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Investigation of the Existence of Supplier-Induced Demand in use of Gastrostomy Among Older Adults

A Retrospective Cohort Study

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Abstract: The aim of this study is to clarify whether there is small area variation in the use of gastrostomy that is explained by hospital physician density, so as to detect the existence of supplier-induced demand (SID).

The study design is a retrospective cohort using claim data of Fukuoka Late Elders' Health Insurance, submitted from 2010 to 2013. Study participants included 51,785 older adults who had been diagnosed with eating difficulties. We designated use of gastrostomy as an event. Multi-level logistic analyses were then used to investigate the existence of SID.

After controlling for patient factors, we found significant regional level variance in gastrostomy use (median odds ratio [MOR]: 1.72, 1.37–2.51). Hospital physician density was significantly positively related with gastrostomy (adjusted OR of hospital physician density: 1.75, 1.25–2.45; $P < 0.001$). MORs were largely reduced for the input variable of hospital physician density.

We found that the small area variation in use of gastrostomy among older adults could be explained by hospital physician density, which might indicate the existence of SID.

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Abbreviations: AIC = Akaike information criterion, CCI = Charlson comorbidity index, CVA = cerebrovascular accident, FY = fiscal year, ICC = intraclass correlation coefficient, ICD-10 = International Disease Classification 10th revision, MOR = median odds ratio, OR = odds ratio, SID = supplier-induced demand, STM = secondary tier of medical care.

INTRODUCTION

After peaking in 2008, the Japanese population as a whole has been decreasing; however, the older population has been consistently increasing. The proportion of adults >65 years old in Japan is now up to approximately one-fourth of the total population, resulting in what is known as a “super-aging” society.¹ Cerebrovascular accident (CVA), dementia, malignancies, and

infections such as pneumonia are prevalent among older adults, as a result of cumulative molecular and cellular damage.² These conditions consequently induce difficulty with intake of adequate nutrition. Gastrostomy for feeding has been commonly used among this population.^{3–5} The All Japan Hospital Association reported there were an estimated 260,000 older adults in Japan with a surgically implanted feeding tube.⁶ However, several studies have found that gastrostomy for older patients, particularly those with advanced dementia, was not associated with prevention of aspiration,^{7–9} recovery from pressure ulcers,^{7,10} or lower mortality.^{7,9,11,12} The Japan Geriatrics Society recently issued a guideline recommending gastrostomy for older adults with eating difficulties only after consideration of whether it would contribute to an improved prognosis or quality of life.¹³ However, it has been reported that the proportion of older patients who were evaluated for swallowing ability before feeding tube placement was as low as 22.9%,¹⁴ which suggests that pre-evaluation and indications for gastrostomy might not be appropriate. It is well known that gastrostomy feeding tube insertion was relatively profitable in Japan before revision of the national fee schedule in 2014, approximately 1000 USD (100 JPY = 1 USD) per procedure.¹⁵ Furthermore, inconsistent information about and explanation of the need for gastrostomy is common among medical staff and physicians, and often leads to

TABLE 1. Study Population, Number of Gastrostomy Procedures, and Hospital Physician Density, by Secondary Tier of Medical Care

STM	Total	Gastrostomy		Hospital Physician Density
	N	N	%	
1	11,358	246	2.2	223.8
2	2230	26	1.2	131.2
3	1537	12	0.8	113.3
4	2735	23	0.8	127.5
5	1357	7	0.5	126.1
6	4559	82	1.8	331.3
7	1549	29	1.9	134.6
8	4526	68	1.5	172.2
9	2794	33	1.2	237.0
10	1527	22	1.4	118.8
11	1987	31	1.6	138.9
12	13,382	265	2.0	213.8
13	2244	49	2.2	85.8
Total	51,785	893		

STM = secondary tier of medical care.

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TABLE 2. Patient Factors, Regional Factors, and Crude Odds Ratios for Gastrostomy

	Gastrostomy		No Gastrostomy		Crude OR	95% CI		P	
	N = 893	%	N = 50,892	%					
Patient factors									
Sex									
Male	%	453	2.1	20,767	97.9	Reference			
Female	%	440	1.4	30,125	98.6	0.67	0.59	0.76	<0.001
Age									
Mean	SD	83.8	6.5	84.9	7.1	—			
<80	%	229	1.9	11,748	98.1	Reference			
80–90	%	491	1.9	25,588	98.1	1.21	1.06	1.38	0.005
≥90	%	173	1.3	13,556	98.7	0.66	0.56	0.78	<0.001
Neurological comorbidity									
Extrapyramidal and movement disorders	%	146	2.8	5006	97.2	1.79	1.50	2.14	<0.001
Other neurological disorder	%	17	3.7	448	96.3	2.19	1.34	3.56	0.002
CVA	%	496	1.8	26,432	98.2	1.16	1.01	1.32	0.033
Dementia	%	237	2.1	11,008	97.9	1.31	1.13	1.52	<0.001
Other comorbidity									
Malignancy	%	108	1.1	9328	98.9	0.61	0.50	0.75	<0.001
Charlson comorbidity index									
0	%	225	2.0	10,869	98.0	Reference			
1–2	%	379	1.7	22,369	98.3	0.94	0.82	1.07	0.367
≥3	%	289	1.6	17,654	98.4	0.90	0.78	1.04	0.148
Economic status									
Low	%	413	1.6	24,813	98.4	Reference			
Middle–high	%	480	1.8	26,079	98.2	1.11	0.97	1.26	0.137
Diagnosed FY									
<2009	%	77	2.0	3799	98.0	1.17	0.92	1.48	0.193
2010	%	296	2.3	12,309	97.7	1.55	1.35	1.79	<0.001
2011	%	225	1.7	12,742	98.3	1.01	0.87	1.17	0.914
2012	%	146	1.2	11,925	98.8	0.64	0.53	0.76	<0.001
2013	%	149	1.5	10,117	98.5	Reference			
Regional factors									
Hospital physician density									
Lower	%	168	1.3	13,011	98.7	Reference			
Higher	%	725	1.9	37,881	98.1	1.48	1.25	1.76	<0.001

CVA = cerebrovascular accident, DPC = diagnosis procedure combination, FY = fiscal year, OR = odds ratio, SD = standard deviation.

insufficient understanding on the part of families or caregivers when deciding if the procedure is necessary.^{14,16,17} This situation could influence gastrostomy use even more than patient characteristics, in addition to economic incentives known as supplier-induced demand (SID).

There are various tools for detecting the existence of SID. They include analysis of small area variation and physician density.¹⁸ We can infer the existence of SID if small area variation can be found, which could in turn be explained by physician density, independent of patient characteristics. Thus, the aim of this study was to clarify whether there is small area variation in gastrostomy use that can be explained by physician density, so as to detect the existence of SID.

MATERIALS AND METHODS

Study Design and Participants

The design of this study was a retrospective cohort. In Japan, those aged ≥75 years, or those aged 65 to 74 years with a specific disability, are eligible for the Late Elders' Health

Insurance. We used claim data submitted to Fukuoka Late Elders' Health Insurance from 2010 to 2013. First, we identified 51,785 participants who had been diagnosed as having difficulty with eating, excluding rule-out diagnoses. We defined placement of a gastrostomy feeding tube as an event that occurred after diagnosis. We categorized eating difficulties according to the International Disease Classification 10th revision (ICD-10), as follows—F50: Eating disorders; J69: Pneumonitis due to solids and liquids; R13: Dysphagia; R630: Anorexia; and R633: Feeding difficulties. We defined a surgically implanted gastrostomy feeding tube as procedure code 150170550 or 50171610. We excluded patients who had a gastrostomy procedure before being diagnosed with any type of eating difficulty. Patients with the following malignancies were also excluded—C00-C14: malignant neoplasms of the lip, oral cavity, and pharynx; C15: malignant neoplasm of the esophagus; and C16: malignant neoplasm of the stomach.

This study was approved by the Institutional Review Board of Kyushu University (Clinical Bioethics Committee of the Graduate School of Healthcare Sciences, Kyushu University).

TABLE 3. Results of Multilevel Logistic Analyses

	Null Model			Model 1			Model 2			
	AOR	95% CI	P	AOR	95% CI	P	AOR	95% CI	P	
Patients factors										
Sex										
Male				Reference			Reference			
Female			0.67	0.58	0.77	<0.001	0.67	0.58	0.77	<0.001
Age										
<80				Reference			Reference			
80–90			1.03	0.88	1.21	0.699	1.03	0.88	1.21	0.692
≥90			0.75	0.61	0.92	0.006	0.75	0.61	0.92	0.006
Neurological comorbidity										
Extrapyramidal and movement disorders			1.63	1.36	1.96	<0.001	1.63	1.36	1.96	<0.001
Other neurological disorder			2.02	1.23	3.31	0.005	2.01	1.22	3.29	0.006
CVA			1.13	0.98	1.29	0.095	1.12	0.98	1.29	0.098
Dementia			1.34	1.15	1.57	<0.001	1.34	1.14	1.56	<0.001
Other comorbidity										
Malignancy			0.60	0.48	0.74	<0.001	0.60	0.48	0.74	<0.001
Charlson comorbidity index										
0				Reference			Reference			
1–2			0.88	0.74	1.05	0.152	0.88	0.74	1.05	0.155
≥3			0.91	0.75	1.11	0.344	0.91	0.75	1.11	0.350
Economic status										
Middle–high			1.00	0.87	1.15	0.972	1.01	0.88	1.16	0.933
Diagnosed FY										
<2009			1.42	1.06	1.90	0.018	1.42	1.06	1.90	0.018
2010			1.71	1.39	2.09	<0.001	1.71	1.39	2.09	<0.001
2011			1.23	1.00	1.52	0.054	1.23	1.00	1.52	0.055
2012			0.84	0.67	1.06	0.140	0.84	0.67	1.06	0.139
2013				Reference			Reference			
Regional factors										
Hospital physician density										
Lower							Reference			
Higher							1.75	1.25	2.45	0.001
Regional level variance										
MOR	0.31	0.11	0.91	0.32	0.11	0.93	0.14	0.04	0.42	
ICC	0.09	0.03	0.22	0.09	0.03	0.22	0.04	0.01	0.11	
AIC		9031.5			8866.1			8859.6		

AIC = Akaike’s information criterion, AOR = adjusted odds ratio, CVA = cerebrovascular accident, DPC = diagnosis procedure combination, FY = fiscal year, ICC = intraclass correlation coefficient, MOR = median odds ratio, OR = odds ratio.

Definition of Variables

We identified sex, age, neurological comorbidities, other comorbidities, year of diagnosis, and economic status as patient factors. We established three age categories: <80 years, 80 to 89 years, and ≥90 years. We defined neurological comorbidities as CVA, dementia, extrapyramidal and movement disorders, and other neurological diseases. We applied the Charlson comorbidity index (CCI)¹⁹ to define CVA and dementia. Extrapyramidal and movement disorders were defined according to the ICD-10, as G20-G26: extrapyramidal and movement disorders. Other neurological disorders were defined as follows—G10-G13: systemic atrophies primarily affecting the central nervous system; G35-G37: demyelinating diseases of the central nervous system; and G70-G73: diseases of the myoneural junction and muscle. We further defined malignancy as other comorbidity using the CCI, except for those malignancies mentioned above. Other than for CVA, dementia, and

malignancy, the possible CCI scores were 0, 1 to 2, or 3 or more. Year diagnosed was categorized as fiscal year (FY) 2009 or earlier, FY2010, FY2011, FY2012, or FY2013. Although the data used in this study were submitted between 2010 and 2013, diagnoses before this data submission period retained their diagnosis year and month; hence, we created a variable FY2009 or earlier. With regard to economic status, participants were categorized into low, middle, and high levels according to prior year incomes.²⁰ We combined middle and high economic levels into a category of middle–high status because the proportion of patients at high economic levels was extremely low.

We used physician density²¹ by secondary tier of medical care (STM) as regional factors. STM is the unit of secondary care governed by a prefecture according to Japan’s Medical Service Law. Each prefecture must set its own STMs; Fukuoka Prefecture has 13 STMs. Gastrostomy is mainly performed in a hospital setting, and hospital physician density reflects health

care resources related to gastrostomy. Therefore, in this study, we defined physician density as hospital physician density. Furthermore, greater hospital density indicates more acute care resources. Hospital physician density was transformed into a binary variable. We used the number of hospital physicians according to the Hospital Report of e-Stat (2011), which was created by the Ministry of Internal Affairs and Communications. Population data were obtained from 2010 census data.

Statistical Analysis

We calculated the percentage of gastrostomy procedures performed by sex, age, neurological comorbidities, other comorbidities, year of diagnosis, economic status, and hospital physician density. We then quantified the strength of relationships using odds ratios (ORs). We performed multilevel logistic analyses with patient factors as level 1 and regional factors as level 2. We first constructed a null model. We then developed model 1, which included patient factors such as sex, age, neurological comorbidities, other comorbidities, diagnosis year, and economic status. Subsequently, we constructed model 2 that included patient factors and hospital physician density. The Akaike information criterion (AIC) was used for goodness of model fit. We used an intraclass correlation coefficient (ICC) for similarity within groups and the median odds ratio (MOR) for variance between groups, in addition to regional level variance. The ICC is the ratio between STM variance and total variance; interpretation of the ICC in a logistic model is limited.²² The MOR is defined as the median of a set of ORs obtained when comparing 2 randomly chosen regions with different random effects.²³ The MOR can be interpreted as the median increased risk of moving from a region with lower risk to one with higher risk, assuming the same patient covariates.²³ If the MOR is equal to 1, there are no differences between regions for the probability of gastrostomy.²⁴ If there were strong regional level differences, the MOR would be larger and the regions involved would be relevant for area variations in the individual probability of gastrostomy.²⁴ MOR is computed on the typical OR scale and is therefore comparable to OR for other patient-level factors.²⁴

The equation for MOR is:

$$\text{MOR} = \exp[\sqrt{(2 \times \delta^2)} \times 0.6745],$$

where δ^2 is the regional level variance.²⁵

All reported *P* values were 2-tailed, and the level of significance was set at *P* < 0.05.

We used Stata statistical software, Release 14 (StataCorp, College Station, TX) for the statistical analyses.

Sensitivity Analysis

For sensitivity analysis, we constructed model 3 by replacing tertile age in model 2 with quantile age (<80, 80 ≤ <85, 85 ≤ <90, 90 ≤), model 4 by replacing tertile age in model 2 with continuous age, and model 5 by replacing binary economic status in model 2 with tertiles that were very low, low, and middle-high.

RESULTS

Regional Information

Information of the study population, number of gastrostomy procedures performed, and number of hospital physicians per 100,000 (hospital physician density) by STM are shown in Table 1. STMs 1 and 12 had markedly more patients with

gastrostomy than the other STMs. The number of study participants in STMs 1 and 12 were 11,358 and 13,382, respectively. STMs with the most gastrostomy procedures were STMs 1 and 13, which were 2.4-fold greater than that with the fewest procedures (STM 5). STMs with the highest hospital physician density were STM 6 (331.3), STM 9 (237.0), STM 1 (223.8), and STM 12 (213.8). The ratio of the highest hospital physician density to the lowest was approximately 3.9-fold.

Results of Patient Factors, Regional Factors, and Crude ORs for Gastrostomy Use

Table 2 shows sex, age, neurological comorbidities, other comorbidities, year of diagnosis, economic status, and hospital physician density by gastrostomy and crude OR for use of gastrostomy. The number and percentage of gastrostomy procedures were 893 and 1.7% of the entire population (n = 51,785). The proportion of gastrostomy among female patients was significantly lower than that among males. Patients in the 80 to 89-year age group had significantly more gastrostomy procedures than the other age groups, whereas those ≥90 years had significantly fewer procedures than patients aged <80 years. Those with neurological comorbidities had a significantly higher proportion of gastrostomy. Conversely, patients with malignancies had a significantly lower proportion of gastrostomy. Economic status was not significantly related to use of gastrostomy. With respect to regional factors, higher hospital physician density was significantly associated with gastrostomy (number of hospital physicians: OR 1.48, 1.25–1.76; *P* < 0.001).

Results of Multilevel Logistic Analyses

Table 3 shows results of the null model and models 1 and 2 after multilevel logistic regression analyses. Females, patients aged ≥90 years, and those with malignancies had significant associations with a lower proportion of gastrostomy. Neurological comorbidities, except for CVA, had significant positive relationships with the proportion of gastrostomy use. CCI and economic status had no relationship with the proportion of gastrostomy, using multivariate analyses. There was significant variance in regional level (MOR 1.71, 1.37–2.49), and MORs between the null model and model 1 were only slightly changed by patient factors (MOR 1.72, 1.37–2.51). In model 2, hospital physician density had a significant relationship with the use of gastrostomy (adjusted OR; 1.75, 1.25–2.45; *P* < 0.001). Moreover, the MOR was 17% lower than for the null model (MOR 1.71 in the null model was reduced to 1.42 in model 2).

Results of Sensitivity Analyses

In sensitivity analyses (Table 4), the results of model 3 with age tertile in model 2 changed to quartile, those of model 4 with categorized age changed to continuous age, and those of model 5 with economic status tertile in model 2 changed to quartile were all similar to the results of model 2.

DISCUSSION

Our study aimed to detect the existence of SID for gastrostomy and to investigate the relationships between small area variation in use of gastrostomy and hospital physician density. We found that there was small area variation in gastrostomy use. This could likely be explained by abundant hospital physician density in settings where acute care resources were also abundant, which could in turn indicate the existence of SID. The notion of SID is that doctors, in acting as agents for their

TABLE 4. Results of Sensitivity Analyses

	Model 3				Model 4				Model 5			
	AOR	95% CI		P	AOR	95% CI		P	AOR	95% CI		P
Patients factors												
Sex												
Male	Reference				Reference				Reference			
Female	0.66	0.57	0.76	<0.001	0.67	0.58	0.77	<0.001	0.68	0.59	0.79	<0.001
Age category												
<80	Reference								Reference			
80–90									1.04	0.88	1.22	0.650
80–85	0.98	0.82	1.19	0.863								
85–90	1.08	0.90	1.30	0.387								
≥90	0.75	0.61	0.92	0.007					0.76	0.62	0.93	0.008
Age (continuous)					0.99	0.98	1.00	0.005				
Neurological comorbidity												
Extrapyramidal and movement disorders	1.64	1.36	1.97	<0.001	1.63	1.36	1.96	<0.001	1.63	1.36	1.96	<0.001
Other neurological disorder	2.02	1.23	3.32	0.005	1.98	1.20	3.24	0.007	2.01	1.22	3.29	0.006
CVA	1.12	0.98	1.29	0.097	1.13	0.98	1.30	0.085	1.12	0.98	1.29	0.102
Dementia	1.33	1.14	1.56	<0.001	1.36	1.17	1.59	<0.001	1.34	1.14	1.56	<0.001
Other comorbidity												
Malignancy	0.60	0.48	0.74	<0.001	0.60	0.49	0.74	<0.001	0.60	0.48	0.74	<0.001
Charlson comorbidity index												
0	Reference				Reference				Reference			
1–2	0.88	0.74	1.05	0.153	0.89	0.74	1.05	0.169	0.88	0.74	1.05	0.150
≥3	0.91	0.75	1.11	0.348	0.92	0.76	1.11	0.379	0.91	0.75	1.10	0.340
Economic status												
Low	Reference				Reference							
Very low									Reference			
Low									1.11	0.91	1.36	0.304
Middle–high	1.01	0.88	1.16	0.923	1.02	0.89	1.17	0.809	1.07	0.89	1.28	0.481
Diagnosed FY												
<2009	1.42	1.06	1.91	0.017	1.41	1.05	1.89	0.021	1.42	1.06	1.90	0.018
2010	1.71	1.39	2.09	<0.001	1.71	1.40	2.10	<0.001	1.71	1.39	2.09	<0.001
2011	1.23	1.00	1.52	0.054	1.23	1.00	1.52	0.049	1.23	1.00	1.52	0.053
2012	0.84	0.67	1.06	0.140	0.84	0.67	1.06	0.147	0.84	0.67	1.06	0.140
2013	Reference				Reference				Reference			
Regional factors												
Hospital physician density												
Lower	Reference				Reference				Reference			
Higher	1.75	1.25	2.45	0.001	1.75	1.25	2.45	0.001	1.75	1.25	2.45	0.001
Regional level variance												
MOR	1.43	1.22	1.86		1.43	1.22	1.86		1.42	1.22	1.86	
ICC	0.04	0.01	0.11		0.04	0.01	0.11		0.04	0.01	0.11	
AIC	8860.5				8863.2				8860.5			

AIC = Akaike’s information criterion, AOR = adjusted odds ratio, CVA = cerebrovascular accident, DPC = diagnosis procedure combination, FY = fiscal year, ICC = intraclass correlation coefficient, MOR = median odds ratio, OR = odds ratio.

patients, may use their “discretionary powers” to shift demand for or encourage certain activities, such that their recommended care differs from care that an informed patient might deem appropriate.¹⁸ Although SID has been studied for some time, its existence has not been proved because it is difficult to define the appropriate supply of care.^{16,21} However, it has been reported that Japan has a higher proportion of gastrectomy among older adults than other countries,^{3,4} which suggests an oversupply of gastrectomy procedures. Another challenge to detecting SID is that it is difficult to differentiate SID from patient preference.²⁶

However, older patients at the end of life do not have the ability to make decisions frequently for themselves. Therefore, family members or caregivers usually decide whether to perform gastrectomy, often at the suggestion of a physician.^{14,17} It is plausible that SID does exist because it is unlikely that patients themselves demand gastrectomy.

With respect to reasons other than economic ones, gastrectomy might be carried out as an opportunity for resident training in an acute care setting.²⁷ Moreover, it has been reported that nursing home residents in Japan had more feeding

tubes than in other countries.⁴ This could be because tube feeding is time saving and economically preferable to hand feeding.^{28,29} It is also possible that patients admitted to acute care facilities have gastrostomy tubes placed for transport to other long-term care facilities.¹⁴

Based on our results, we cannot rule out the possibility that the significant relationship between hospital physician density and gastrostomy is not owing to SID, but rather to physician practice style, uncertainty of clinical outcomes, expectations of family or caregivers, or regional or cultural backgrounds.^{16,26,30} Further studies are needed to clarify whether the variation found here arises from SID or other factors.

It is curious that no relationship was found between patient economic status and gastrostomy. Some studies have reported that small area variations in health care technologies are affected by socioeconomic status.^{16,18,31} Our study was not consistent with those studies, which might be because Late-Elders' Health Insurance approves all patients for gastrostomy, owing to lower coinsurance rates and reductions in the high cost of health care.

Another outstanding finding is that patients with dementia received more gastrostomy procedures, approximately 30% more than those without dementia. This is despite previous reports that gastrostomy for advanced dementia does not prevent aspiration,^{7,8} pressure sores,^{7,10} or mortality.^{7,11,12} However, our study used claim data; therefore, the stage of patient dementia was unknown.

The strength of this study is that it covered nearly every older adults in Fukuoka Prefecture. A study limitation is that we did not use information about patient daily life activities or laboratory data; instead, we used insurance claim data. In addition, we had no information about advance directives, which have an important role in decision making with respect to gastrostomy.³²

In conclusion, this study revealed that inappropriate use of gastrostomy in Japan is likely. The use of surveillance systems to monitor quality of care in certain settings is advisable.

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