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Market Competition and Hospital Specialization in Inpatients with Disease of Circulatory System in Korea

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This study examines the effect of market competition on hospital specialization among inpatients with diseases of the circulatory system. Data used the national claim database from 2002 to 2013 by the National Health Insurance Service. A sample of 4,928 were analyzed at baseline (2002). Market competition was defined using Herfindahl-Hirschman Index (HHI) and hospital specialization was inner Herfindahl-Hirschman Index (IHI) and Category Medical Specialization (CMS) The primary analysis was based on generalized estimating equation regression model accounting for the correlation among individuals and hospitals within each region of hospital. IHI and CMS were significantly elevated (B: 0.1638, $p < 0.0001$; 0.0047, $p < .0001$, respectively) in the region with high market competition, compared with those in the region with low market competition. Compared with low market competition, the odds ratio (OR) of the factor loading value of disease of the circulatory system in high and middle market competition was 1.0562 times higher ($p < 0.0026$) and 1.3435 times higher ($p < .0001$), respectively. Our results demonstrate that an increase in market competition had a substantial effect on hospital specialization among inpatients with disease of the circulatory system. Our findings provide useful information to health policy makers and hospital managers.

Keywords: Competition, Hospital, Specialization

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Ⅰ. Introduction

In the Republic of Korea, since the establishment of the National Health Insurance (NHI) in 1977, with a universal health care coverage attained since 1989, the demand for hospital services has significantly risen with the increasing number of hospitals. Unfortunately, as competition between hospitals has increased over the years, hospital closure rates have also increased (Lee & Alexander, 1999).

According to one report (Yang, 2002), 8.1% of all hospitals in 2001 were in a state of bankruptcy, and between 1996 and 2002, the average annual hospital closure rate was 4.2%. This rate is about 3 times higher than that of the US (1.3%) in 1999(Office of Inspector General, 2001). This high rate of hospital closure has been a major source of concern for the hospital sector. Accordingly, many hospitals have been faced with financial deterioration, with many external forces, such as the prospective payment system (Moon, 2015) further worsening financial performance of the hospital sector (Levit et al., 2002).

In some cases higher market competition has resulted in high efficiency,(Lee et al., 2015), affected quality of care and health care service utilization(Kim et al., 2017). In light of the current competitive marketplace, the Korean government have designated hospitals meeting certain structural requirements as specialty hospitals since 2011 (Kim et al., 2013) such as hospitals specialized in heart disease. Especially, death from heart disease is a main health issue not only in Korea but worldwide (Jee et al., 2014). In worldwide, an estimated 17.7 million people died from cardiovascular disease (CVDs) that generally incurred from the presence of one or more risk factors such as hypertension, diabetes, hyperlipidemia in 2015, representing 31% of all global deaths. Of these deaths, an estimated 7.4 million were due to coronary heart disease and 6.7 million were due to stroke.

In markets where specialty hospitals exist, bigger general hospitals often experience decreasing market-share. By offering multiple services, hospitals may retain overall market-shares. To compete aggressively with specialty hospitals, these hospitals need

to consider whether they should develop similar dedicated centers and if so, which sites offer the greatest benefits from specialization (Berenson et al., 2006).

The hospital specialization may benefit from economies of scale to reduce average healthcare costs (Kim et al., 2015; Lee & Chun, 2010), improve quality of care such as thirty day mortality and length of stay(Cho et al., 2016; Kim et al., 2015; Luft, 1986), and achieve efficiency (Kim et al., 2015; Lee et al., 2008) by deploying workers based on their individual skills (Taylor, 1911).

In light of the increasing levels of market competition in the hospital sector, we lack empirical evidence of the effects of market competition on hospital specialization. Therefore, the aim of this study was to investigate the effect of market competition on hospital specialization among inpatients with diseases of the circulatory system.

Ⅱ. Materials and Methods

1. Data Sources

Data were from the National Health Insurance Service – Cohort Sample Database (NHIS-CSD) from 2002 to 2013, released by the Korean National Health Insurance Service (KNHIS) (Lee et al., 2016). The initial NHIS-CSD cohort data comprised of 1,025,340 participants, approximately 2.2% of the entire population in 2002 and established by stratified random sampling using a systematic sampling method to generate a representative sample of the 46,605,433 Korean residents recorded in 2002, excluding non-citizens and special purpose employees with an unidentifiable income level. The baseline cohort members were followed for 11 years until 2013, unless the beneficiaries were disqualified due to death or emigration. Detailed methods for establishing and ensuring the representativeness of NHIS-CSD cohort

are documented in the Korean National Health Insurance Service website.(Lee et al., 2016)

2. Study design

We linked each inpatient with diseases of the circulatory system according to the hospital's license number, using a separate licensure hospital database containing information on calendar years, and transposed claim data into a longitudinal design for repeated measurement. Linkage between each inpatient with diseases of the circulatory system and the individual hospitals allowed us to investigate the association between market competition and hospital specialization in a 12-year follow-up sample.

To measure the market competition (Herfindahl–Hirschman Index, HHI) for 16 administrative districts per year, we included only patients who were admitted to the general hospital or hospitals with diseases of the circulatory system (I00-I99), as the main diagnosis based on the International Classification of Diseases, Tenth Revision (ICD-10). In terms of dependent variables, inner Herfindahl–Hirschman Index (IHI) and Category Medical Specialization (CMS) as hospital specialization were measured for all hospitals each year. To account for hospitals specialized in diseases of the circulatory system in each factor category, we conducted a factor analysis for hospitals comprising of 21 disease categories based on the ICD-10 in each year. Factor analysis is a method for investigating whether a number of variables of interest are linearly related to a smaller number of unobservable factors. After extracting the factor loading values from factor analysis in each year, we identified whether hospitals are specialized in diseases of the circulatory system or not based on the factor loading values in each factor category, and dichotomized them as high or low using the SAS Rank function as the dependent variable (high: specialized in disease of the circulatory system and low: not specialized in disease of the circulatory disease).

3. Study variables

A. Independent variables

1) Market Competition [Herfindahl-Hirschman Index (HHI)]

We measured market competition using the Herfindahl - Hirschman Index (HHI). To calculate the HHI, we distinguished hospital markets according to 16 administrative districts (Seoul, Daejeon, Daegu, Busan, Incheon, Kwangju, Ulsan, Kyoungki, Kangwon, Chungbuk, Chungnam, Jeonbuk, Jeonnam, Gyeongbuk, Gyeongnam and Jeju) within Korea. The equation for HHI is as follows:

$$\text{Herfindahl - Hirschman Index (HHI)} = \sum_{t=1}^{n} S_I^2$$

The HHI is the sum of squared market share of the hospital under the defined market. Market share, S_j, is calculated using **only** the total number of inpatients with diseases of circulatory system. The term indicates each hospital and n is the total number of hospitals in a specific market area. To measure the different effects of market competition, market competition was categorized into three groups as high, middle or low using SAS *rank* function.

B. Dependent variables

1) Inner Herfindahl-Hirschman Index (IHI)

Zwanziger, Melnick, and Rahmian (Zwanziger et al., 1996) initially has proposed IHI to measure market concentration using the sum of squares of the discharges from a disease category, viewed as a proportion of all discharges from the hospital.

$$IHI = \sum_{i=1} (P_i^2)$$

where

P_i = proportion of the hospital's inpatients accounted for by the i^{th} disease category

2) Category Medical Specialization (CMS)

In order to account for the diversification of organizations and the idea that hospitals can be specialized in terms of professional expertise or technical equipment within a given diagnosis category, CMS index are based on patient volumes rather than patient proportions (Lindlbauer & Schreyogg, 2014), as measured by IHI that rely solely on patient proportions. It might be problematic for larger hospitals that provide a high number of diagnosis categories, as the patient proportions in each category are relatively smaller in such hospitals. Previous study (Lindlbauer & Schreyögg, 2014) shows that specialization as quantified by our novel measures has effects on efficiency that are the opposite of those obtained using earlier measures of specialization. In addition, to avoid disadvantaging smaller hospitals, CMS chose an alternative criterion for sensitivity analyses, defining specialization in category j as treating more than 80 % of patients in that category.

$$\mathrm{CMS} = \frac{\sum_{i=1}^{I} \zeta_{\mathrm{ij}}}{\sum_{i=1}^{I} \eta_{\mathrm{ij}}}$$

with $\zeta_{ij} = 1 \,\mathrm{if}\, n_{ij} \geq \psi_j \; or \; P_{ij} \geq 0.8, otherwise \; 0$

$\eta_{ij} = 1 \,\mathrm{if}\, P_{ij} \geq 1/21, otherwise \; 0$

where

ψ_i = mean number of patients treated nationally in category j.

η_i = diagnosis category η_{ij} in hospital i if the proportion of overall patients treated who are in that category is greater than 1/21(number of disease

categories). Hospital i can be identified as a specialized hospital only if a defined minimum number of treatments, ψ_j, is reached in category j. To avoid disadvantaging smaller hospitals, we define specialization in category j as the case where more than 80% of patients treated are in that category.

C. Control variables

This study incorporated individual- (e.g., age, sex, residential region, patient clinical complexity level [PCCL]) and hospital-level (e.g., hospital type, organization type, number of beds, number of doctors, region of hospital) variables, with year as a dummy variable. Residential region was categorized into three groups: metropolitan (Seoul), urban (Daejeon, Daegu, Busan, Incheon, Kwangju, or Ulsan), and rural (otherwise). Hospital type dichotomized as general hospital (including tertiary care hospitals) or hospital. The organization type was categorized into public, corporate, and private. The number of beds was categorized into nine groups: $\leq$ 199, 200-299, 300 - 399, 400-499, 500-599, 600-699, 700-799, 800-899 and $\geq$ 900. The number of doctors was categorized into six groups: $\leq$ 49, 50 - 99, 100 - 149, 150-199, 200-299 and $\geq$ 300.

4. Statistical analysis

In this study, the units of analysis are each individual, each hospital, and the region hospitals are located. We employed the analysis of variance (ANOVA) (Perneger & Perrier, 2004) and generalized estimating equation (GEE) regression model, accounting for correlation among individuals and hospitals within the specific regions (Twisk, 2004). In GEE, *proc genmod* was used, with *link log*, *distribution normal* given that the distribution of hospital specialization varies nonlinearly with market competition. SAS 9.4 (SAS Institute, Cary, NC) was used in all analyses. All

statistical tests were two-tailed, with the null hypothesis of no difference being rejected if $p < 0.05$.

5. Results

Of the 4,928 inpatients with diseases of the circulatory system included in our study at baseline, the mean of IHI was 0.190 (SD: 0.158) and the mean of CMS was 0.970 (SD: 0.080). In terms of market competition, low market competition was 0.158 (SD: 0.126) in IHI and 0.962 (SD: 0.094) in CMS. For high market competition the values were 0.207 (SD: 0.161) in IHI and 0.979 (SD: 0.060) in CMS. (Table 1). Table 2 present the adjusted effect of market competition on hospital specialization during 12 years. The estimates of IHI of hospitals in the region with high market competition, compared with those in the region with low market competition, significantly (B: 0.1638, $p < .0001$) increased by 16.38%. In terms of CMS, hospitals in the region with high market competition, compared with those in the region with low market competition, exhibited a high possibility of hospital specialization (B: 0.0047, $p < .0001$).

Table 3 shows the adjusted effect between market competition and factor loading values categorized as high or low through the SAS rank function which computes ranks for one or more numeric variables across the observations. Compared to low market competition, the odds ratios (OR) of a high factor loading value of diseases of the circulatory system in the high and middle market competition were 1.0562 ($p < 0.0026$) and 1.3435 ($p < .0001$), respectively. We also examined the association between market competition and hospital specialization according to the degree of factor loading values of diseases of the circulatory system. Results of a subgroup analysis according to the degree of factor loading values found hospital specialization for IHI and CMS in both the low and high factor loading values (Table 4).

Table 1. General characteristics of subjects included for analysis at baseline (2002)

	Total		IHI		P-value	CMS		P-value
	N	%	Mean	SD		Mean	SD	
Market Competition (HHI)					<.0001			0.098
High	2,360	47.9	0.207	0.161		0.979	0.060	
Middle	808	16.4	0.214	0.194		0.961	0.091	
Low	1,760	35.7	0.158	0.126		0.962	0.094	
Hospital Level								
Type					<.0001			<.0001
General hospital	3,906	79.3	0.132	0.057		0.986	0.046	
Hospital	1,022	20.7	0.416	0.209		0.910	0.134	
Organization type					0.032			<.0001
Public	69	1.4	0.124	0.11		0.985	0.047	
Corporate	3,942	80.0	0.144	0.096		0.980	0.067	
Private	917	18.6	0.397	0.201		0.928	0.112	
Bed					<.0001			<.0001
≤199	862	17.5	0.434	0.194		0.921	0.127	
200-299	268	5.4	0.211	0.107		0.912	0.096	
300-399	283	5.7	0.224	0.207		0.915	0.119	
400-499	176	3.6	0.177	0.092		0.961	0.056	
500-599	276	5.6	0.116	0.032		0.979	0.042	
600-699	291	5.9	0.130	0.087		0.986	0.039	
700-799	255	5.2	0.141	0.077		0.957	0.109	
800-899	315	6.4	0.096	0.008		0.998	0.014	
≥900	2,202	44.7	0.126	0.036		0.998	0.011	
Doctor					<.0001			<.0001
≤49	1,648	33.4	0.327	0.207		0.916	0.118	
50-99	230	4.7	0.132	0.061		0.987	0.057	
100-149	490	9.9	0.113	0.053		0.992	0.025	
150-199	336	6.8	0.102	0.012		0.992	0.021	
200-249	263	5.3	0.106	0.016		0.997	0.016	
250-299	280	5.7	0.119	0.066		1.000	0.000	
≥300	1,681	34.1	0.13	0.031		1.000	0.000	
Region of Hospital					<.0001			<.0001
Metropolitan	1,687	34.2	0.209	0.144		0.978	0.062	
Urban	1,610	32.7	0.191	0.171		0.960	0.093	
Rural	1,631	33.1	0.171	0.155		0.971	0.080	
Individual Level								
Sex					0.455			0.090
Male	2,598	52.7	0.187	0.154		0.974	0.075	
Female	2,330	47.3	0.195	0.161		0.965	0.085	
Age					<.0001			0.019
≤39	313	6.4	0.258	0.209		0.962	0.083	

	Total		IHI		P-value	CMS		P-value
	N	%	Mean	SD		Mean	SD	
40-49	462	9.4	0.293	0.207		0.961	0.079	
50-59	755	15.3	0.233	0.189		0.967	0.087	
60-69	932	18.9	0.174	0.135		0.974	0.073	
70-79	1,287	26.1	0.154	0.112		0.979	0.068	
≥80	1,179	23.9	0.159	0.124		0.965	0.089	
Residential region					0.002			0.880
Metropolitan	1,127	22.9	0.224	0.168		0.974	0.073	
Urban	1,285	26.1	0.192	0.163		0.960	0.092	
Rural	2,516	51.1	0.175	0.148		0.973	0.075	
Patient clinical complexity level (PCCL)					0.001			0.341
0	4,856	98.5	0.190	0.157		0.970	0.080	
1	68	1.4	0.207	0.185		0.967	0.062	
2	3	0.1	0.143	0.008		0.891	0.128	
3	1	0.0	0.143	.		0.933	.	
Total	4,928	100.0	0.190	0.158		0.970	0.080	

Table 2. Adjusted effect between market competition and hospital specialization

	IHI			CMS		
	B	SE	P-value	B	SE	P-value
Market competition						
High	0.1638	0.0041	<.0001	0.0047	0.0009	<.0001
Middle	0.1353	0.0034	<.0001	0.0046	0.0008	<.0001
Low	ref			ref		
Hospital Level						
Type						
≥ General hospital	-0.6076	0.0055	<.0001	0.1066	0.0013	<.0001
Hospital	ref			ref		
Organization type						
Public	-0.1502	0.0115	<.0001	-0.0053	0.0020	0.0091
Corporate	-0.0606	0.0038	<.0001	-0.0021	0.0011	0.0599
Private	ref			ref		
Bed						
≤199	0.1274	0.0113	<.0001	-0.1041	0.0022	<.0001
200-299	-0.1095	0.0115	<.0001	-0.0680	0.0021	<.0001
300-399	-0.0123	0.0116	0.2904	-0.0450	0.0020	<.0001
400-499	0.0084	0.0120	0.4831	-0.0345	0.0019	<.0001
500-599	-0.1843	0.0126	<.0001	-0.0236	0.0018	<.0001
600-699	-0.1185	0.0118	<.0001	-0.0170	0.0016	<.0001

	IHI			CMS		
	B	SE	P-value	B	SE	P-value
700-799	-0.0087	0.0113	0.4380	-0.0100	0.0016	<.0001
800-899	-0.1876	0.0133	<.0001	-0.0035	0.0015	0.0210
≥900	ref			ref		
Doctor						
≤49	0.0766	0.0117	<.0001	-0.0393	0.0020	<.0001
50-99	0.0073	0.0115	0.5278	-0.0190	0.0017	<.0001
100-149	-0.2050	0.0148	<.0001	-0.0072	0.0018	<.0001
150-199	-0.1962	0.0128	<.0001	0.0006	0.0016	0.6930
200-249	-0.2373	0.0127	<.0001	-0.0050	0.0015	0.0009
250-299	-0.1243	0.0098	<.0001	-0.0032	0.0013	0.0148
≥300	ref			ref		
Region of Hospital						
Metropolitan	0.1506	0.0047	<.0001	0.0050	0.0010	<.0001
Urban	0.2818	0.0045	<.0001	-0.0033	0.0010	0.0014
Rural	ref			ref		
Individual Level						
Sex						
Male	-0.0061	0.0026	0.0192	-0.0018	0.0006	0.0033
Female	ref			ref		
Age						
≤39	0.1438	0.0056	<.0001	0.0197	0.0015	<.0001
40-49	0.1408	0.0050	<.0001	0.0210	0.0014	<.0001
50-59	0.0819	0.0044	<.0001	0.0099	0.0010	<.0001
60-69	0.0557	0.0040	<.0001	0.0048	0.0009	<.0001
70-79	0.0473	0.0039	<.0001	0.0040	0.0008	<.0001
≥80	ref			ref		
Residential region						
Metropolitan	-0.0159	0.0046	0.0005	0.0011	0.0010	0.2520
Urban	0.0115	0.0042	0.0059	-0.0029	0.0010	0.0021
Rural	ref			ref		
Patient clinical complexity level (PCCL)						
0	0.0556	0.0051	<.0001	0.0121	0.0011	<.0001
1	0.0195	0.0057	0.0006	0.0021	0.0012	0.0724
2	0.0209	0.0056	0.0002	-0.0020	0.0012	0.0992
≥3	ref			ref		
QIC		143,012			136,860	

Table 3. Adjusted effect between market competition and factor loading value

	Factor loading value		
	OR	SE	P-value
Market competition			
High	1.0562	0.0182	0.0026
Middle	1.3435	0.0164	<.0001
Low	1.0000		
Hospital Level			
Type			
≥ General hospital	0.8549	0.0246	<.0001
Hospital	1.0000		
Organization type			
Public	0.1358	0.0595	<.0001
Corporate	0.6282	0.0203	<.0001
Private	1.0000		
Bed			
≤199	0.2313	0.0440	<.0001
200-299	0.1320	0.0430	<.0001
300-399	0.1633	0.0425	<.0001
400-499	0.3032	0.0396	<.0001
500-599	0.1728	0.0377	<.0001
600-699	0.1921	0.0352	<.0001
700-799	0.2743	0.0334	<.0001
800-899	0.5365	0.0310	<.0001
≥900	1.0000		
Doctor			
≤49	0.8714	0.0409	0.0008
50-99	2.1464	0.0375	<.0001
100-149	1.1408	0.0391	0.0008
150-199	1.3488	0.0344	<.0001
200-249	0.4197	0.0328	<.0001
250-299	0.8330	0.0278	<.0001
≥300	1.0000		
Region of Hospital			
Metropolitan	1.1883	0.0209	<.0001
Urban	2.2605	0.0207	<.0001
Rural	1.0000		
Individual Level			
Sex			
Male	1.0175	0.0121	0.1540
Female	1.0000		
Age			
≤39	1.3259	0.0303	<.0001

	Factor loading value		
	OR	SE	P-value
40-49	1.7738	0.0274	<.0001
50-59	1.4306	0.0204	<.0001
60-69	1.2412	0.0174	<.0001
70-79	1.2533	0.0162	<.0001
≥80	1.0000		
Residential region			
Metropolitan	0.9304	0.0205	0.0004
Urban	0.9096	0.0195	<.0001
Rural	1.0000		
Patient clinical complexity level (PCCL)			
0	0.9778	0.0216	0.2976
1	0.9119	0.0237	<.0001
2	0.9569	0.0240	0.0662
≥3	1.0000		

Table 4. Adjusted effect between market competition and hospital specialization according to degree of factor loading value

	Hospital specialization					
	Factor loading value (High)			Factor loading value (Low)		
	B	SE	P-value	B	SE	P-value
Market competition						
IHI						
High	0.0874	0.0047	<.0001	0.0962	0.0061	<.0001
Middle	0.0706	0.0037	<.0001	0.0507	0.0055	<.0001
Low	ref			ref		
CMS						
High	0.0058	0.0012	<.0001	0.0014	0.0014	0.3174
Middle	-0.0015	0.0010	0.1276	0.0082	0.0013	<.0001
Low	ref			ref		

* Adjusting for all variables

A. Discussion

In a nationally representative sample of inpatients with disease of circulatory system, the results of this study of a nationally representative sample of inpatients with diseases of the circulatory system indicate inter-hospital competition, using both

IHI and CMS indices, as a plausible explanation for the high possibility of hospital specialization. In addition, the association between market competition and factor loading values were statistically significant, with higher market competition being significantly associated with increased rates of factor loading values, denoting hospital specialization.

The rise and fall of a hospital may be determined by financial pressure at multiple time points rather than a single time point. Thus, hospital specialization would be the result of a successive series of long-term exposure of market competition rather than from an exposure at a one specific point in time. Our study used longitudinal data with repeated measurements in the same subjects, taking into account correlations at the individual level and regional level of hospitals.

Hospitals specializing in certain areas, such as cardiology (Al-Amin et al., 2010), benefit from economies of scale and have the potential for higher quality associated with providing one or two service lines. They that focus on a selective range of profitable services, have better control over costs, and deliver higher quality of care.

The increase in hospital specialization with an increased market competition could be explained by the "resource partitioning theory" developed by Caroll.(Carroll, 1985) According to this theory, although competitive markets impede other general healthcare organizations from entering the market, it eventually encourages the specialization of hospitals. Al-Amin et al. (2010) reported that competitive market environments have a positive effect on the entry of specialty hospitals. Increased market competition encourages the market entry of specialized hospitals that focus on one or two service lines like "focused factories." In addition, Tiwari V et al. (Tiwari & Heese, 2009) showed that the value of specialization is contingent upon the competitive pressure that the specialized competitor exerts on the market. Specializing one facility yields the greatest benefits for the market when the competitor is located at the fringe of the market, thus presenting a reduced threat to the hospital market. Prior studies have shown that hospitals with greater number of specialized services are reportedly associated with a lower likelihood to

close,(Longo et al., 1996; Williams et al., 1992) and by providing differentiated services from others reduce competitive pressures (Robinson & Luft, 1987).

In South Korea, since the National Health Insurance (NHI) was instituted in 1977 and universal coverage achieved in 1989, the healthcare delivery scheme was set up to provide specialty care in the hospital through the referral by primary care physicians (Noh et al., 2006). Moreover, universal coverage based on a low physician fee schedule and the recent introduction of a prospective payment system (Moon, 2015) that originally was designed to promote efficiency of hospital operations (Lee et al., 2008) have further accelerated inter-hospital competitions. In response to this situation, designation of a specialty hospital by the government has driven hospitals to diversify and concentrate on providing specialized health services.

In today's health care industry, we believe that our findings will prove useful to health policymakers and hospital managers who anticipate future threats and opportunities. Especially, the insights from our results can provide useful guidelines for policymakers and social planners while formulating policies that impact competition in the healthcare markets. In addition, our findings add to mounting evidence on the influence of hospital market competition on hospital specialization. These results could serve as a basis for adopting policies and regulations of the hospital industry.

This study has several limitations worth noting that warrant caution in interpreting the findings. First, due to the lack of an official designation of hospital markets in South Korea, we used geopolitical administrative districts as a proxy measure for the hospital market. This might have introduced some bias on the impact of market competition on hospital specialization. Further research is needed to define hospital markets that are specific to South Korea. Second, a distinct market position of hospitals has significant implications for the competitive market environment. Failure to consider a hospital's market position may over- or under-estimate competition in a given market. Thus, a hospital positioned above the market average may experience weaker competitive pressures than an equal-sized hospitals located on the

market average. Third, a lack of data in terms of aspects of hospital performance was another limitation of our study. Our data set did not include the institution's financial statements, prohibiting examination of the financial viability of individual hospitals. Finally, the ICD-10 coding of principal diagnosis was used for the selection of participant. Because we used an anonymized database it was not possible to validate individual ICD codes, and thus cannot rule out errors related to coding.

Despite these limitations, to the best of our knowledge, this study is the first to examine the effect of market competition on hospital specialization in South Korea. In addition, this study is based on claims database from a nationally representative Korean sample of NHIS, with long follow-up of observations to verify the impact of market competition on hospital specialization. Therefore, our results can be generalized to the South Korean population.

B. Conclusion

Our results showed that an increase in market competition had a substantial effect on hospital specialization among inpatients with diseases of the circulatory system. In the era of increasing market competition, our results may help hospital administrator and health policymakers better understand the effects of inter-hospital competition on hospital specialization. Further replication of this work in other countries and healthcare settings are warranted.

김재현은 연세대학교에서 보건학 박사학위를 받았으며, 현재 단국대학교 보건과학대학 보건행정학과에서 조교수로 재직 중이다. 주요 관심분야는 건강보험, 경제성 평가 건강의 형평성 등이다.
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Appendix 1. Number of participants included for analysis by year

Year	N	%
2,002	4,928	3.7
2,003	7,090	5.3
2,004	8,584	6.4
2,005	9,725	7.2
2,006	10,319	7.7
2,007	11,192	8.3
2,008	11,754	8.7
2,009	11,672	8.7
2,010	12,125	9.0
2,011	16,696	12.4
2,012	15,308	11.4
2,013	15,518	11.5

Appendix 2. Results from factor analysis about Diseases of the circulatory system (I00-I99)

2002		2003		2004		2005		2006		2007		2008		2009		2010		2011		2012		2013	
Disease	Factor loading	Disease	Factor loading	Disease	Factor loading	Disease	Factor loading	Disease	Factor loading	Disease	Factor loading	Disease	Factor loading	Disease	Factor loading	Disease	Factor loading	Disease	Factor loading	Disease	Factor loading	Disease	Factor loading
I00-I99	0.7175	I00-I99	0.6742	I00-I99	0.6315	I00-I99	0.6902	I00-I99	0.6375	I00-I99	0.6917	I00-I99	0.6977	I00-I99	0.7028	I00-I99	0.7443	I00-I99	0.6983	U00-U99	-0.0026	I00-I99	0.7725
K00-K93	0.4144	K00-K93	0.3309	K00-K93	0.2647	K00-K93	0.3374	K00-K93	0.2980	K00-K93	0.2876	K00-K93	0.2669	K00-K93	0.2807	K00-K93	0.2835	K00-K93	0.2279	V01-Y98	0.0008	K00-K93	0.2701
C00-D48	0.2071	C00-D48	0.1707	G00-G99	0.1267	N00-N99	0.1943	N00-N99	0.1396	N00-N99	0.1567	N00-N99	0.1647	N00-N99	0.1778	N00-N99	0.1976	N00-N99	0.1757	O00-O99	0.0231	N00-N99	0.2474
N00-N99	0.1824	N00-N99	0.1542	N00-N99	0.1259	G00-G99	0.1662	G00-G99	0.1257	C00-D48	0.1543	H60-H95	0.1525	C00-D48	0.1694	C00-D48	0.1780	C00-D48	0.1560	P00-P96	0.0473	C00-D48	0.2186
H60-H95	0.1696	G00-G99	0.1540	H60-H95	0.1134	C00-D48	0.1615	H60-H95	0.1083	E00-E90	0.1407	G00-G99	0.1490	H60-H95	0.1466	H60-H95	0.1595	H60-H95	0.1329	H00-H59	0.0504	H60-H95	0.1803
E00-E90	0.1398	E00-E90	0.1216	E00-E90	0.1058	H60-H95	0.1502	C00-D48	0.1035	G00-G99	0.1357	C00-D48	0.1341	E00-E90	0.1288	R00-R99	0.1515	E00-E90	0.1198	F00-F99	0.0521	R00-R99	0.1424
G00-G99	0.1341	H60-H95	0.1168	C00-D48	0.0955	E00-E90	0.1409	E00-E90	0.0960	H60-H95	0.1327	E00-E90	0.1272	G00-G99	0.1203	E00-E90	0.1448	G00-G99	0.1147	M00-M99	0.0535	E00-E90	0.1328
S00-T98	0.1303	Q00-Q99	0.1125	Q00-Q99	0.0930	S00-T98	0.1191	Q00-Q99	0.0896	R00-R99	0.1194	Q00-Q99	0.1164	R00-R99	0.1202	Q00-Q99	0.1312	Q00-Q99	0.1100	Z00-Z99	0.0801	L00-L99	0.1276
L00-L99	0.1267	S00-T98	0.1056	D50-D89	0.0892	D50-D89	0.1118	D50-D89	0.0889	Q00-Q99	0.1165	A00-B99	0.1130	D50-D89	0.1200	A00-B99	0.1200	R00-R99	0.1061	J00-K99	0.0857	D50-D89	0.1092
J00-K99	0.1258	L00-L99	0.1044	L00-L99	0.0867	L00-L99	0.1110	R00-R99	0.0886	D50-D89	0.1030	R00-R99	0.1119	Q00-Q99	0.1163	G00-G99	0.1180	D50-D89	0.1061	R00-R99	0.0926	S00-T98	0.1061
Q00-Q99	0.1201	R00-R99	0.1006	R00-R99	0.0841	R00-R99	0.1012	L00-L99	0.0867	S00-T98	0.0939	L00-L99	0.1053	A00-B99	0.1057	D50-D89	0.1134	Z00-Z99	0.0858	S00-T98	0.1032	Q00-Q99	0.1058
A00-B99	0.1167	D50-D89	0.0909	S00-T98	0.0751	A00-B99	0.0931	S00-T98	0.0841	A00-B99	0.0937	P00-P96	0.0958	L00-L99	0.1016	L00-L99	0.1103	L00-L99	0.0852	Q00-Q99	0.1034	A00-B99	0.0988
R00-R99	0.1096	A00-B99	0.0770	P00-P96	0.0559	P00-P96	0.0889	A00-B99	0.0816	L00-L99	0.0844	D50-D89	0.0945	P00-P96	0.0923	Z00-Z99	0.1060	P00-P96	0.0846	D50-D89	0.1049	Z00-Z99	0.0977
P00-P96	0.1052	M00-M99	0.0719	A00-B99	0.0554	J00-K99	0.0873	P00-P96	0.0659	P00-P96	0.0831	S00-T98	0.0922	Z00-Z99	0.0861	P00-P96	0.1020	S00-T98	0.0824	L00-L99	0.1082	J00-K99	0.0889
D50-D89	0.1043	P00-P96	0.0681	M00-M99	0.0502	Q00-Q99	0.0849	J00-K99	0.0603	J00-K99	0.0721	J00-K99	0.0780	S00-T98	0.0798	S00-T98	0.0881	J00-K99	0.0749	G00-G99	0.1089	G00-G99	0.0843
M00-M99	0.0902	Z00-Z99	0.0497	J00-K99	0.0488	M00-M99	0.0745	M00-M99	0.0579	Z00-Z99	0.0674	Z00-Z99	0.0661	J00-K99	0.0639	J00-K99	0.0847	A00-B99	0.0726	A00-B99	0.1190	H00-H59	0.0658
Z00-Z99	0.0702	H00-H59	0.0482	Z00-Z99	0.0448	H00-H59	0.0538	Z00-Z99	0.0428	M00-M99	0.0612	M00-M99	0.0613	M00-M99	0.0553	M00-M99	0.0653	M00-M99	0.0524	E00-E90	0.1232	M00-M99	0.0628
H00-H59	0.0697	J00-K99	0.0473	H00-H59	0.0390	Z00-Z99	0.0459	H00-H59	0.0398	H00-H59	0.0469	H00-H59	0.0470	H00-H59	0.0481	H00-H59	0.0552	H00-H59	0.0475	C00-D48	0.1572	F00-F99	0.0565
F00-F99	0.0446	O00-O99	0.0265	F00-F99	0.0226	O00-O99	0.0267	F00-F99	0.0198	F00-F99	0.0287	F00-F99	0.0271	F00-F99	0.0311	F00-F99	0.0236	F00-F99	0.0390	H60-H95	0.1615	P00-P96	0.0337
O00-O99	0.0430	F00-F99	0.0250	V01-Y98	0.0210	F00-F99	0.0257	O00-O99	0.0177	O00-O99	0.0230	O00-O99	0.0219	O00-O99	0.0197	O00-O99	0.0235	O00-O99	0.0170	N00-N99	0.2057	O00-O99	0.0256
V01-Y98	0.0137	V01-Y98	0.0018	O00-O99	0.0181	V01-Y98	-0.0006	U00-U99	0.0001	V01-Y98	0.0121	U00-U99	0.0002	V01-Y98	-0.0006	U00-U99	0.0111	V01-Y98	0.0000	K00-K93	0.2492	U00-U99	0.0034
U00-U99	0.0000	U00-U99	0.0000	U00-U99	0.0000	U00-U99	-0.0009	V01-Y98	-0.0001	U00-U99	-0.0005	V01-Y98	0.0000	U00-U99	-0.0010	V01-Y98	0.0000	U00-U99	-0.0050	I00-I99	0.7661	V01-Y98	0.0000
Variance	0.9618	Variance	0.7462	Variance	0.5866	Variance	0.8167	Variance	0.6226	Variance	0.7524	Variance	0.7588	Variance	0.7826	Variance	0.8901	Variance	0.7209	Variance	0.8605	Variance	0.9472

시장경쟁과 병원전문화의 관련성:
순환계통질환자를 중심으로

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이 연구는 순환계통질환자에서 시장경쟁과 병원전문화와의 관련성을 알아보기 위한 연구이다. 자료는 2002-2013 국민건강보험공단 환자코호트자료를 이용하였다. 이 연구의 독립변수인 시장경쟁지수는 허핀달-허쉬만 지수를 이용하였고, 종속변수인 병원전문화지수는 내부허핀달-허쉬만지수(IHI)와 질병군별 의료전문화지수(CMS)를 이용하였다. 주요 통계분석방법으로 개인, 병원, 지역을 고려한 일반화추정방정식모형을 사용하였다. 분석결과 병원경쟁수준이 증가할수록 내부허핀달-허쉬만 지수와 질병군별 의료전문화지수가 유의하게 증가하였다(B: 0.1638, $p < 0.0001$; 0.0047, $p < .0001$, respectively). 또한 순환기계통질환에 대한 병원전문화를 측정하기 위해 요인분석을 실시하여 요인적재량값을 산출후 해당질환의 병원전문화 정도를 산출하였다. 병원전문성 낮은 시장경쟁수준과 비교하였을 때 경쟁수준이 가장 높은 지역과 보통수준에 있는 경쟁지역의 요인적재량값은 각각 1.056배($p<0.0026$)와 1.344배($p<.0001$) 높았다. 우리의 결과는 시장경쟁수준의 증가는 병원전문화와 상당한 관련성을 가진 것을 보여주었다. 그러므로 우리의 결과는 보건의료정책결정자에게 유용한 정보를 줄 수 있을 것이다.

주요 용어: 경쟁, 병원, 전문화