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Original Article

National Statistics of Endoscopic Submucosal Dissection for Early Gastric Cancer in Korea

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ABSTRACT

Purpose: Endoscopic submucosal dissection (ESD) is the standard treatment for early gastric cancer (EGC) with a low risk of lymph node metastasis. In Korea, ESD was included in the National Health Insurance (NHI) coverage in 2011, which was expanded in 2018. In the present study, we investigated the status and trends of ESD for EGC over the past decade since its incorporation into the NHI system.
Materials and Methods: We analyzed the data from the National Health Insurance Service (NHIS) database from 2011 to 2021, focusing on patient characteristics, number of ESD procedures, in-hospital length of stay (LOS), and total medical cost (TMC) per admission. In addition, we conducted an interrupted time series analysis to assess the impact of changes in insurance coverage on these variables.
Results: Overall, 95,348 cases of ESD for EGC were identified. A consistent annual increase in ESD procedures was observed, particularly in tertiary care hospitals and among patients aged >60 years. The overall median LOS and TMC were 4 days and 2,123,000 KRW, respectively. The 2018 insurance coverage expansion did not significantly affect the number of ESD procedures or LOS; however, the TMC increased significantly.
Conclusions: Our study illustrates decade-long trends in the ESD for EGC in Korea. The policy needs to be revised continuously to optimize ESD use and improve resource allocation within healthcare systems.

Keywords: Endoscopic submucosal dissection; Gastric cancer; National Health Insurance; South Korea; Healthcare policy

INTRODUCTION

Endoscopic submucosal dissection (ESD) is the standard treatment for premalignant lesions and early gastric cancers (EGCs) with a low risk of lymph node metastasis [1,2]. The adoption of population-based gastric cancer screening in 2002 as part of the National Cancer Screening Program has led to its early detection [3-8]. ESD was first introduced in Korea in the late 1990s and gained widespread acceptance as a treatment option for EGC in 2003 [9-11]. Although it was initially performed as a non-insured procedure, it was brought under the National Health Insurance (NHI) coverage in September 2011 (The first date of insurance

Journal of Gastric Cancer

Conflict of Interest
No potential conflict of interest relevant to this article was reported.

Author Contributions
Conceptualization: N.S.J.; Data curation: L.S.H., C.H.; Formal analysis: L.S.H., C.H., L.M.N., N.S.J.; Methodology: N.S.J.; Writing - original draft: L.S.H., C.H., N.S.J.; Writing - review & editing: L.M.N., N.S.J.

coverage was September 1, 2011; however, the actual starting date that aligns with the recent insurance criteria up to October 2018 is November 1, 2011). The NHI coverage for ESD was expanded in November 2018, including insurance benefits for all current indications of ESD for EGC.

ESD is currently a popular procedure in Korea [12,13]. However, only one published report is available on the national statistics of ESD for EGC, which is limited to the early periods of insurance coverage (2011–2014) [12]. Therefore, we investigated the status of ESD for EGC over the past decade in Korea since its introduction into the NHI system and studied the impact of insurance expansion in 2018 on the number and cost of ESD procedures.

MATERIALS AND METHODS

Ethics statement

The research was ethically conducted in accordance with the World Medical Association Declaration of Helsinki. The study protocol was approved by the institute's committee on human research (Institutional Review Board approval No. KNUH-2022-05-006-002). Informed consent or ethical committee review was waived off because personal medical information was excluded from data collection.

Data source

Data between 2011 and 2021 were collected from the National Health Insurance Service (NHIS) database. The NHIS is a government agency responsible for overseeing all health services in Korea. The Korean NHI program was initiated in 1977 and achieved national coverage in 1989. The NHIS covers 97% of the Korean population, which is approximately 50 million people, whereas the remaining 3% is supported by medical aid (MA) [14]. Consequently, the NHIS database provides complete information on health insurance coverage in Korea and contains detailed records, including unique identification numbers for each patient, demographic details, pharmacy claims, history of procedures based on the electronic data interchange code and diagnoses coded according to the International Classification of Diseases, 10th Revision (ICD-10).

Patient selection and definitions for variables and ESD procedure

The NHIS database was used to identify patients with gastric cancer who underwent ESD. Patients with gastric cancer (ICD-10 codes C16.0–C16.9) who underwent ESD (procedure codes: QZ933, QX704, QX701, Q7652, and Q7653) from November 1, 2011, to December 31, 2021, were enrolled. The exclusion criteria were as follows: i) no records of hospitalization days or costs, ii) treatments without an ESD material code, and iii) missing health insurance qualification details.

We analyzed the age, sex, underlying diseases, Charlson Comorbidity Index (CCI), type of health insurance, type of medical institution, in-hospital length of stay (LOS), total medical costs (TMCs) per admission, procedure indications, and en bloc resection rates. The CCI (updated weight) was calculated as described previously [15]. Two types of health insurance are available in Korea: health insurance (HI), which is mandatory for most people, and MA, a public assistance system that guarantees medical support to low-income citizens who cannot maintain their livelihoods. TMC consists of two components: "out-of-pocket costs," which are paid directly by the patients, and the "national burden," which is covered by the

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government (primarily through NHIS). These 2 components were analyzed separately in certain cost analyses. Medical institutions in the NHIS database were classified according to the Korean Medical Service Act and Ordinance of the Ministry of Health and Welfare. Among several types of institutions (including clinics, public health centers, long-term care facilities, hospitals, general hospitals, and tertiary hospitals), ESD was performed in clinics, hospitals, general hospitals, and tertiary hospitals. A clinic is an institution where a doctor primarily provides medical services to outpatients. A hospital is an institution with more than 30 beds, where doctors provide medical services primarily to inpatients. General hospitals are institutions with at least 100 beds. A tertiary hospital is a general hospital that provides highly specialized medical services for treating severe diseases and satisfies the following requirements: has at least 20 specialized departments prescribed by the Ordinance of the Ministry of Health and Welfare, is an institution that trains a person who intends to become a medical specialist, has human resources, facilities, and equipment prescribed by the Ordinance of the Ministry of Health and Welfare, and meets the standards prescribed by the Ordinance of the Ministry of Health and Welfare for patient distribution in each diagnosis-related group.

Initially, in November 2011, the insurance coverage for ESD was divided into two categories: partial and full out-of-pocket payments. "Partial co-payment" applied to differentiated EGCs without ulcers and confined to the mucosa, measuring 2 cm or less (procedure code QZ933 or Q7652). For other EGCs without lymph node metastasis, a "full out-of-pocket payment" was applied, making the patient responsible for 100% of procedure costs (procedure code QX704 or QX701). In both cases, claims could be raised for ESD if the tissue was resected en bloc (procedure code QZ933 or QX704). However, if en bloc resection was not achieved (i.e., piecemeal resection), claims had to be raised for an endoscopic mucosal resection (EMR) procedure (procedure code Q7652 or QX701) rather than for ESD, although ESD had been performed. Starting on November 1, 2018, insurance policies were changed, allowing claims for all ESD procedures, irrespective of whether the tissue was resected en bloc or piecemeal, and the procedure code was unified to Q7653. In addition, cases previously requiring full out-of-pocket payments were adjusted to 80% co-payment, with the remaining 20% covered by national insurance, expanding insurance coverage for ESD procedures.

We classified the analysis into 2 periods, owing to a procedural code change on November 1, 2018, as follows: from November 1, 2011 to October 31, 2018 and November 1, 2018 to December 31, 2021. During the first period, we identified the ESD procedure by combining procedure codes (QZ933, QX704, Q7652, or QX701) and ESD material codes. The procedure was classified as en bloc resection if the combination included an ESD code (QZ933 or QX704) and ESD material codes and piecemeal resection if it included an EMR code (Q7652 or QX701) and ESD material codes [12]. In addition, according to the insurance criteria for ESD procedures, the indication for ESD was classified as absolute if the combination included a coinsured procedure code (QZ933 or Q7652) and an ESD material code and as an expanded indication if it included a non-covered procedure code (QX704 or QX701) and an ESD material code. Starting on November 1, 2018, a single ESD code (Q7653) was used for both types of resection (en bloc and piecemeal resection) and indications (absolute and expanded indications), which precluded differentiation between these two resection types or indications thereafter.

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Statistical analysis

Demographics including age, sex, comorbidities, CCI, hospital type; LOS, medical costs, procedure indication and en bloc resection rate were summarized using descriptive statistics such as frequency, proportion, mean, standard deviation, median, and range. The impact of insurance expansion in November 2018 on the number of ESD procedures, LOS, and costs of ESD procedures was evaluated using the standard interrupted time series (ITS) analysis [16]. The following segmented regression model was used: $Y_T = \beta_0 + \beta_1 T + \beta_2 X_T + \beta_3 (T-T_0) X_T$, where β_0 is the baseline intercept, β_1 is the average monthly change before policy change, β_2 is the level change (immediate effect), and β_3 indicates the slope change (sustained effect) following the policy change (with T_0 as the time of the beginning of insurance change). The time variable "T" ranged from 1 to 36 months (January 2017 to December 2019); X_T is a dummy variable indicating the period before (coded as 0) and after (coded as 1) policy change; and Y_T is a dependent variable, such as the number of ESD procedures, mean LOS, or mean TMC in a month. All tests were 2-tailed, and the statistical significance was set at $P<0.05$. Statistical analyses were performed using the SAS software version 9.2 (SAS Inc., Cary, NC, USA). Trend tests, ITS analysis, and plotting of a color-coded map of Korea showing the regional distribution of ESD procedures were performed using R version 4.3.1 (R Foundation for Statistical Computing, Vienna, Austria).

RESULTS

Number of ESD procedures and patient characteristics

A total of 95,348 ESD cases for EGC were identified. The proportion of males and mean age were 74.1% and 66.6 years, respectively. The most prevalent age group was the 60s (34.0%), followed by the 70s (32.7%) and 50s (18.8%). Hypertension and diabetes mellitus were observed in 53.3% and 33.9% of patients, respectively. In total, 16.2%, 19.7%, and 39.0% of patients had CCI scores of >4, 3, and 2, respectively. This study included 53 tertiary hospitals, 185 general hospitals, 47 hospitals, and 4 clinics. Clinics were included in the hospital category for the analysis because of their small numbers. ESD was performed in tertiary care hospitals, general hospitals, and hospitals in 71.3%, 28.0%, and 0.7% of the procedures, respectively (**Table 1**). Types of health insurance included HI (94.7%) and MA (3.6%).

We observed a continuous annual increase in the number of ESD procedures, except for a decline during the coronavirus disease 2019 (COVID-19) pandemic in 2020 (**Fig. 1**). The percentage of ESD cases increased annually in the age groups of 60–69, 70–79, and ≥80 years ($P<0.001$) (**Table 1**, **Fig. 2**). In particular, patients aged ≥80 years showed a >4-fold increase over 10 years.

We analyzed the annual trends in the proportion of ESD procedures by regional distribution and found that most procedures were consistently performed in metropolitan areas over the past decade (**Table 2**, **Fig. 3**, and **Supplementary Fig. 1**).

We next assessed the impact of insurance expansion in November 2018 on the number of ESD procedures performed. The ITS analysis revealed no significant increase in the number of ESD procedures following the policy amendment (immediate effect, $P=0.252$; sustained effect, $P=0.849$; **Fig. 4A**).

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Table 1. Baseline patient characteristics

Characteristics	Total	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Sex												
Male	70,650 (74.1)	847 (76.1)	5,186 (73.9)	5,977 (75.1)	6,140 (74.3)	6,259 (73.7)	7,151 (74.4)	7,615 (74.5)	7,696 (74.4)	8,161 (74.2)	7,401 (73.8)	8,217 (72.8)
Female	24,698 (25.9)	266 (23.9)	1,834 (26.1)	1,983 (24.9)	2,129 (25.7)	2,228 (26.3)	2,466 (25.6)	2,611 (25.5)	2,644 (25.6)	2,841 (25.8)	2,627 (26.2)	3,069 (27.2)
Total	95,348 (100.0)	1,113 (100.0)	7,020 (100.0)	7,960 (100.0)	8,269 (100.0)	8,487 (100.0)	9,617 (100.0)	10,226 (100.0)	10,340 (100.0)	11,002 (100.0)	10,028 (100.0)	11,286 (100.0)
Age												
Total	66.59±10.05	63.59±10.35	65.16±9.93	65.79±9.98	65.83±9.97	66.17±10.03	66.34±10.02	66.55±9.96	66.86±10.08	67.10±10.10	67.60±10.04	67.78±10.01
0–9	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
10–19	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
20–29	27 (0.0)	0 (0.0)	5 (0.1)	5 (0.1)	1 (0.0)	0 (0.0)	3 (0.0)	2 (0.0)	3 (0.0)	2 (0.0)	2 (0.0)	4 (0.0)
30–39	497 (0.5)	11 (1.0)	42 (0.6)	58 (0.7)	37 (0.4)	41 (0.5)	38 (0.4)	55 (0.5)	58 (0.6)	64 (0.6)	45 (0.4)	48 (0.4)
40–49	4,416 (4.6)	90 (8.1)	393 (5.6)	400 (5.0)	424 (5.1)	434 (5.1)	492 (5.1)	452 (4.4)	444 (4.3)	478 (4.3)	388 (3.9)	421 (3.7)
50–59	17,902 (18.8)	273 (24.5)	1,548 (22.1)	1,591 (20.0)	1,767 (21.4)	1,688 (19.9)	1,891 (19.7)	1,951 (19.1)	1,917 (18.5)	1,912 (17.4)	1,644 (16.4)	1,720 (15.2)
60–69	32,430 (34.0)	376 (33.8)	2,375 (33.8)	2,765 (34.7)	2,728 (33.0)	2,881 (33.9)	3,264 (33.9)	3,537 (34.6)	3,451 (33.4)	3,694 (33.6)	3,385 (33.8)	3,974 (35.2)
70–79	31,147 (32.7)	306 (27.5)	2,228 (31.7)	2,574 (32.3)	2,681 (32.4)	2,734 (32.2)	3,092 (32.2)	3,297 (32.2)	3,412 (33.0)	3,700 (33.6)	3,389 (33.8)	3,734 (33.1)
≥80	8,929 (9.4)	57 (5.1)	429 (6.1)	567 (7.1)	631 (7.6)	709 (8.4)	837 (8.7)	932 (9.1)	1,055 (10.2)	1,152 (10.5)	1,175 (11.7)	1,385 (12.3)
Conditions												
HTN	50,808 (53.3)	527 (47.3)	3,438 (49.0)	4,111 (51.6)	4,224 (51.1)	4,447 (52.4)	5,028 (52.3)	5,447 (53.3)	5,563 (53.8)	6,035 (54.9)	5,617 (56.0)	6,371 (56.5)
DM	32,327 (33.9)	329 (29.6)	1,990 (28.3)	2,398 (30.1)	2,541 (30.7)	2,706 (31.9)	3,200 (33.3)	3,478 (34.0)	3,598 (34.8)	3,941 (35.8)	3,845 (38.3)	4,301 (38.1)
COPD	12,651 (13.3)	181 (16.3)	1,121 (16.0)	1,196 (15.0)	1,059 (12.8)	1,097 (12.9)	1,252 (13.0)	1,391 (13.6)	1,420 (13.7)	1,516 (13.8)	1,297 (12.9)	1,121 (9.9)
Renal failure	3,366 (3.5)	13 (1.2)	169 (2.4)	227 (2.9)	231 (2.8)	240 (2.8)	305 (3.2)	367 (3.6)	394 (3.8)	449 (4.1)	449 (4.5)	522 (4.6)
CLD	9,259 (9.7)	95 (8.5)	638 (9.1)	707 (8.9)	750 (9.1)	720 (8.5)	762 (7.9)	880 (8.6)	1,104 (10.7)	1,206 (11.0)	1,184 (11.8)	1,213 (10.7)
IHD	13,322 (14.0)	118 (10.6)	878 (12.5)	1,110 (13.9)	1,116 (13.5)	1,205 (14.2)	1,378 (14.3)	1,446 (14.1)	1,486 (14.4)	1,482 (13.5)	1,481 (14.8)	1,622 (14.4)
Other cancers	9,724 (10.2)	86 (7.7)	588 (8.4)	640 (8.0)	761 (9.2)	756 (8.9)	1,053 (10.9)	1,135 (11.1)	1,154 (11.2)	1,164 (10.6)	1,112 (11.1)	1,275 (11.3)
CCI												
0	16,076 (16.9)	222 (19.9)	1,201 (17.1)	1,317 (16.5)	1,440 (17.4)	1,391 (16.4)	1,638 (17.0)	1,765 (17.3)	1,663 (16.1)	1,700 (15.5)	1,639 (16.3)	2,100 (18.6)
1	7,898 (8.3)	101 (9.1)	635 (9.0)	741 (9.3)	694 (8.4)	767 (9.0)	800 (8.3)	889 (8.7)	896 (8.7)	935 (8.5)	758 (7.6)	682 (6.0)
2	37,202 (39.0)	442 (39.7)	2,783 (39.6)	3,156 (39.6)	3,249 (39.3)	3,300 (38.9)	3,716 (38.6)	3,857 (37.7)	3,813 (36.9)	4,143 (37.7)	3,900 (38.9)	4,843 (42.9)
3	18,744 (19.7)	206 (18.5)	1,493 (21.3)	1,674 (21.0)	1,742 (21.1)	1,738 (20.5)	1,849 (19.2)	2,019 (19.7)	2,078 (20.1)	2,290 (20.8)	1,927 (19.2)	1,728 (15.3)
≥4	15,428 (16.2)	142 (12.8)	908 (12.9)	1,072 (13.5)	1,144 (13.8)	1,291 (15.2)	1,614 (16.8)	1,696 (16.6)	1,890 (18.3)	1,934 (17.6)	1,804 (18.0)	1,933 (17.1)
Health insurance type												
HI	90,285 (94.7)	1,044 (93.8)	6,582 (93.8)	7,415 (93.2)	7,829 (94.7)	8,042 (94.8)	9,171 (95.4)	9,717 (95.0)	9,843 (95.2)	10,431 (94.8)	9,518 (94.9)	10,693 (94.7)
MA	3,462 (3.6)	35 (3.1)	233 (3.3)	284 (3.6)	316 (3.8)	310 (3.7)	317 (3.3)	374 (3.7)	349 (3.4)	414 (3.8)	392 (3.9)	438 (3.9)
N/A	1,601 (1.7)	34 (3.1)	205 (2.9)	261 (3.3)	124 (1.5)	135 (1.6)	129 (1.3)	135 (1.3)	148 (1.4)	157 (1.4)	118 (1.2)	155 (1.4)
Hospital type												
Tertiary hospital	67,943 (71.3)	784 (70.4)	4,981 (71.0)	5,542 (69.6)	5,613 (67.9)	5,916 (69.7)	6,780 (70.5)	7,216 (70.6)	7,484 (72.4)	8,015 (72.9)	7,219 (72.0)	8,393 (74.4)
General hospital	26,704 (28.0)	324 (29.1)	1,991 (28.4)	2,348 (29.5)	2,601 (31.5)	2,496 (29.4)	2,765 (28.8)	2,943 (28.8)	2,790 (27.0)	2,908 (26.4)	2,733 (27.3)	2,805 (24.9)
Hospital	701 (0.7)	5 (0.4)	48 (0.7)	70 (0.9)	55 (0.7)	75 (0.9)	72 (0.7)	67 (0.7)	66 (0.6)	79 (0.7)	76 (0.8)	88 (0.8)

The 2011 data included only cases from November to December. Values are presented as mean ± standard deviation or number (%).
HTN = hypertension; DM = diabetes mellitus; COPD = chronic obstructive pulmonary disease; CLD = chronic liver disease; IHD = ischemic heart disease; CCI = Charlson Comorbidity Index; HI = health insurance; MA = medical aid; N/A = not applicable.

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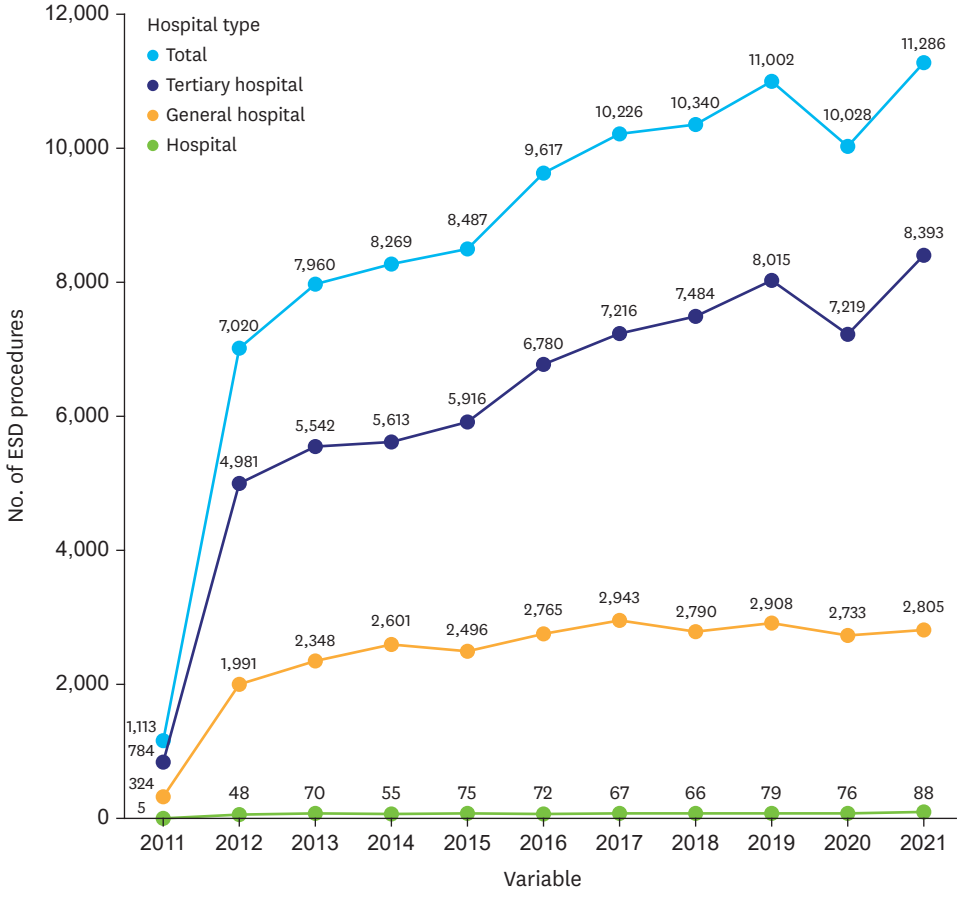

Fig. 1. Annual trend in the number of ESD procedures for early gastric cancer. The data for 2011 include only cases from November to December.
ESD = endoscopic submucosal dissection.

LOS

The LOS showed a decreasing trend, from a median of 5 days to 3 or 4 days, over the past decade (**Table 3**). The overall median LOS was 4 days (interquartile range [IQR], 4–5 days) throughout the 10 years (November 1, 2011 to December 31, 2021) (**Supplementary Table 1**). Specifically, the median LOS was 4 (IQR, 4–5), 5 (IQR, 4–6), and 4 (IQR, 3–5) days in tertiary care hospitals, general hospitals, and hospitals, respectively.

Overall, LOS showed a decreasing trend when the periods before and after the insurance policy change were compared (the mean value decreased from 5.15 days [for the period from January 1, 2011 to October 31, 2018] to 4.65 days [for the period from November 1, 2018 to December 31, 2021]). However, the ITS analysis attributed this decrease to the ongoing trend of reducing LOS over the past decade rather than the change in the insurance policy (immediate effect, P=0.481; sustained effect, P=0.555; **Fig. 4B**).

TMC per admission

Medical costs were expressed in Korean currency, with the unit of measurement being 1,000 KRW. The TMC steadily increased annually in tertiary care hospitals, general hospitals, and hospitals, with the most significant increase reported in general hospitals (**Table 4**). Medical costs have doubled over the past decade. However, the rate of cost increase declined after

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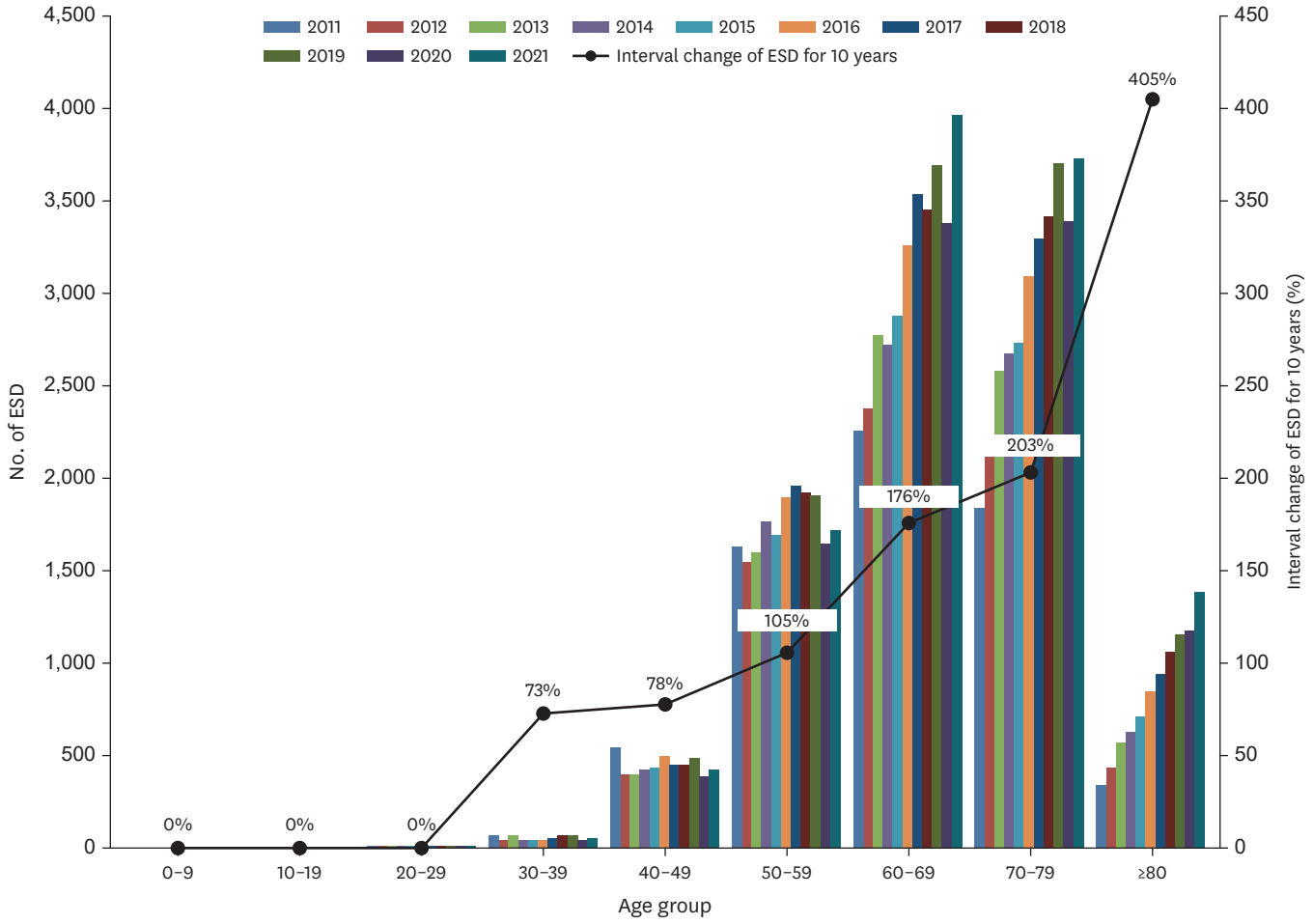

Fig. 2. Interval change in the number of ESD procedures over 10 years by age group. The percentage displayed in the graph indicates the number of times the ESD procedures in 2021 increased compared to that in 2011 for specific age groups*. The number of ESD procedures in 2011 was multiplied by 6 to account for data only from November to December, using this multiplier to estimate the full-year count for 2011.
ESD = endoscopic submucosal dissection.
*Formula: Number of ESD Procedures in 2021/(Number of ESD Procedures in 2011×6) (unit: %).

inflation was considered. For instance, from 2011 to 2016, inflation-adjusted TMC showed minimal changes. Beginning in 2017, the inflation-adjusted costs increased until 2020 (**Table 4**). The median TMC for ESD procedures from November 2011 to December 2021 was 2,123 (IQR, 1,538–2,752). The median TMC in tertiary care hospitals, general hospitals, and hospitals were 2,100 (IQR, 1,532–2,715), 2,202 (IQR, 1,567–2,849), and 1,724 (IQR, 1,268–2,118), respectively (**Supplementary Table 2**).

A comparison of the TMC before and after insurance coverage expansion in November 2018 revealed that the mean TMC increased significantly after the policy change (**Supplementary Table 3**). However, this result is largely attributed to a steady increase in medical costs over the years rather than a change in the insurance policy, as depicted in the graph obtained from the ITS analysis (**Fig. 4C**). The ITS analysis revealed a trend toward a reduced rate of cost increase after the policy change, although this was statistically insignificant (immediate effect, P=0.022; sustained effect, P=0.066; **Fig. 4C**). Unexpectedly, an immediate increase in costs was noted at the time of change in the insurance policy. Therefore, a detailed analysis was conducted. The TMC is the sum of two components: “out-of-pocket costs” and the

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Table 2. Regional distribution of endoscopic submucosal dissection procedures

Hospital region	Total	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Seoul	39,271 (41.2)	489 (43.9)	3,105 (44.2)	3,344 (42.0)	3,552 (43.0)	3,462 (40.8)	4,020 (41.8)	4,368 (42.7)	4,280 (41.4)	4,419 (40.2)	3,938 (39.3)	4,294 (38.0)
Busan	6,973 (7.3)	110 (9.9)	547 (7.8)	563 (7.1)	631 (7.6)	616 (7.3)	609 (6.3)	633 (6.2)	684 (6.6)	834 (7.6)	801 (8.0)	945 (8.4)
Daegu	6,832 (7.2)	94 (8.4)	630 (9.0)	630 (7.9)	582 (7.0)	590 (7.0)	687 (7.1)	699 (6.8)	669 (6.5)	733 (6.7)	693 (6.9)	825 (7.3)
Incheon	3,701 (3.9)	31 (2.8)	229 (3.3)	238 (3.0)	215 (2.6)	306 (3.6)	345 (3.6)	417 (4.1)	464 (4.5)	503 (4.6)	427 (4.3)	526 (4.7)
Gwangju	2,157 (2.3)	23 (2.1)	154 (2.2)	233 (2.9)	238 (2.9)	233 (2.7)	214 (2.2)	235 (2.3)	193 (1.9)	212 (1.9)	176 (1.8)	246 (2.2)
Daejeon	3,879 (4.1)	34 (3.1)	298 (4.2)	402 (5.1)	379 (4.6)	374 (4.4)	398 (4.1)	429 (4.2)	423 (4.1)	400 (3.6)	350 (3.5)	392 (3.5)
Ulsan	1,468 (1.5)	19 (1.7)	114 (1.6)	135 (1.7)	144 (1.7)	136 (1.6)	143 (1.5)	131 (1.3)	131 (1.3)	174 (1.6)	165 (1.6)	176 (1.6)
Sejong	26 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	5 (0.0)	21 (0.2)
Gyeonggi Province	15,606 (16.4)	154 (13.8)	997 (14.2)	1,242 (15.6)	1,348 (16.3)	1,381 (16.3)	1,618 (16.8)	1,662 (16.3)	1,762 (17.0)	1,906 (17.3)	1,629 (16.2)	1,907 (16.9)
Gangwon State	2,581 (2.7)	29 (2.6)	151 (2.2)	235 (3.0)	240 (2.9)	239 (2.8)	271 (2.8)	268 (2.6)	251 (2.4)	254 (2.3)	297 (3.0)	346 (3.1)
Chungcheongbuk-do	1,065 (1.1)	13 (1.2)	78 (1.1)	85 (1.1)	87 (1.1)	106 (1.2)	98 (1.0)	128 (1.3)	110 (1.1)	122 (1.1)	120 (1.2)	118 (1.0)
Chungcheongnam-do	2,030 (2.1)	22 (2.0)	127 (1.8)	159 (2.0)	143 (1.7)	141 (1.7)	191 (2.0)	220 (2.2)	245 (2.4)	283 (2.6)	244 (2.4)	255 (2.3)
Jeollabuk-do	2,372 (2.5)	29 (2.6)	176 (2.5)	197 (2.5)	221 (2.7)	204 (2.4)	222 (2.3)	238 (2.3)	238 (2.3)	287 (2.6)	282 (2.8)	278 (2.5)
Jeollanam-do	2,969 (3.1)	23 (2.1)	151 (2.2)	165 (2.1)	180 (2.2)	302 (3.6)	350 (3.6)	330 (3.2)	304 (2.9)	370 (3.4)	404 (4.0)	390 (3.5)
Gyeongsangbuk-do	357 (0.4)	1 (0.1)	30 (0.4)	45 (0.6)	35 (0.4)	37 (0.4)	37 (0.4)	35 (0.3)	49 (0.5)	23 (0.2)	30 (0.3)	35 (0.3)
Gyeongsangnam-do	3,620 (3.8)	40 (3.6)	200 (2.8)	234 (2.9)	245 (3.0)	320 (3.8)	381 (4.0)	391 (3.8)	475 (4.6)	422 (3.8)	423 (4.2)	489 (4.3)
Jeju	441 (0.5)	2 (0.2)	33 (0.5)	53 (0.7)	29 (0.4)	40 (0.5)	33 (0.3)	42 (0.4)	62 (0.6)	60 (0.5)	44 (0.4)	43 (0.4)
Total	95,348 (100.0)	1,113 (100.0)	7,020 (100.0)	7,960 (100.0)	8,269 (100.0)	8,487 (100.0)	9,617 (100.0)	10,226 (100.0)	10,340 (100.0)	11,002 (100.0)	10,028 (100.0)	11,286 (100.0)

The 2011 data included only cases from November to December. Values are presented as number (%).

"national burden." We analyzed these components separately. As of November 2018, out-of-pocket costs increased significantly (immediate effect, P<0.001; sustained effect, P=0.0657; **Supplementary Fig. 2A**). In contrast, the national burden showed no significant change (immediate effect, P=0.945; sustained effect, P=0.113; **Supplementary Fig. 2B**). An abrupt increase in the "out-of-pocket cost" was responsible for the increase in the TMC in November 2018. Further cost analysis to determine the reason was limited by our dataset format.

Trends in resection types and treatment indications

The en bloc resection rates analyzed from November 1, 2011 to October 31, 2018 were 99.1%, 98.9%, and 99.0% in tertiary care hospitals, general hospitals, and hospitals, respectively. These rates did not significantly change over time (**Table 5**).

Most ESD procedures (>90%) were performed for EGC measuring less than 2 cm in diameter and exhibiting differentiated histopathology without ulceration (absolute indication). Almost all procedures in the first year of insurance coverage (2011) were conducted under absolute indications; however, the number of cases with expanded indications has gradually increased and stabilized at approximately 8% since 2014 (**Table 6**).

DISCUSSION

Only a single study is available on the national statistics of ESD for EGC, analyzing the early period of insurance coverage from 2011 to 2014 [12]. Our study aimed to broaden this scope by covering a comprehensive decade-long period up to 2021 and capturing significant changes in the health insurance policy in November 2018. After the insurance policy change, the NHIS adjusted its coverage to include previously uncovered cases (personal payment rate of 100%) to a personal payment rate of 80%. Our study explored different national aspects of ESD, including the number of procedures, patient characteristics, LOS, medical costs, treatment indications, and en bloc resection rates on an annual basis.

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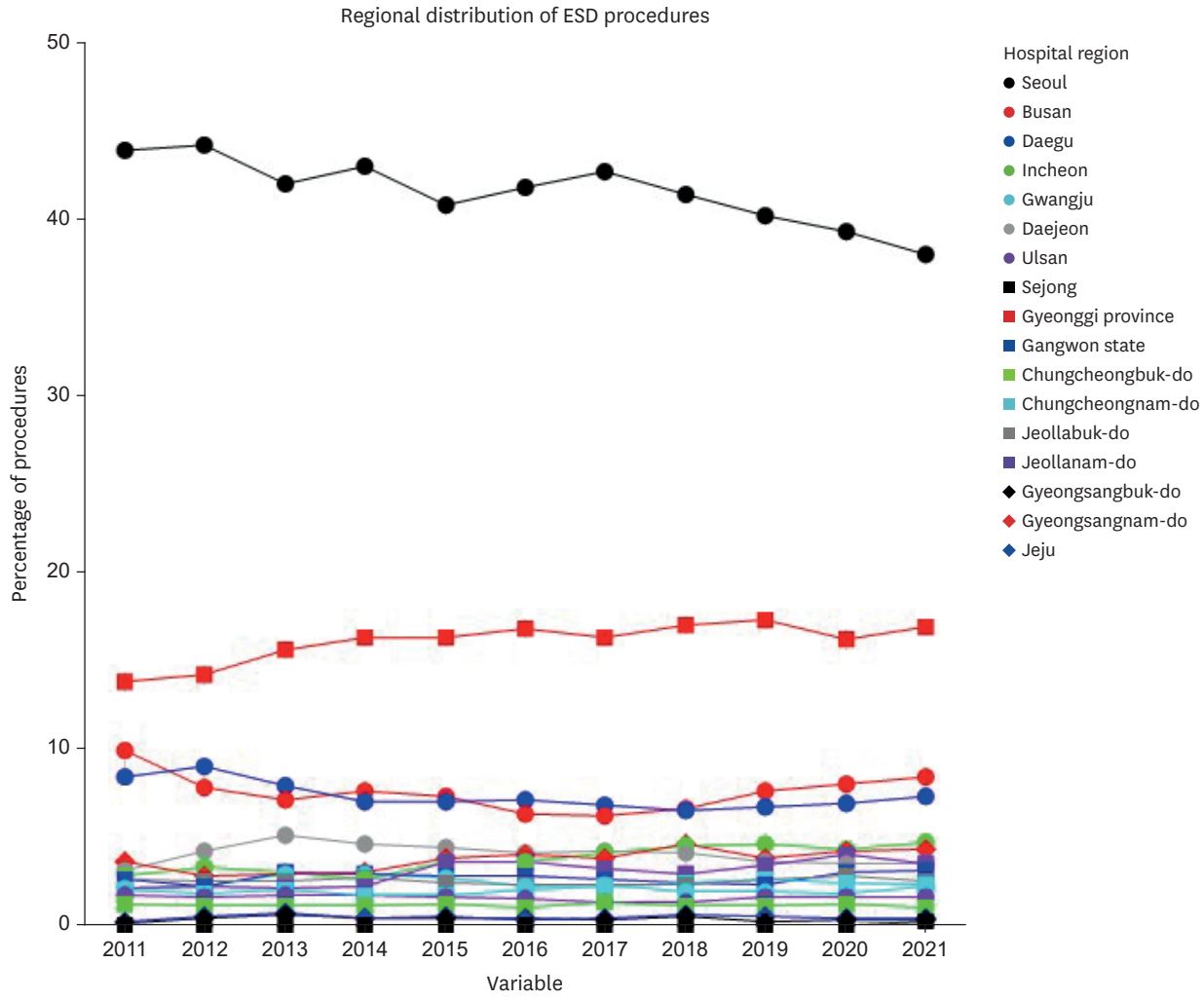

Fig. 3. Regional distribution of ESD procedures over 10 years. South Korea's administrative regions were categorized into 17 areas (7 metropolitan cities, 1 self-governing city, and 9 provinces), and the trend of ESD procedures by year was analyzed. For each year, the proportion of ESD procedures in each specific region was calculated as a percentage of the total number of procedures. The data for 2011 included only cases from November to December.
ESD = endoscopic submucosal dissection.

We demonstrated that the number of ESD procedures for EGC has increased annually. This trend was primarily driven by tertiary care hospitals (**Fig. 1**). The number of ESD procedures performed during the COVID-19 pandemic temporarily declined in 2020, mirroring the trends observed in other areas of healthcare utilization. This decline was primarily due to a significant reduction in the number of ESD procedures performed in tertiary care hospitals. The number of cases returned to the pre-pandemic levels after the relaxation of quarantine measures and social distancing guidelines. Despite more than 20 years of experience in ESD in Korea and a consistent increase in the number of ESD procedures, this technique has not yet been widely adopted in small (30–100 beds) or general hospitals (**Fig. 1**). This could be attributed to the difficulty in managing complications such as perforation or severe bleeding.

We found that the regional distribution of ESD procedures was largely concentrated in metropolitan areas, underscoring the regional imbalances (**Supplementary Fig. 1**). Healthcare disparities and medically underserved areas remain a persistent concern, both domestically and internationally. Several countries are implementing policies tailored to their

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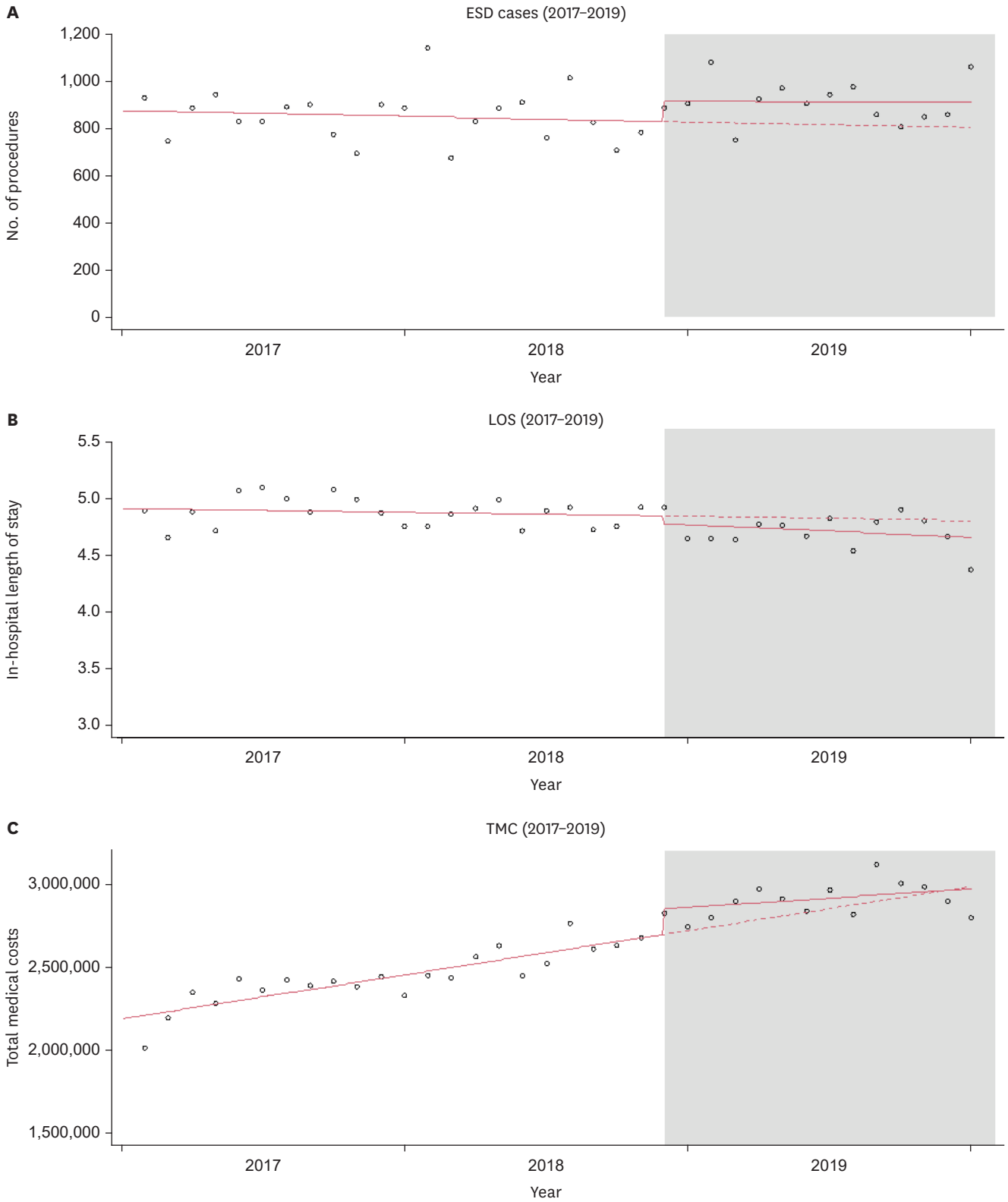

Fig. 4. Interrupted time series analysis demonstrating the impact of insurance expansion in November 2018 on the number of ESD procedures (A), LOS (B), and hospitalization costs (C). The Y-axis shows the average value of each variable per month. The X-axis spans from January 2017 to December 2019 in monthly increments, highlighting changes before (white background) and after (gray background) the insurance policy change on November 1, 2018. The continuous line shows the predicted trend based on the regression model and the dashed line shows the counterfactual scenario.
ESD = endoscopic submucosal dissection; LOS = in-hospital length of stay; TMC = total medical cost.

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Table 3. In-hospital stay (days)

Year	Tertiary hospital		General hospital		Hospital		Total	
	Median	IQR	Median	IQR	Median	IQR	Median	IQR
2011	5	4–6	5	4–6	5	5–8	5	4–6
2012	5	4–5	5	4–6	4	4–5	5	4–6
2013	5	4–5	5	4–6	4	3–5	5	4–6
2014	5	4–5	5	4–6	4	3–5	5	4–5
2015	4	4–5	5	4–6	4	3–4	4	4–5
2016	4	4–5	5	4–6	4	3–5	4	4–5
2017	4	4–5	5	4–6	4	3–4	4	4–5
2018	4	4–5	5	4–6	4	3–4	4	4–5
2019	4	4–5	5	4–5	4	3–4	4	4–5
2020	4	4–5	4	4–5	4	3–5	4	4–5
2021	4	4–5	4	4–5	3	3–4	4	4–5

IQR = interquartile range (Q1–Q3).

Table 4. Total medical costs per admission (1,000 KRW)

Year	Tertiary hospital	General hospital	Hospital	Total		Total (inflation-adjusted)*	
	Median	Median	Median	Median	IQR	Median	IQR
2011	1,387	1,332	1,023	1,368	1,151–1,676	1,523	1,281–1,865
2012	1,393	1,345	1,200	1,379	1,184–1,703	1,502	1,290–1,855
2013	1,387	1,378	1,149	1,384	1,171–1,727	1,488	1,259–1,857
2014	1,471	1,486	1,134	1,473	1,234–1,825	1,564	1,310–1,937
2015	1,582	1,709	1,325	1,612	1,369–1,960	1,699	1,443–2,066
2016	1,657	1,771	1,445	1,686	1,442–2,013	1,760	1,505–2,102
2017	2,061	2,182	1,788	2,102	1,786–2,499	2,153	1,829–2,559
2018	2,357	2,503	1,900	2,393	2,051–2,854	2,415	2,070–2,880
2019	2,577	2,793	2,033	2,624	2,281–3,105	2,638	2,293–3,122
2020	2,694	2,848	2,124	2,742	2,378–3,223	2,742	2,378–3,223
2021	2,800	2,906	2,048	2,828	2,456–3,341	2,759	2,396–3,260

Two cases with a cost of zero were excluded in 2012 and 2014.
IQR = interquartile range (Q1–Q3).
*Costs adjusted for inflation to 2020-KRW values using the South Korea Consumer Price Index.

Table 5. En bloc resection rate

Year	Tertiary care hospital			General hospital			Hospital		
	Total	En bloc	Piecemeal	Total	En bloc	Piecemeal	Total	En bloc	Piecemeal
2011	784	772 (98.5)	12 (1.5)	324	319 (98.5)	5 (1.5)	5	5 (100.0)	0 (0.0)
2012	4,981	4,933 (99.0)	48 (1.0)	1,991	1,970 (98.9)	21 (1.1)	48	48 (100.0)	0 (0.0)
2013	5,542	5,485 (99.0)	57 (1.0)	2,348	2,331 (99.3)	17 (0.7)	70	69 (98.6)	1 (1.4)
2014	5,613	5,562 (99.1)	51 (0.9)	2,601	2,572 (98.9)	29 (1.1)	55	55 (100.0)	0 (0.0)
2015	5,916	5,868 (99.2)	48 (0.8)	2,496	2,457 (98.4)	39 (1.6)	75	75 (100.0)	0 (0.0)
2016	6,780	6,714 (99.0)	66 (1.0)	2,765	2,731 (98.8)	34 (1.2)	72	70 (97.2)	2 (2.8)
2017	7,216	7,150 (99.1)	66 (0.9)	2,943	2,907 (98.8)	36 (1.2)	67	66 (98.5)	1 (1.5)
2018.01–2018.10	6,210	6,168 (99.3)	42 (0.7)	2,286	2,274 (99.5)	12 (0.5)	51	51 (100.0)	0 (0.0)

Values are presented as number (%).

Table 6. Types of indications for endoscopic submucosal dissection procedure

Year	Absolute indication	Expanded indication	Total
2011	1,108 (99.6)	5 (0.4)	1,113
2012	6,618 (94.3)	402 (5.7)	7,020
2013	7,451 (93.6)	509 (6.4)	7,960
2014	7,573 (91.6)	696 (8.4)	8,269
2015	7,777 (91.6)	710 (8.4)	8,487
2016	8,814 (91.7)	803 (8.3)	9,617
2017	9,442 (92.3)	784 (7.7)	10,226
2018.01–2018.10	7,808 (91.4)	739 (8.6)	8,547

Values are presented as numbers (%).

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healthcare systems to address these disparities [17,18]. Similarly, we need to develop policies that address regional imbalances and are appropriately aligned with our healthcare system. However, ESD procedures should not be equated with medical services, such as emergency medicine, delivery rooms, trauma centers, or cardiovascular centers. ESD for gastric cancer is not an emergency procedure, and a few studies have reported lower complications in high-volume centers [19]. Therefore, the completeness and safety of the procedure are important considerations. We believe that an in-depth discussion that weighs the advantages and disadvantages of both sides is required to develop an optimal medical policy for ESD.

An analysis of the number of ESD procedures by age group revealed a continuous annual increase among older age groups (>60 years) over the past decade (**Fig. 2**). The safety and efficacy of ESD in older adults are well documented [20,21]. In addition, its usefulness for EGC has been demonstrated in cases with indications beyond the conventional ESD criteria among older patients at high risk for surgery [22]. As Korea has transitioned into an aged society, the prevalence of EGC in older patients is expected to increase, with a consequent increase in the number of ESD procedures.

The LOS for ESD of EGC declined annually, which may be attributed to the widespread adoption of ESD techniques, enhanced awareness regarding ESD techniques, and improvements in medical devices [23]. Moreover, this trend was observed in all types of hospitals (tertiary hospitals, general hospitals, and hospitals), indicating an overall increase in ESD proficiency.

Although ESD was covered by the NHIS in November 2011, and its expansion included most indications of ESD for EGC in November 2018, the TMC increased in contrast to the situation in Japan [24]. In Japan's Diagnosis Procedure Combination payment system, hospitals that reduce material or hospitalization expenses are compensated for their savings, thereby promoting cost efficiency. Furthermore, medical costs in Japan have decreased because of increased ESD proficiency and the ability to rapidly predict or respond to complications [24]. Conversely, hikes in medical expenses observed in Korea are believed to be primarily associated with increases in medical fees, material costs, and several other expenses, along with rising prices. For example, Dahan et al. [25] emphasized that although compared to surgery, ESD is cost-effective for patients, the use of ESD medical devices primarily contributes to the increase in medical expenses. Notably, the medical cost in this study includes all costs billed during the hospitalization period for the ESD procedure, and we could not separately analyze the expenses associated with ESD procedures or materials. However, the decrease in the LOS suggests that complications may have decreased in Korea as ESD proficiency increased, mirroring the situation in Japan.

In addition, we evaluated the impact of insurance expansion in November 2018 on the number of ESD procedures, LOS, and medical costs using the ITS analysis. The insurance expansion in November 2018 did not significantly affect the number of ESD procedures performed. However, our analysis was limited to the total number of ESD procedures rather than to individual analyses of absolute or expanded ESD indications because of the unification of the procedure code to Q7653 following the insurance policy change in November 2018. Therefore, analyzing these subgroups could reveal meaningful changes in these parameters, as the policy change was primarily aimed at expanding reimbursements to the expanded indications. LOS was not affected, which is reasonable because insurance expansion for ESD indications possibly exerted little effect on hospitalization duration.

https://doi.org/10.5230/jgc.2024.24.e41

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The significant elevation in TMC following the policy change is ascribed to an increase in "out-of-pocket costs" (**Supplementary Fig. 2**). The fee for ESD procedures did not change in November 2018 (as of October 1, 2018, the procedure fee for QZ933 or QX704 was 552,530 KRW, and as of November 1, 2018, the procedure fee for Q7653 was 552,530 KRW). Therefore, the observed increase was not attributable to changes in the procedure fee. Several factors may have contributed to the increase in "out-of-pocket costs." First, some procedures (QX704, QX701) that might not have been well-claimed to the Health Insurance Review and Assessment Service previously due to the 100% personal payment rate may have been claimed completely after the expansion of insurance coverage which reduced the personal payment rate to 80%. Second, cases of piecemeal resection, which were previously reimbursed with the EMR fee (265,140 KRW), may have been properly claimed at the ESD fee (611,920 KRW) following the policy change. As piecemeal resection is more common in cases with the expanded indication (which has an 80% personal payment rate), these changes could have primarily impacted "out-of-pocket costs" rather than "national burden."

This study had several limitations. First, we could not differentiate the expenses associated with the ESD procedure from the overall costs incurred during hospitalization. Second, the ESD code was merged into Q7653 after November 1, 2018, making it impossible to distinguish between en bloc and piecemeal resections, or absolute and expanded indications. Third, the number of ESD procedures for EGC may have been underestimated because procedures uncovered by insurance were excluded from the study. However, we believe that the number of uninsured procedures was extremely small to affect the overall findings significantly.

In conclusion, we used the NIHS database data to comprehensively analyze the current status of ESD for EGC in Korea. It revealed a continuous increase in ESD procedures, particularly among the older population, and an increasing trend in medical costs, whereas LOS decreased. Furthermore, persistent regional disparities were observed in the number of ESD procedures performed throughout the study period. We believe this study will provide valuable insights to efficiently optimize the distribution of medical resources and implement a healthcare delivery system for the better management of EGC in Korea.

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SUPPLEMENTARY MATERIALS

Supplementary Table 1
Median in-hospital LOS from 2011 to 2021

Supplementary Table 2
Median value of total medical costs from 2011 to 2021 (1,000 KRW)

Supplementary Table 3
Mean total medical costs between the 2 periods (2011–2018, 2018–2021)

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Supplementary Fig. 1

Color-coded map of Korea showing the regional distribution of the total number of endoscopic submucosal dissection procedures from 2011 to 2021. The data for 2011 included only cases from November to December.

Supplementary Fig. 2

Interrupted time series analysis demonstrating the impact of insurance expansion in November 2018 on the out-of-pocket cost (A) and national burden (B). The Y-axis shows the average value of expenses per month. The X-axis spans from January 2017 to December 2019 in monthly increments, highlighting changes before (white background) and after (gray background) the insurance policy change on November 1, 2018. The continuous line shows the predicted trend based on the regression model and the dashed line shows the counterfactual scenario.

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