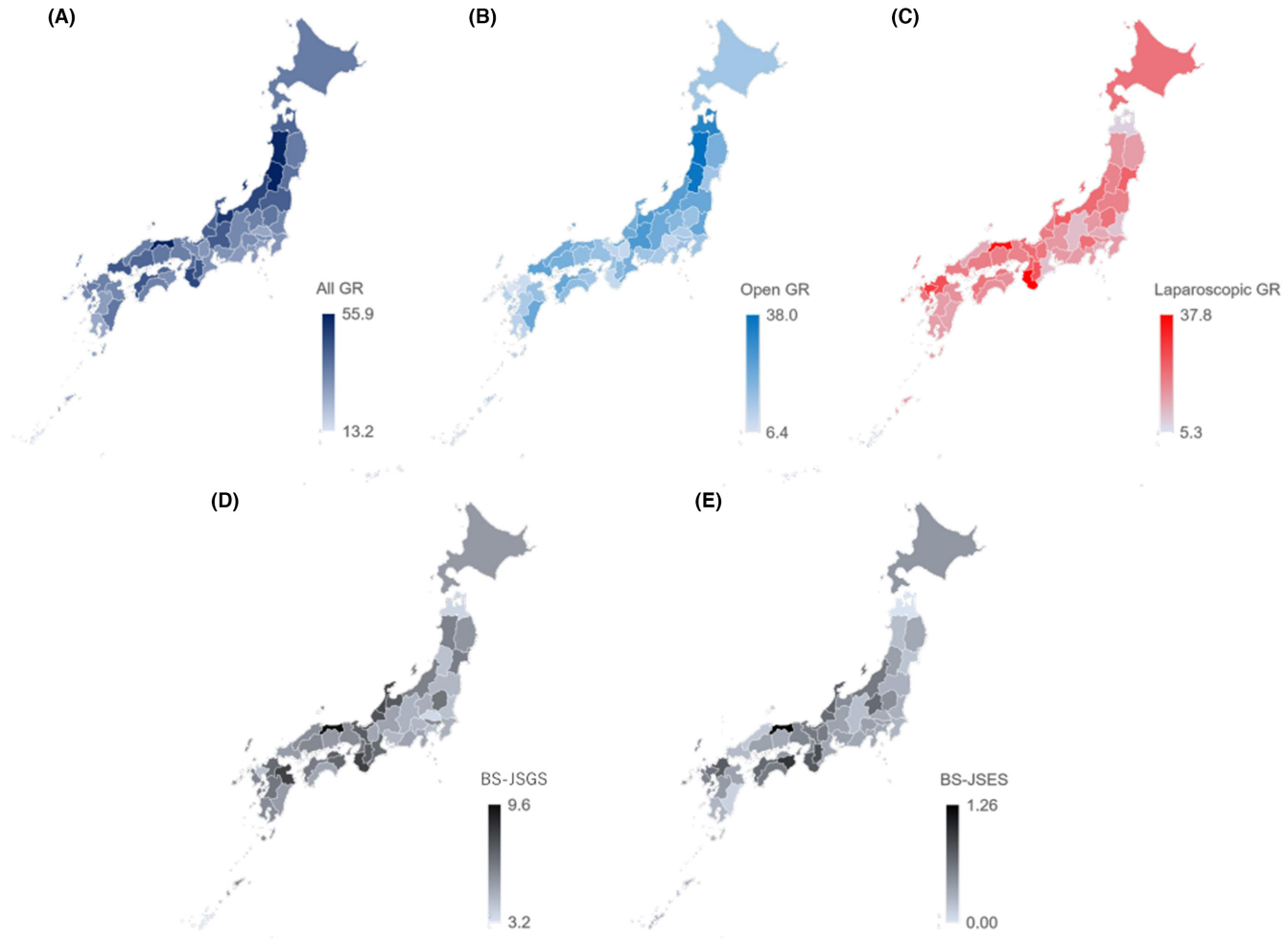

FIGURE 3 Heat maps for the number of (A) gastrectomies (all sites and all approaches), (B) open gastrectomies, (C) laparoscopic gastrectomies, (D) board-certified surgeons in gastroenterology by the Japanese Society of Gastroenterological Surgery, and (E) board-certified surgeons by the Japan Society for Endoscopic Surgery by prefecture in 2018 or 2019. All the data except for the number of board-certified surgeons in gastroenterology by the Japanese Society of Gastroenterological Surgery is from 2019. The data on board-certified surgeons in gastroenterology by the Japanese Society of Gastroenterological Surgery is from 2018. GR, gastrectomies; BS-JSGS, board-certified surgeons in gastroenterology by the Japanese Society of Gastroenterological Surgery; BS-JSES, board-certified surgeons by the Japan Society for Endoscopic Surgery.

TABLE 2 Comparison of GC, GR, BS-JSGS, and BS-JSES, and aging rate in densely (urban) vs sparsely populated (rural) prefectures.

	Urban	Rural	
	Densely populated area ($n=7$)	Sparsely populated area ($n=40$)	*P* values
GC per 100 000 person-years			
2016	95.4 (10.0)	119.4 (27.4)	**<0.05**
2017	92.6 (10.5)	114.2 (25.3)	**<0.05**
2018	89.7 (10.6)	112.1 (24.5)	**<0.05**
2019	88.5 (10.7)	111.4 (25.1)	**<0.05**
All GR per 100 000 person-years			
2014	36.6 (4.4)	44.8 (10.4)	**<0.01**
2015	36.1 (3.8)	43.8 (10.5)	**<0.01**
2016	36.0 (3.9)	42.5 (9.7)	**<0.01**
2017	32.5 (3.3)	38.3 (8.6)	**<0.01**
2018	32.4 (4.1)	38.4 (8.8)	**<0.01**
2019	31.7 (4.3)	37.9 (8.4)	**<0.01**
DGR (both) per 100 000 person-years			
2014	25.3 (3.9)	31.0 (7.1)	**<0.01**
2015	25.1 (3.2)	30.7 (7.1)	**<0.01**
2016	23.7 (2.9)	28.4 (6.5)	**<0.01**
2017	23.3 (2.8)	27.4 (5.9)	**<0.01**
2018	22.0 (2.9)	26.0 (6.3)	**<0.05**
2019	21.5 (3.2)	25.9 (5.9)	**<0.05**
DGR (open) per 100 000 person-years			
2014	13.2 (1.8)	17.2 (5.2)	**<0.001**
2015	12.7 (1.2)	16.8 (5.3)	**<0.001**
2016	11.2 (1.6)	14.6 (4.8)	**<0.01**
2017	10.2 (1.2)	13.6 (4.1)	**<0.001**
2018	8.9 (1.6)	11.9 (4.3)	**<0.01**
2019	7.9 (1.6)	11.1 (4.4)	**<0.01**
DGR (laparoscopic) per 100 000 person-years			
2014	12.1 (3.3)	13.8 (4.2)	0.3
2015	12.4 (3.2)	13.9 (4.6)	0.3
2016	12.5 (3.1)	13.8 (4.3)	0.4
2017	13.2 (3.0)	13.9 (3.9)	0.6
2018	13.1 (2.8)	14.0 (4.5)	0.5
2019	13.6 (3.6)	14.9 (4.6)	0.4
TGR (open) per 100 000 person-years			
2014	10.0 (1.0)	12.7 (3.7)	**<0.001**
2015	9.6 (0.8)	11.8 (3.3)	**<0.001**
2016	8.2 (0.8)	10.1 (3.0)	**<0.01**
2017	7.4 (1.0)	9.3 (3.0)	**<0.01**
2018	6.1 (0.9)	8.4 (2.8)	**<0.001**
2019	5.6 (0.9)	7.3 (2.8)	**<0.01**
BS-JSGS per 100 000 person-years			
2014	4.6 (1.0)	5.1 (1.2)	0.3
2016	4.8 (1.0)	5.3 (1.2)	0.2
2018	5.2 (1.2)	5.9 (1.3)	0.2
BS-JSES per 100 000 person-years			
2014	0.25 (0.11)	0.24 (0.16)	0.9
2015	0.28 (0.13)	0.27 (0.16)	0.9
2016	0.31 (0.14)	0.32 (0.19)	0.9
2017	0.35 (0.16)	0.36 (0.20)	1
2018	0.37 (0.16)	0.42 (0.21)	0.6
2019	0.41 (0.16)	0.45 (0.25)	0.6
Aging rate			
2014	0.241 (0.012)	0.281 (0.025)	**<0.001**
2015	0.247 (0.013)	0.289 (0.025)	**<0.001**
2016	0.253 (0.015)	0.296 (0.025)	**<0.001**
2017	0.257 (0.016)	0.303 (0.025)	**<0.001**
2018	0.260 (0.017)	0.308 (0.025)	**<0.001**
2019	0.262 (0.018)	0.313 (0.026)	**<0.001**

Note: The results are expressed as the mean (standard deviation). The bold values indicate a statistically significant difference ($P < 0.05$).

Abbreviations: BS-JSES, board-certified surgeons by the Japan Society for Endoscopic Surgery; BS-JSGS, board-certified surgeons in gastroenterology by the Japanese Society of Gastroenterological Surgery; DGR, distal gastrectomies; GC, gastric cancer; GR, gastrectomies; PGR, proximal gastrectomies; TGR, total gastrectomies.

AUTHOR CONTRIBUTIONS

Conceptualization: Masamitsu Kido and Katsutoshi Shoda; Methodology: Masamitsu Kido and Katsutoshi Shoda; Formal analysis and investigation: Masamitsu Kido and Katsutoshi Shoda; Writing–original draft preparation: Masamitsu Kido; Writing–review and editing: Katsutoshi Shoda, Luying Yan, and Kazuya Ikoma; Supervision: Daisuke Ichikawa.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest for this article.

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Daisuke Ichikawa is a current Editor or Editorial Board Member of the *Annals of Gastroenterological Surgery*. This study did not require Institutional Board approval or informed consent because of its retrospective nature and the use of legally anonymized public data.

Approval of the research protocol: N/A.

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