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Effects of high-speed rail on health-care service utilization

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ABSTRACT

Introduction: The development of public transportation in a community might facilitate the utilization of health-care services in the region. The purpose of this study was to identify the effects of high-speed rail service on the utilization of health-care services among the patients diagnosed with cancer.

Methods: The study population comprised patients living in rural regions and who were diagnosed as having cancer during a five year period (2002–2006). The final sample included 3449 (49% men, 51% women). Of those, 918 participants used health-care services in Seoul. The pattern of outpatient and inpatient visits was estimated using interrupted time series analysis.

Results: There were significant differences in healthcare utilization by gender, age, region, and income levels. In the patient population studied, prior to the introduction of the Korean Train Express, the utilization of outpatient services had been increasing. Beginning with the introduction of the Korean Train Express, the number of patients utilizing outpatient services significantly increased across time. The introduction of the Korean Train Express did not influence the utilization of inpatient health-care services among those in the population studied.

Conclusions: The development of public transportation appeared to help facilitate the utilization of outpatient services for higher income patients diagnosed with cancer in Korea. This research can inform both transportation and Healthcare service planning for rural communities. Additional efforts need to be considered for low income populations.

1. Introduction

The availability of transportation is an important enabling factor for the utilization of healthcare services (Andersen et al., 2011). In addition, the distance patients are required to travel can be a barrier to the utilization of healthcare services (Nemet and Bailey, 2000). Poorer access to healthcare may be, in part, demonstrated by poorer health associations with physical environment features (Bernard et al., 2007). The physical environment that the patient has to manage can include the accessibility of a local public transportation system, healthcare facilities, and land use (Northridge et al., 2003). Other factors can include patient fit with healthcare services and providers.

In Korea, a public transportation system is available, which is a commercial high-speed rail service called the Korean Train Express (hereafter the KTX). The KTX is a type of bullet train capable of sustaining speeds upwards of 300 km/h. Korea began commercial service of the bullet train on April 1, 2004, and was the fifth country in the world to initiate this type of superior commuter railway system, modeled after similar train systems operating in Japan, France, Germany, and Spain. To most popular

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destinations in Korea, the KTX reduced rail travel time by about half.

Patients with physician referrals are permitted to go to any doctor or medical institution within the country of Korea, without any restraint on health-care services sought for treatment (Anonymous, 2012; Lee et al., 2014). Most of the tertiary hospitals in the country possess high-tech equipment and are able to train top-level personnel, but these facilities are located in Seoul, the capital of Korea (Jeon et al., 2012). Also, the top-five hospitals for patient care in Korea are located in Seoul. Therefore, patients diagnosed with severe diseases were forced to go to Seoul in order to access advanced medical technology and skills, and they needed a way to travel to these services. Patients with severe diseases may migrate from the rural districts to large metropolitan areas in order to utilize the high-quality health-care services available in those regions (Tullock, 1971; Borders and Rohrer, 2001).

Few natural experiments of public transportation and patient utilization of healthcare services exist. The purpose of this study was to identify the effects of high-speed rail on the utilization of available health-care services among patients with cancer in Korea living in rural regions using an interrupted time series (ITS) analysis. This will inform whether improved transportation can facilitate healthcare utilization in rural regions.

2. Literature review

Although many studies have identified the effects of the availability of the KTX on various issues (such as those that have reported the effects of the KTX on regional economic growth and inequality (Kim et al., 2013; Jiang and Kim, 2016)), few studies have investigated the effects of KTX on patients' utilization of health-care services outside of the region in which they live. The uniform and equal access to health-care services has affected a large array of patient health outcomes. According to Andersen's Behavioral Model of Health Service Use, access to patient health care was composed of two critical elements: "the use of health-care services" and the "medium which facilitates or obstructs the use of health-care services" (Andersen et al., 2011). The characteristics of the physical environment, such as connectivity and travel time, play a major role in the lives of patients who have been diagnosed with chronic or acute illnesses and are seeking health-care services or selecting medical institutions for their treatment (Heller, 1982). The development of accessible transportation might facilitate a patient's utilization of health-care services.

Literature related to the accessibility of transportation to needed health-care services has mostly focused on the general barriers to patients with regard to this issue. For example, numerous studies have dealt with the barriers typical to a specific residential district, such as rural or mountainous areas (Sibley and Weiner, 2011; Goodridge et al., 2010; Meina et al., 2007; Gesler et al., 2000), or to a specific group or demographic of patients, such as those who are disabled or injured (Yen et al., 2009; Dryden et al., 2004).

Patients who live in rural districts have limited access to viable transportation to medical services. The literature review revealed studies in the US focusing on residents living in mountainous regions whose geographical locations affected their access to public transportation, and therefore, their health care–based chronic and regular care visits (Arcury et al., 2005b, 2005a).

Patients with disabilities or injuries generally have poorer access to transportation and therefore a harder time finding accessible health-care services than patients who are not disabled or injured (Rimmer and Rowland, 2008; Dryden et al., 2004). Patients with disabilities or injuries are frequently unable to move or ambulate as well as those who are not disabled or injured. The outcome variables that have been confirmed in analyses include chronic-care or regular-care visits, emergency care, influenza vaccination, and the self-perceived, unmet needs of this sensitive population (those with limited access to transportation to health care).

Distance factors related to how patients obtain access to medical facilities are associated with utilization of health-care services (Nemet and Bailey, 2000). Residents living in the district regions have differing access to three types of transportation: 1) individual access, 2) access to a ride from a relative or friend, 3) access to public transportation (Hagerstrand, 1982). Patients who have a driver's license or have family or friends who can provide transportation have more opportunities to visit medical facilities than patients who do not have such access to transportation (Arcury et al., 2005b). Transportation is a factor affecting patient utilization of health-care services. However, access to public transportation for health-care services in rural communities is far from universal and can pose barriers to patients requiring care outside of their residential districts.

3. Material and methods

3.1. Data and study population

The National Health Insurance Service (NHIS) has established a nationwide cohort recording system containing medical care claims and checkup data from 2002, which is consider the baseline year for this research (Lee et al., 2017). The NHIS cohort consisted of 1,025,340 participants, which accounted for nearly 2% of the total Korean population. The cohort was followed up annually until the year 2013. The sampling method used in the study is a stratified sampling of participants by gender, age, and income level.

The study population consisted of cancer patients living in the Yeungnam region of Korea and who were diagnosed as having cancer (C code) according to the International Classification of Diseases 10th revision (ICD-10) during the 5 year period (2002~2006). The participants who died during the study period (n = 269) were excluded from further analyses. The Yeungnam region is located in the southeastern area of Korea. It includes Busan, Ulsan, Daegu, Gyeongbuk, and Gyeongnam (Fig. 1). Distances between Seoul and various points in Yeungnam range from 238 km to 423 km. The final sample included 3449 (men: 1689 (49%), women: 1760 (51%)). Among these, the number of patients who utilized health-care services in Seoul was 918 (26.6%). All components and procedures of this study were approved by the Institutional Review Board of National Health Insurance Medical Center (approval No.: 2017-05-005). The formal name of the study data is the National Sample Cohort Data (data No.: NHIS-2017-2-535), provided by NHIS.

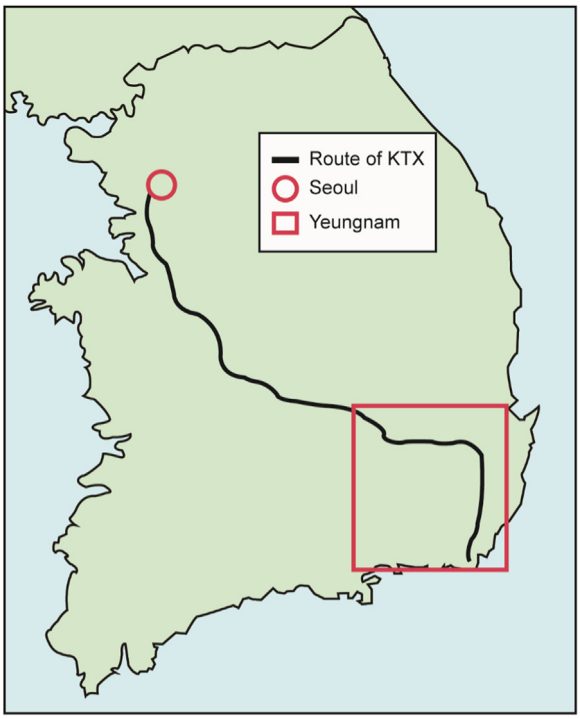

Fig. 1. The route map of KTX.

3.2. Study variables

A minimum of three variables are required for an ITS analysis. A dependent variable is a health-care utilization factor composed of outpatient and inpatient data for a patient who has been diagnosed with cancer. The health-care utilization for this study was

Table 1
Characteristics of study population.

		Study population		Patients utilizing healthcare in Seoul		p-value
		n	%	n	%	
Total		3,449	100	918	26.6	
Gender	Men	1,689	49.0	478	28.3	0.028
	Women	1,760	51.0	440	25.0	
Age group (years)	< = 49	1,102	32.0	319	28.9	< 0.001
	50–59	840	24.4	257	30.7	
	60–69	975	28.3	242	24.8	
	70 < =	531	15.4	100	18.8	
Region	Busan	983	28.5	189	19.2	< 0.001
	Daegu	694	20.1	104	15.0	
	Ulsan	128	3.7	72	56.3	
	Gyeongbuk	787	22.8	335	42.6	
	Gyeongnam	857	24.8	218	25.4	
Type of social security	Medical aid	82	2.4	15	18.3	0.070
	Industrial worker	1,926	55.8	536	27.8	
	Self-employee	1,441	41.8	367	25.5	
Income level	1 quintile(lowest)	430	12.5	85	19.8	< 0.001
	2 quintile	476	13.8	90	18.9	
	3 quintile	580	16.8	132	22.8	
	4 quintile	841	24.4	220	26.2	
	5 quintile (highest)	1,122	32.5	391	34.8	
Disability	No	3,202	92.8	856	26.7	0.576
	Yes	247	7.2	62	25.1	

Data are expressed as N (%).
Notes: P-value means differences in the distribution between patients utilizing healthcare services in Seoul and patients not utilizing healthcare services in Seoul.

measured by the number of patient who utilized health-care service (outpatient and inpatient) in Seoul, Korea. The applicable time variable is the number of months, from January 2002 (as 1) to December 2006 (as 60). ITS works best with short-term outcomes that are expected to change either relatively quickly after an intervention is implemented or after a clearly defined period of time (Bernal et al., 2017). The intervention variable is defined as a dummy variable with the value 0 for segment before the introduction of KTX, and 1 for segment after the introduction of KTX. KTX started on April 1, 2004. The interaction variable is the number of months after the introduction of KTX, with the value 0 for the segment before the introduction of KTX.

3.3. Statistical analysis

The applicable statistical analyses were conducted using the x^2 test to investigate the differences in socio-economic factors. The ITS model was used to estimate the pattern of outpatient and inpatient visits of the participants. The ITS model estimated linear trends separately for the periods before KTX (2002.1–2004.3) and after KTX (2004.4–2006.12), and it tested the difference between the pre- and post-intervention trends. In this model, the adjusted independent variables are time, intervention, and interaction. The

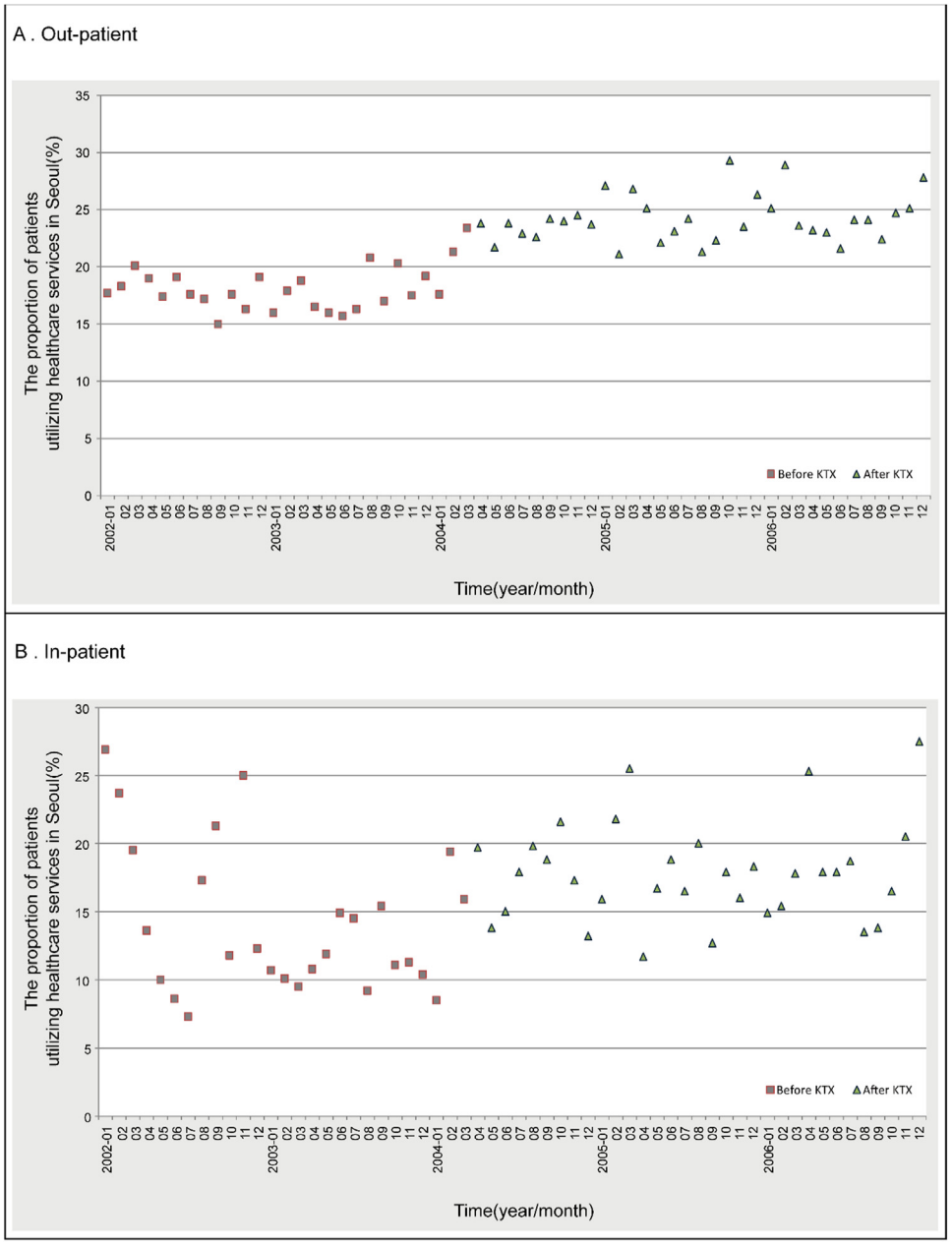

Fig. 2. Proportion of patient utilizing healthcare services in Seoul (Unit: %).

multivariate model used the constant estimates of the baseline level of the rates, as noted at the beginning of the observation; the coefficient of time estimates the base rate trend before the introduction of KTX; the coefficient of intervention estimates the change in rate level after the introduction of KTX; the coefficient of interaction estimates the change in rate slope after the introduction of KTX. A p-value < 0.05 was considered statistically significant. All data were analyzed using the SAS 9.4 (SAS Institute, Cary, North Carolina).

The ITS analysis is an effective and powerful quasi-experimental design for evaluating the effects of an intervention implemented at a clearly defined point in time (Taljaard et al., 2014; Lopez Bernal et al., 2016). In particular, the ITS model is suitable for evaluating the effects of interventions implemented at a population level (Wagner et al., 2002). The ITS analysis method has been used for evaluating a wide range of interventions (Lopez Bernal et al., 2016). When utilizing this model, the sequential measures of the outcome should be available both before and after the intervention so that the most accurate data in a study can be recorded.

4. Results

Table 1 summarizes the basic characteristics of people. Among the patients living in the Yeungnam region, there were 3,449 who were diagnosed with cancer. Of these, 1,689 were men (49%) and 1,760 were women (51%). The number of patients who utilized health-care services in Seoul was 918 (26.6%). Of the patients in the study who utilized healthcare in Seoul, 28.3% were men, and 25.0% were women. The number of patients who utilized health care in Seoul increased with age up to 60 years and peaked at 30.7% in the age group of 50 to 59 years, then decreasing to 18.8% among those ages 70+ years. The patients living in Ulsan (56.3%) and Gyeongbuk (42.6%) utilized medical facilities in Seoul more than average (26.6%). The rate of patients who utilized health-care services in Seoul was higher among industrial workers (27.8%) and the self-employed (25.5%) than in the medical aid (18.3%) group. The patients were 19.8% and 34.8% among those in the first and fifth quintiles of household income, respectively, indicating that the utilization of health-care services in Seoul by patients increases with income. The rate at which patient utilized health-care services in Seoul was similar between patients with disabilities (26.7%) and those without a recorded disability (25.1%). There were significant differences in healthcare utilization by gender, age, region, and income level.

Fig. 2 shows that proportion of patients with cancer who living in Yeungnam region who utilized health-care services in Seoul during the study period. The proportion of outpatients who utilized health-care services in Seoul increased after the introduction of the KTX services. However, the proportion of patient utilized health-care services in Seoul remained unchanged. Fig. 3 shows a distinct pattern of health-care service utilization before and after introduction of the KTX by income level. Income level was divided

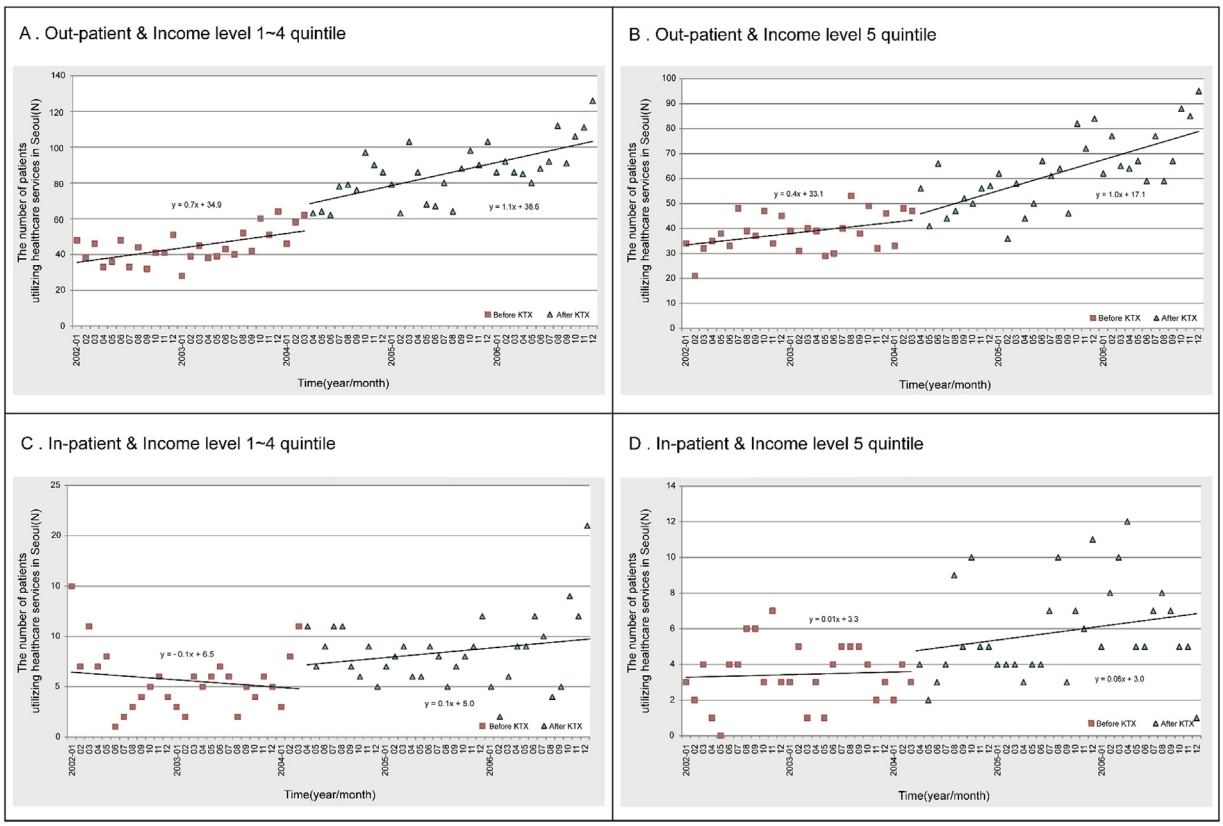

Fig. 3. Scatter plot of healthcare utilization (Unit: N).

Table 2
Effect of introduction of KTX on healthcare utilization.

	Outpatient		Inpatient	
	B	p-value	B	p-value
Intercept	97.6		8.3	
Time	1.1	0.017	−0.1	0.546
Intervention	16.7	0.067	3.5	0.099
Interaction	1.1	0.046	0.2	0.097
Post-intervention	2.1	< 0.001	0.2	0.045

KTX, Korean Train Express.

into two categories (1–4 quintiles and 5 quintile). In both high-income and non-high-income groups, outpatient visits has been increasing. However, there has been little difference in inpatient visits since the introduction of KTX.

We also identified the pattern of health-care service utilization with time-trend analyses (Table 2). The number of outpatients utilizing health-care services significantly increased across time (B = 1.1 utilization per month, p-value = 0.017) prior to the introduction of the KTX. After the introduction of the KTX, the number of outpatient utilization significantly increased across time (B = 2.1 utilization per month, p-value = < 0.001). The pre- and post-intervention slopes significantly differed from one another (p-value = 0.046). The model-predicted increase in the number of outpatient utilizations was non-significant after the introduction of the KTX (B = 16.7, p-value = 0.067). In the case of inpatient use, there were no significant variables except for post-intervention. Beginning with the introduction of the KTX, the number of inpatient utilizations significantly increased across time (B = 0.2 utilization per month, p-value = 0.045).

5. Discussion

Using longitudinal administrative data and time trend analysis, we were able to evaluate a natural experiment of the KTX's influences on the pattern of health-care service utilization in a specified patient population. Of the patients with cancer living in the Yeungnam region, 26.6% utilized health-care services in Seoul for five years before and after the introduction of the KTX. The findings revealed an association between the development of public transportation and the utilization of health-care services among patients in rural districts near Seoul, Korea. In particular, the utilization of outpatient services has increased since the introduction of the KTX. As a result of the introduction of the KTX, there was an upward trend in patients who utilized outpatient services in Seoul. According to the interaction effect, the rate slope of outpatient services changed in the segment after the introduction of the KTX. In the case of inpatients, there were no significant variables, except for the post-intervention phase of reporting of the study. As of the timeframe of the introduction of the KTX, the number of inpatient utilizations of public transportation significantly increased across time. The factor affecting utilization of outpatient is interaction variable in high income group. In non-high income group, the factor affecting utilization of outpatient were time and intervention, not interaction. In other words, utilization of outpatient of high-income group was affected by the introduction of KTX. According to the ITS analysis, there were no factors that affected inpatient utilization in both high-income and non-high-income groups.

The results reported in this study have important implications for public health policy makers, legislators, and administrators at all levels regarding the initiation of better health-care drivers to benefit the public and the community. Regional and national government agencies and administrators should invest resources in medical institutions in order to enhance easier access to health-care services, especially for patients living in the often inaccessible rural districts. The improvement in the access to health-care services will work to enhance the health outcomes. The implementation of the KTX public transportation service might produce positive effects on the health-care outcomes of patients with severe conditions, debilitating diseases, or recent diagnoses of chronic and acute diseases or ailments. Health-care facilities and services should be equally distributed across rural markets. The KTX continues to contribute positively to augment and accelerate regional economic convergence, even as it may cause regional inequality (Jiang and Kim, 2016).

There are some limitations of this study. First, there may be patients who were able to utilize health-care service in Seoul, but who did not use the KTX to access those services. The ITS model is particularly suitable for interventions introduced at a population level and utilized in a clearly defined timeframe and time reference. The ITS model compares both trends and levels during before, and after intervention, controlling for autocorrelation as well as all other unknown factors. Second, other factors not dealt with in this analysis might have an effect on the utilization of health care by a patient in Seoul. For example, there is no information on the severity of a patient's cancer (as referenced in the study). This is one of many decisive factors that will influence the health-care service utilization of any patient seeking care for a cancer management treatment plan. Also, there may have been patterns of utilization that were different and were caused by the severity of the patient's cancer.

A major strength of our study was in analyzing the effects of high-speed rail on the utilization of health-care services in a nationwide, population-based cohort dataset in Korea. Although many studies worldwide have identified factors associated with the utilization of health-care service, few have investigated the effects of the development of public transportation on the utilization of health-care service. Furthermore, we used an ITS design model that showed changes in outpatient and inpatient visits that clearly corresponded to the introduction of the KTX public transportation service in the region. Research studies that are able to evaluate the

effects of intervention randomized controlled trials (RCTs) have long been considered the gold standard design (Victora et al., 2004). However, it is noted that for health policies and programs targeted at the population level, it would appear that RCTs are impossible. An alternative methodological approach model useful in this interpretation of evidence is to use an ITS analysis. ITS analysis is an effective and powerful quasi-experimental design for evaluating health-care service utilization volume before and after the introduction of high-speed rail. It is appropriate for evaluating the effectiveness of population-level health interventions (Lopez Bernal et al., 2016).

6. Conclusion

The development of public transportation has an effect on the utilization of outpatient services for a patient population or demographic (such as patients living in rural districts). In order to promote better health outcomes for all patients in a country, the government should ensure that all patients have access to appropriate health-care options. Health-care facilities and services should be equally distributed across rural markets to prevent the creation of underserved populations. For this reason, it is necessary to identify whether limited access to health-care services has a decisive effect on health outcome, or whether this is not a significant factor or barrier to prevent patients from seeking and accessing care in any particular region or demographic area. Further studies should identify any measurable differences in the results of treatment for patients who utilize health-care services in Seoul.

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Conflict of interest

The authors report that they have no conflicts of interest.

Ethical approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

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