How close are trauma centers?: Application of driving time data to measure trauma center accessibility*

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May 14, 2018

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Abstract

Severe physical injury, or trauma in medical terms, is one of the leading causes of deaths under age 40 worldwide. An important aspect of treating the severely injured is to have them reach a hospital within an hour, often called as the "golden hour." South Korean policy makers have been putting forth effort to expand trauma centers nationally in recent years. However, surprisingly little has been known on what fraction of population resides within the golden hour of the existing trauma centers. Using driving directions database, we construct a novel data on how long it takes to get to the nearest trauma center by car for the every township (*eup*, *myeon*, and *dong*) in contiguous South Korea and Jeju Island. We find that a significant number of population lacks the golden hour access. Residents of about 800 townships (23%), out of total 3,430, cannot reach a trauma center within an hour. In terms of population, almost 6 million (12%), out of 49 million, are outside of the golden hour coverage. We also find a significant regional variation in the driving time to trauma centers. In major cities, most residents are covered within 60 minutes. In contrast, almost 50% of residents in Gangwon and three southern provinces cannot reach trauma centers within the golden hour.

Keywords: trauma, transportation access, South Korea

JEL Classification: I14, H51, R53

*We thank Sok Chul Hong and Chulhee Lee for valuable feedback and suggestions. Yunji Choi provided excellent research assistance. Changseung Ha, Yeonsoo Kim, and Kyungmin Lee at GrayPoint, Inc. provided insightful technical advice and example programming codes for extracting driving directions data online. All errors are ours.

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1 Introduction

Severe physical injury, or trauma in medical terms, is one of the leading causes of deaths under age 40 in many countries such as the United States and South Korea (Harmsen et al., 2015; Yoon, 2016). For trauma patients, it is critical to provide adequate medical treatments in a timely manner. A widely known principle in emergency care for trauma patients is called the "golden hour." The term emphasizes the importance of having the severely injured arrive at a hospital promptly for treatment preferably within an hour (Little, 2010; Harmsen et al., 2015).

Recently, policy makers have been putting forth effort to expand trauma centers (TC henceforth) throughout the country in South Korea. However, surprisingly little has been known on what fraction of population resides within the golden hour of the nearest TC.

To find out the golden hour accessibility, we introduce a novel measure of travel time to TCs by car from all 3,430 townships (*eup*, *myeon*, and *dong*) in contiguous South Korea and Jeju Island. This way, we are able to determine whether residents in a township can reach a TC within the golden hour or not. Additionally, we can investigate regional differences in travel time for residents to arrive at TCs. We focus on travel time by car because most trauma patients are transported by auto vehicles.[1]

As we construct the travel time data, we also introduce a new and convenient method to collect a large scale real-time data from a remote server through a communication protocol called Application Programming Interface (API). APIs are widely used in many online services, for example, an online flight booking websites. These websites utilize APIs to fetch real-time pricing data from multiple airlines for price comparisons. In similar way, we use simple programming codes and an API to fetch driving hours and distances for approximately 10,000 origin-destination pairs from a car navigation data provider in less than half an hour.

Using the generated travel time data between townships and TCs, we find that a significant number of population lacks the golden hour access to TCs. Residents in 785 townships (23%), out of total 3,430, cannot reach a trauma center within an hour. In terms of population, 5.7 million (12%), out of 49 million, are outside of the golden hour

[1] About 98% of trauma patients arrived at a hospital by auto vehicles such as an ambulance in 2016 (National Emergency Medical Center, 2016).

coverage. We also find a significant regional variation in the driving time to trauma centers. In major cities, most residents are covered within 60 minutes. In contrast, almost 50% of residents in Gangwon and three southern provinces, Jeonla South, Kyungsang North, and Kyungsang South, cannot reach trauma centers within the golden hour.

To our knowledge, we are the first to introduce a medical accessibility measure in South Korea incorporating driving distances and time, as well as to provide it in the smallest administrative unit for the whole country. The existing literature mostly used linear distance measures (Shin and Lee, 2011; Hong, 2017). However, linear distance does not take the road network and geography into account, even though most trauma patients are transported by auto vehicles. Therefore, we believe our approach of using travel time by car is an improved measure reflecting the reality of trauma patient transportation.

This paper proceeds as follows. In Section 2, we provide background on the golden hour and regional TCs in South Korea. In Section 3, we describe the data and data extraction method we used. In Section 4, we present descriptive statistics from the data. We provide concluding remarks in Section 5.

2 Background

Trauma is a leading cause of death worldwide. For example, more than five million people die every year in the world due to trauma (National Institute of Health, 2010). Trauma systems were designed to provide timely medical care for trauma patients. The "golden hour" of trauma is considered as a well known principles in medicine which states that the patient outcome will be better if trauma patients can reach a trauma center within an hour of injury (Dinh et al., 2013).

There exists ample empirical evidence in medical literature which supports idea behind the golden hour principle that reduced travel time helps patient outcome. For example, the reduced time to treatment was associated with improved mortality for patients with Acute Subdural Hematoma (Tien et al., 2011) and with severe brain injury (Newgard et al., 2015).[2]

Additionally, there are several papers claiming the relationship between geographical accessibility and health outcomes. An increased distance to hospital led to higher mor-

[2] However there has not been uniform acceptance of the golden hour principle in medicine. See Little (2010) for further discussion.

tality rate from unintentional injuries (Buchmueller et al., 2006) and from cardiovascular disease (Avdic, 2016). Improved geographic accessibility increases the mental health care utilization (Hong, 2017), or enhances self-perceived medical status for the rural elderly (Yi and Kim, 2015).

Another strand of medical literature documents the positive impacts of dedicated trauma systems on health outcomes for trauma patients (Nathens et al., 2000; MacKenzie et al., 2006). Through these results, there has been strong arguments for designing emergency medical services with an emphasis on the reduced transportation time, represented by the golden hour principle, combined with establishing dedicated trauma centers (Little, 2010).

In South Korea, there was a drastic increase in interests, as well as the government budget, on emergency medical services after 2010. Before 2010, the annual budget of emergency services were less than 60 billion Korean Won.[3] However, since 2010, the budget has been exceeding 250 billion Korean Won, a more than 4-fold increase (Yoon, 2016).[4]

Along with the rapid budget increase, the Korean government established 16 regional trauma centers throughout the country so far (see Figure 1). These newly established regional trauma centers are all located within existing university hospitals.

3 Data

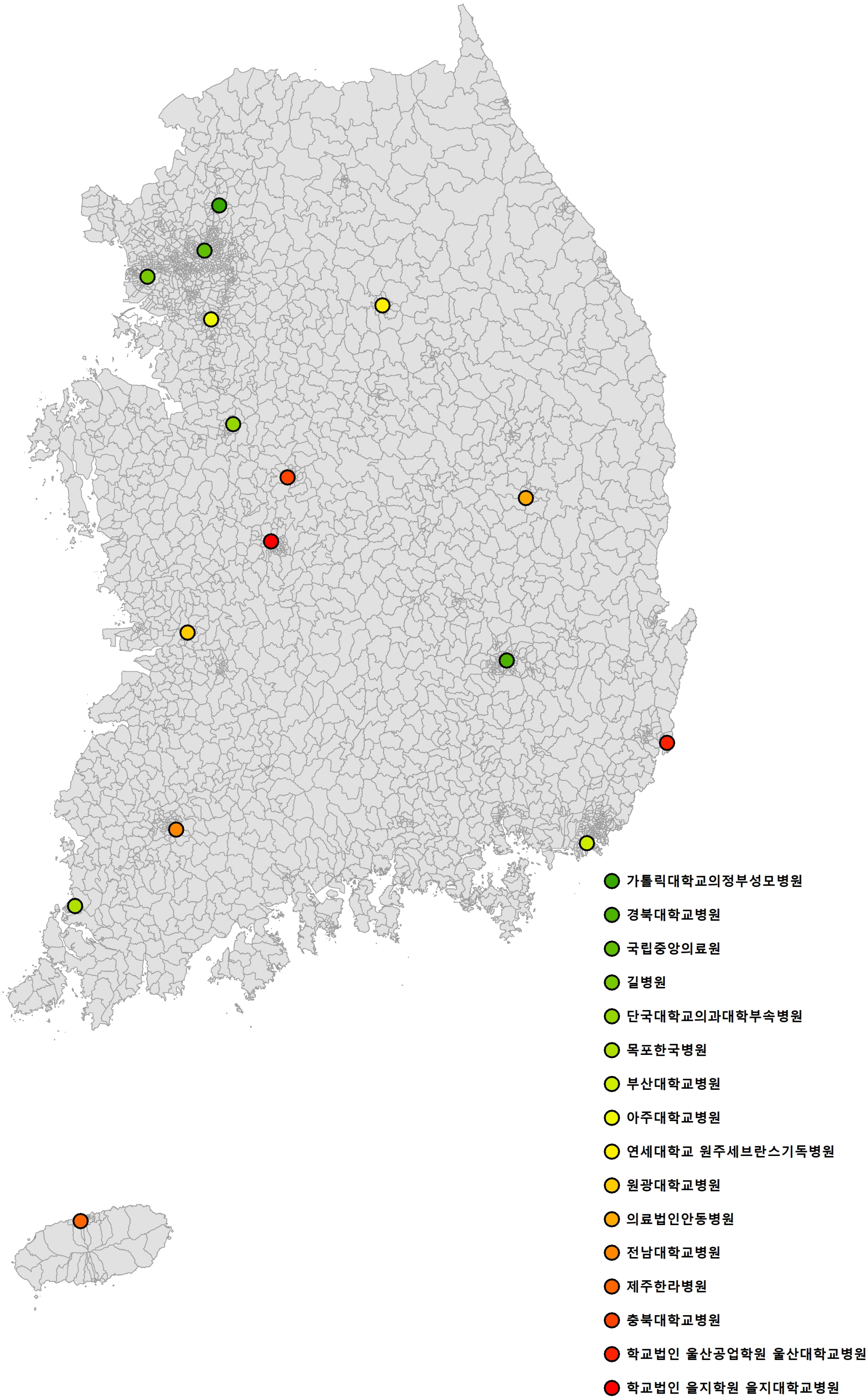
The main objective of this paper is to show, descriptively, the accessibility of regional trauma centers from each rural and urban township in South Korea. A township (*eup, myeon, dong*) is the smallest administrative unit. More specifically, we investigate how many townships are within the golden hour from the nearest TC. Additionally, we provide number of population that are covered by the golden hour. We also show regional differences in the golden hour accessibility.

The most common, and most convenient, approach to measure distance from a TC is to use linear distance. Given the location of two points, in our case the central point of

[3]One billion Korean Won is approximately one million US Dollar.

[4]Many attribute this rapid increase in budget and interests in emergency care to the rescue mission of a Korean ship which was kidnapped by Somalian pirates around that time. The severely injured captain was miraculously recovered after the successful trauma care.

Figure 1: Location of regional trauma centers



each township or district and the location of the nearest TC, it is easy to calculate linear distance using a GIS software, such as ArcGIS or QGIS.[5]

However, linear distance may contain serious measurement errors as a measure of the accessibility to TCs. Most trauma patients arrives at a TC by car (National Emergency Medical Center, 2016). Hence the location of highway entrance or existence of high quality regional roads may matter for measuring time to reach the nearest TC. Furthermore, there is no clear way of converting a linear distance to travel time. Therefore, the most reasonable way of measuring time and distance to reach the nearest TC is to use driving directions data, which contain the time and distance for a passenger car to reach TCs.

In the next subsections, we first introduce driving direction data and other spatial data we use. Then we explain the method we use to extract information on driving directions from a real time remote server through programming codes and an API.

3.1 Driving directions database

The main source of the driving directions database is from a major commercial car navigation software provider in South Korea. For a pair of origin and destination, the company's database provides a real-time information on: driving distance (kilometers), driving hours (minutes), the taxi fare (Korean Won), navigation directions, etc. While there are many possible options for driving routes available, such as "fastest" or "excluding highways", we use the default "fastest" option when we fetch data. These data were publicly available without costs for noncommercial usages via the company's API as of February 2018.

3.2 Location of townships and regional TCs

In order to calculate driving time, we need addresses of a central point of each township (origins) and TCs (destinations). We chose the central point of each township as the location of government township offices. The official list of street addresses and the names of government township offices are obtained from the Ministry of the Interior and Safety. We retrieved the names and the street addresses of regional TCs from Health Insurance Review and Assessment Service. For the data collection, we excluded townships located

[5]These programs calculate linear distance between two locations by using the haversine formula which provides the great-circle distance between two points on a sphere.

in islands, except Jeju Island in our final sample.

After we compiled the street addresses of townships and TCs, we converted them into GPS coordinates in terms of the latitude and longitude. While most navigational database and online maps allow street addresses for either origins or destinations, we chose GPS coordinates to ensure the best location accuracy. We used multiple methods, such as navigation database and Google Maps, to convert street addresses into GPS coordinates.

In principle, all conversion methods should provide the identical GPS coordinates for the same street address. To prevent conversion errors, we checked the differences in linear distance of coordinates among various conversion methods, given the same street address. If the distances for any two GPS coordinates originating from the same street address were more than 1 kilometer, we manually checked the coordinates to pick the most accurate ones.[6]

3.3 Method of extracting driving time data

There are more than 3,400 townships and 16 TCs in Korea. Therefore, it can be an extremely time consuming process to manually record travel time by car for township-TC pairs, for example by typing in origins and destinations in an online map service such as Google Maps.

Instead, we utilized an API, which provides a convenient way to collect travel time from the car navigation software provider's database we use. Using Google Apps Script and the API, we were able to collect driving time for about 10,000 origin-destination pairs in less than half an hour. In this subsection, we explain how to extract a large volume of real time data in detail.

APIs are a protocol for communicating data between remote servers and a client who wants to fetch the data. An API typically provides an web address and detailed instructions on how to include parameters or inputs for requests. In our example, inputs are GPS coordinates for both an origin and a destination. Additionally, an API key is required, so that the data provider can identify who the client is, or charge to the client. In the end, the web address to request driving time through the API for driving time will be look like: "https://api.website.com/route?apikey=...&startX=...&startY=...'&endX=...," where '...'

[6]Further details on conversion are available upon request.

will be replaced with actual values of an API key and GPS coordinates for origin and destination.

When the request is sent to the remote server, the information provider's database will process the request. Then it will send back the requested information, the driving time for example, to the client in a structured format which can be easily converted as values in columns in a spreadsheet.

Given a list of origin and destination pairs, we wrote programming codes to expedite the process of fetching a large batch of information of driving time and distance for multiple origin-destination pairs through the API. For the purpose, we used Google Apps Script and Google Sheets. Google Apps Script is a Javascript-based language which enables scripting and automation of tasks for Google's cloud products such as Google Sheets, a cloud spreadsheet program.

The actual Google Apps Script codes we wrote for fetching API data are displayed in Figure 2. We wrote the codes to create a custom function for Google Sheets, which is similar to Microsoft Excel's functions.[7] The function *tcar()* take four inputs, longitude and latitude of origin and destination. Using Google Sheets, we created a spreadsheet. Each row has four variables, longitude and latitude of each township office (origin) and of a TC (destination). In the fifth column, we run the *tcar()* function taking first four columns as the input. The function will fetch driving time and hours through the API and records these as variables in the same row of the spreadsheet.

One important advantage of using Google Sheets and Google Apps Script is the speed. Since the execution of the function *tcar()* for each row as well as fetching data are all done using Google's computing power and its Internet bandwidth. Therefore it is much faster compared to running custom codes on a researcher's own desktop computer.

There have been an increasing number of private firms and government agencies who offer real time data through APIs. The basic structure of fetching data using an API is the same as how we fetch driving time data in this paper. Therefore, we believe that our codes can be applied in many different settings when fetching data through an API is needed.

To determine the nearest TC from each township and disctrict, first we picked three TCs with the least linear distances from each township. Then we constructed driving

[7]For example, Microsoft Excel has AVERAGE() function which calculate means.

Figure 2: Google Script codes

```
function tcar(input) {
  // last modified: 11/7/2017 by HY
  var results=[]; // initiate result array

  for (i in input) {

    // Create origin and destination vars
    var startX = input[i][1]; // lon
    var startY = input[i][0]; // lat
    var endX = input[i][3]; // lon
    var endY = input[i][2]; // lat

    var start = startY + ',' + startX;
    var end = endY + ',' + endX;
    var reqCoordType = 'WGS84GEO' // use WGS84. If omitted, default is EPSG3857 (Google Mercator)
    var apiKey = [redacted]// HY's
    var url = 'https://apis[redacted].com/[redacted]/routes?version=1' +
      '&startX=' + startX +
      '&startY=' + startY +
      '&endX=' + endX +
      '&endY=' + endY +
      '&reqCoordType=' + reqCoordType +
      '&appKey=' + apiKey;

    // Fetch JSON response from server
    var response = UrlFetchApp.fetch(url); // get api endpoint
    var json = response.getContentText(); // get the response content as text
    var data = JSON.parse(json); //parse text into json

    // Get total fare, total time, total distance, taxi fare
    // var totalFare = data.features[0].properties.totalFare;
    var totalDistance = data.features[0].properties.totalDistance; // meters
    var totalTime = data.features[0].properties.totalTime; // seconds
    var taxiFare = data.features[0].properties.taxiFare; // KRW

    // Convert seconds to minutes, meters to km
    var totalDistanceKM = Math.round(totalDistance/1000); // meter -> km
    var totalTimeM = Math.round(totalTime/60); // seconds -> minutes

    // Combine all results into one array  (distance, time, fare)
    var output = [totalDistanceKM, totalTimeM, taxiFare];
    results.push(output);

    // Wait for 0.1-0.6 second (random wait)
    var rnumber = Math.floor((Math.random() * 6) + 1)*100;
    Utilities.sleep(rnumber);
  }
return results;
}
```

hours from each township to these three TCs. We chose the shortest driving hours among them. Using Google Sheets and our custom function using Google Apps Script, it took us less than 20 minutes for collecting driving directions data for 10,000 origin-destination pairs.[8]

We ran the codes and collected driving time data multiple times. The first batch of collection was at 4 pm, Friday on January 26th, 2018. Second and third batches were at 8pm, Friday on February 16th and at 12 am, Wednesday on February 28th. The data set we use for this paper is the first batch. However, there was little difference in results when we used the other batch (see Figure 8 and 9).

4 Results

Table 1 provides the summary statistics. The average driving distance to the nearest TC is 36.5 kilometers. However, there is a substantial variation with standard deviation of 34.6 kilometers. The maximum driving distance was 183 kilometers, whereas the minimum was 0 kilometers.[9]

Table 1: Summary statistics (National)

Variable	**Mean**	**Std. Dev.**	**Min.**	**Max.**	**N**
Driving distance (km)	36.5	34.6	0	183	3,430
Driving time (minutes)	44.7	25.7	1	159	3,430
Taxi fare (Korean Won)	38,823	36,722	2,800	208,320	3,430
overGH dummy=1 if over golden hour	0.23	0.42	0	1	3,430

Note: Unit of observations is township (*eup, myeon, dong*). The total number of townships included in the summary statistics is 3,430. We restrict the sample in our analysis for townships in contiguous South Korea and Jeju Island. The taxi fare is calculated based on the taxi fare system for Seoul. overGH dummy equals one for a township if the driving time to the nearest trauma center exceeds 60 minutes and zero otherwise.

The average driving hours is 44.7 minutes, which is well within the golden hour of 60 minutes. However, since the standard deviation is 25.7 minutes, many townships with

[8] There are 3,430 townships. We compute the driving hours from each township to the three closest regional trauma centers. Hence the origin-destination pairs for fetching driving direction data points are total $3 \times 3{,}430 = 10{,}290$.

[9] Of course, it is not possible to have exact zero kilometers of driving distance. This is due to the rounding, that is, the distance of less than 500 meters is rounded as zero kilometer.

one standard deviation above the mean is already above the golden hour. The minimum driving hours is 1 minute and the maximum was almost 2.5 hours.

We also generated a dummy variable which equals one if the driving hours to the nearest TC is more than the golden hour and zero otherwise. The descriptive statistics show that 23% of townships do not have access to the nearest TC within an hour by car.

While not central information for the context of this study, the driving directions data also provide approximate taxi fare. The average fare is about 40 thousand Korean Won with the maximum fare was almost 210 thousand Korean Won.

To investigate regional variation in accessibility to TCs, we also generated summary statistics by province (see Table 2). We observed stark regional differences. Major metropolitan cities, such as Seoul, Pusan, or Daegu, the average driving hours are mostly 30 minutes or less. And most townships within these cities have access to TCs within the golden hour. Kyeonggi province, though not a metropolitan city but surrounds Seoul, also have 98% of its townships have the access within the golden hour.

In contrast, many provinces had long travel time. Among them, Gangwon and Kyungsang South provinces had the longest average travel time to TCs. The average driving hours for townships in Gangwon was about 1 hour and 20 minutes, well above the golden hour. The maximum was 2.5 hours. Only 27% of the townships there had the driving hours within the golden hour. Kyungsang South province had similar results as Gangwon. Only one-quarter of townships in Kyungsang South had TCs within one-hour driving. The average driving hours is similar to Gangwon, with 79 minutes.

Figure 3 offers a spatial distribution of driving hours to the nearest TC. Driving time from each township is represented by 20-minute bins, from zero minute to 20 minutes, from 20 minutes to 40 minutes, so on. Darker blue color is within 20-minute-reach of the nearest TC. Lighter blue means the driving time with between 20 and 40 minutes from the nearest TC. If a township has a driving time between 40 to 60 minutes, then it is green-colored. If the driving time is more than one hour, then the town is represented by red colors, with darker colors progressively indicate longer driving time.

Figure 3 confirms a large regional differences in the TC accessibility as we observed from descriptive statistics. Major metropolitan cities, as well as non-metropolitan regions near Seoul are all within the reach of the golden hour. On the other hand, Gangwon

Table 2: Summary statistics by province

	Driving distance (km)			**Driving time (min.)**			**OverGH**
	Mean	Min.	Max.	Mean	Min.	Max.	Mean
Seoul	11.5	1	23	34.5	5	56	0
Pusan	12.7	0	39	28.4	1	56	0
Incheon	11.6	1	70	27.9	2	87	0.08
Daegu	7.5	1	37	21.9	3	56	0
Daejeon	6.9	1	15	18.7	3	44	0
Gwangju	8.1	1	29	20.4	2	50	0
Ulsan	17	1	46	29.4	3	69	0.05
Sejong	21.3	15	27	31.7	23	41	0
Kyeonggi	22.3	1	69	34.7	3	76	0.02
Gangwon	95.3	1	183	78.9	2	159	0.73
Chungbuk	37.1	2	86	41.6	4	80	0.15
Chungnam	49.1	4	130	51.5	7	126	0.31
Cheonbuk	42.3	1	93	44.4	4	89	0.19
Cheonnam	55.2	1	127	53.9	4	106	0.38
Kyungbuk	52.8	2	167	57.0	4	128	0.43
Kyungnam	76.7	20	166	79.2	33	142	0.76
Jeju	22.5	1	46	38.8	6	72	0.29
Overall	36.5	0	183	44.7	1	159	0.23

Note: Unit of observations is township (*eup, myeon, dong*). The total number of townships included in the summary statistics is 3,430. We restrict the sample in our analysis for townships in contiguous South Korea and Jeju Island. The unit of the variable Driving distance is kilometer. The unit of the variable Driving time is minute. overGH dummy equals one for a township if the driving time to the nearest trauma center exceeds 60 minutes and zero otherwise. The "Overall" in the last row is national statistics using all townships in our sample.

Figure 3: Driving time to the nearest trauma center (minutes)

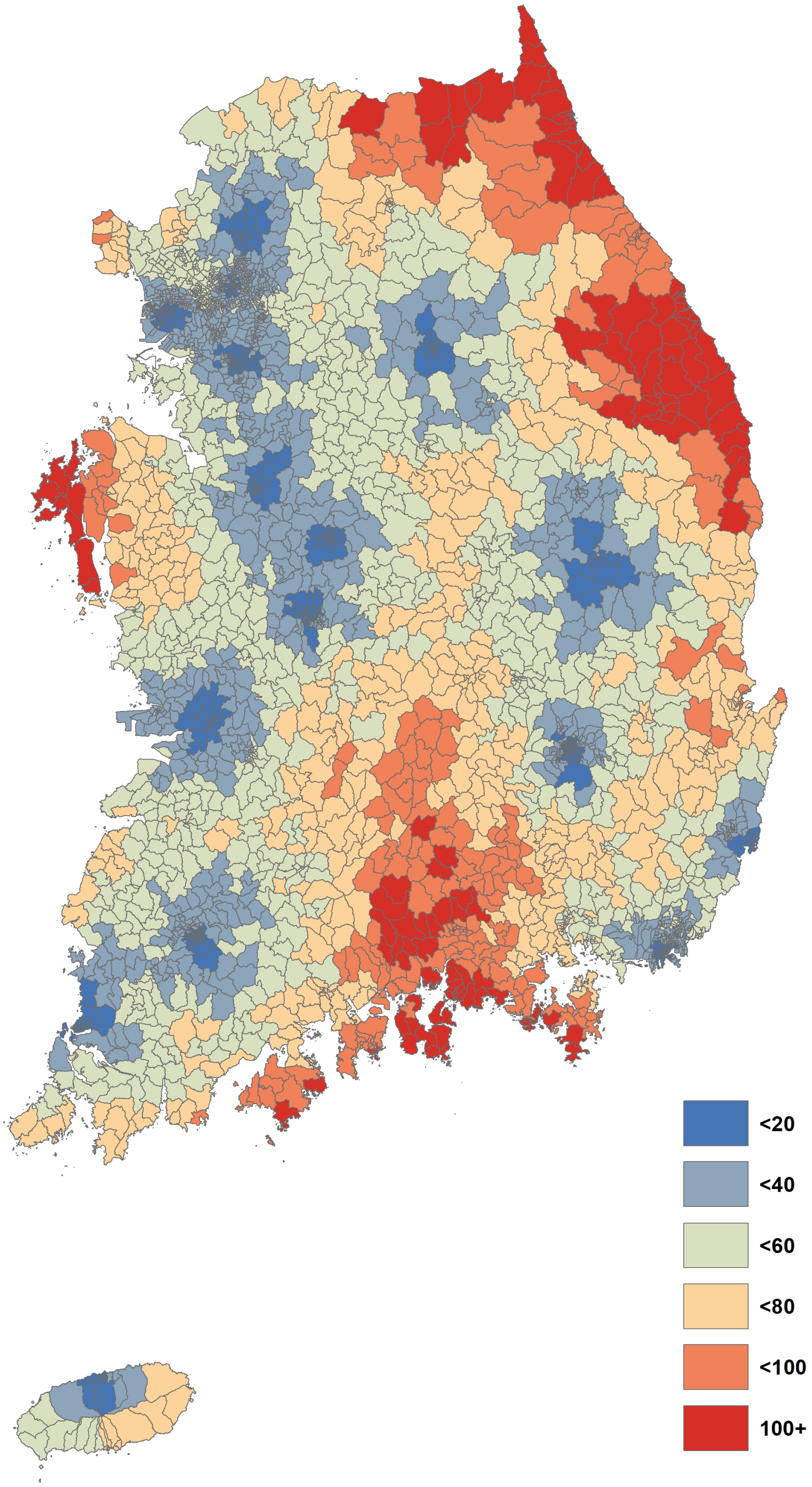
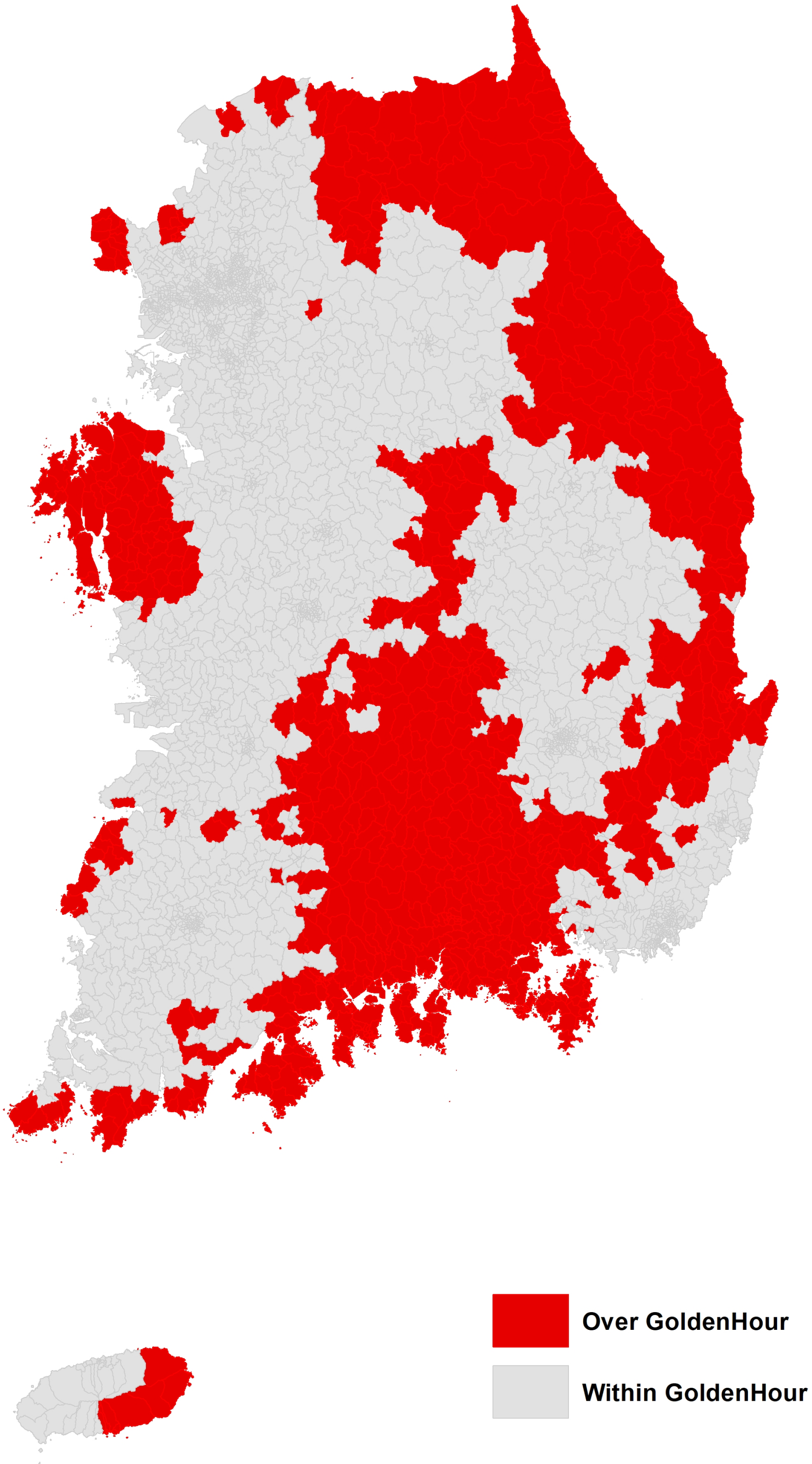


Figure 4: Townships with driving time over golden hour



province (in the north east) and Kyungsang South (in the south east) shows the worst accessibility.

Figure 4 shows TC accessibility in more stark contrast by displaying whether townships are within the golden hour driving time or not. There are large chunks of townships without the golden hour access in the northeastern region, middle west and mid-south regions.

Table 3: Golden hour accessibility to TCs by population

Province	**# townships**	**overGH**	**Share**	**Pop.**	**overGH pop.**	**Share**
Seoul	424	0	0	9,357,863	0	0
Pusan	206	0	0	3,358,259	0	0
Incheon	136	10	.07	2,703,066	55,948	.02
Daegu	139	0	0	2,397,933	0	0
Daejeon	79	0	0	1,496,855	0	0
Gwangju	95	0	0	1,458,116	0	0
Ulsan	56	3	.05	1,121,023	8,258	.01
Sejong	13	0	0	209,481	0	0
Kyeonggi	555	13	.02	11,997,891	309,579	.03
Gangwon	187	136	.74	1,482,342	929,735	.63
Chungbuk	153	23	.15	1,539,529	70,621	.05
Chungnam	207	65	.31	2,031,838	478,690	.24
Cheonbuk	239	45	.19	1,776,775	111,371	.06
Cheonnam	260	100	.38	1,619,250	800,288	.49
Kyungbuk	329	141	.43	2,581,761	1,166,916	.45
Kyungnam	311	237	.76	3,205,384	1,692,846	.53
Jeju	41	12	.29	595,054	107,111	.18
Overall	3,430	785	.23	48,932,420	5,731,363	.12

Note: Unit of observations is township (*eup, myeon, dong*). The total number of townships included in the summary statistics is 3,430. We restrict the sample in our analysis for townships in contiguous South Korea and Jeju Island. The column "# townships" means the number of townships in each province. The column "overGH" shows the number of townships in each province whose driving time to the nearest trauma center exceeds 60 minutes. The column "overGH Share" means "overGH" divided by the number of townships . The column "Pop." is the total number of residents in each province in 2017. The column "overGH pop." means the sum of the number of residents in "overGH" townships in each province. The column "overGH pop. Share" is "overGH pop." divided by the total number of residents.

Additionally, we used the recent resident registration data from the National Statistics Office to calculate the size of the population which lacks the golden hour access. Table 3 provides the results by province. Nationally, approximately 5.7 millions, out of total 49 millions, lacked the golden hour access (12% of population). About 23% of townships in the country lacks the golden hour access. The difference between the population number

(12%) and townships count number (23%) is due to population density. Those townships with relatively lower driving times, such as most metropolitan cities, are relatively densely populated.

By province, Kyungsang South had the largest size of population of 1.7 million who lacks of the golden hour access, followed by Kyungsang North of 1.2 million. Gangwon was the third, with 0.9 million people. In terms of the share of population, three southern provinces, Kyungsang South, Kyungsang North, and Jeonla South, had roughly 50% of population lacking the golden hour access. On the other hand, virtually all residents of major metropolitan cities had the golden hour access which show significant regional differences in accessibility.

5 Conclusion

In this paper, we introduce a novel data on driving time from each township to arrive at the nearest regional TC in South Korea. Using the collected data, we show how many population and townships are within the reach of a TC under 60-minute-driving by car (the golden hour). We also investigate the regional differences in the TC accessibility.

Our data show that most residents from metropolitan cities are within the golden hour of near TCs. However, in many provinces, especially southern ones and Gangwon, we find almost half of residents do not have the golden hour access, which shows a significant regional differences in one aspect of medical accessibility.

Our results informs policy makers where the current geographical blind spots are in terms of emergency trauma care. Additionally, this paper introduces novel data collection methods and transportation accessibility data to investigate other types of accessibility of medical facilities, educational institutions or amenities. For example, which type of hospitals is further away for the elderly in rural area via public transportation? Does lack of transportation access to obstetrics exacerbate low birth rate? These topics are left for future research.

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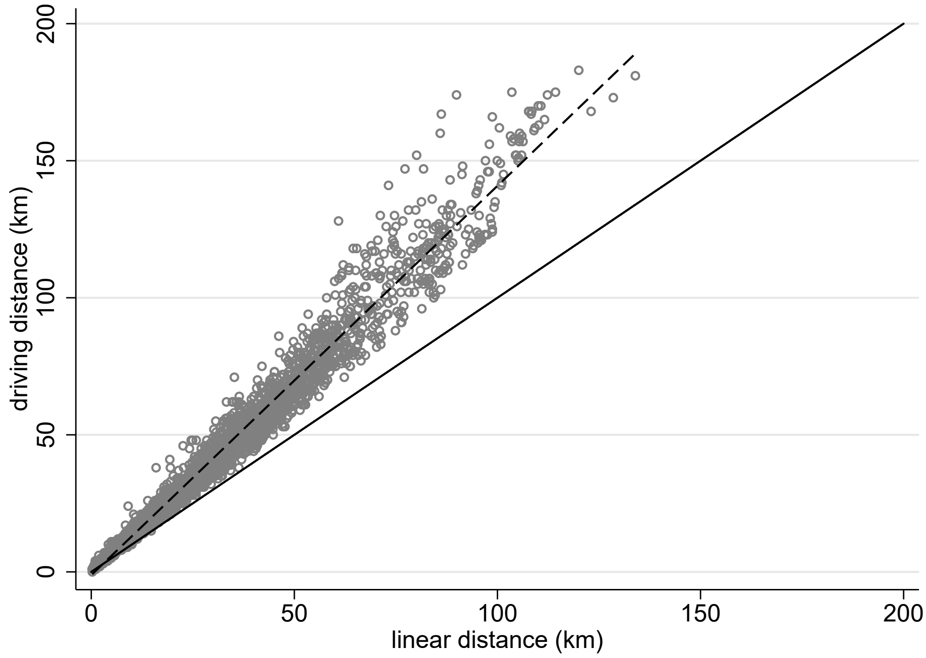
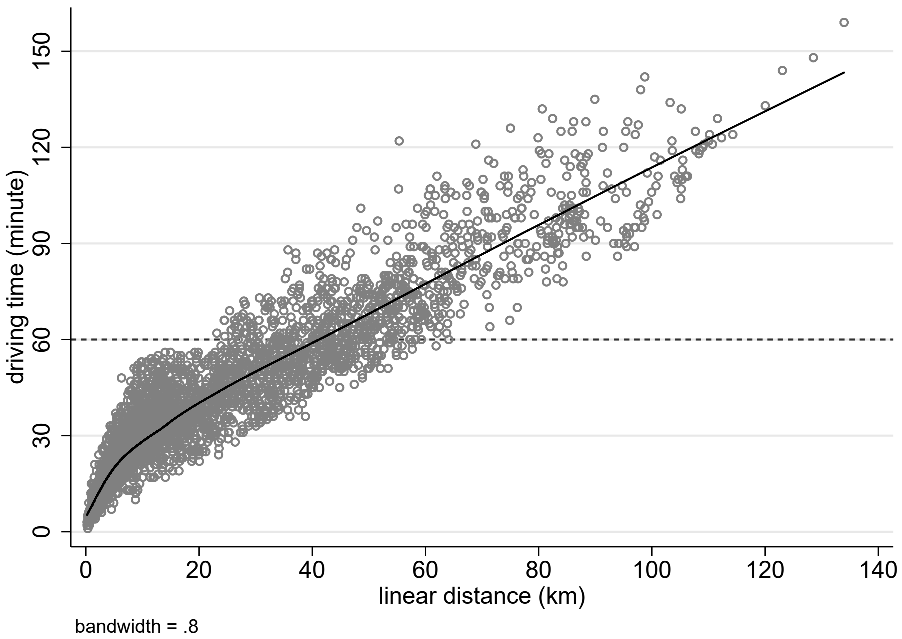
Figures

Figure 5: Linear distance and driving distance



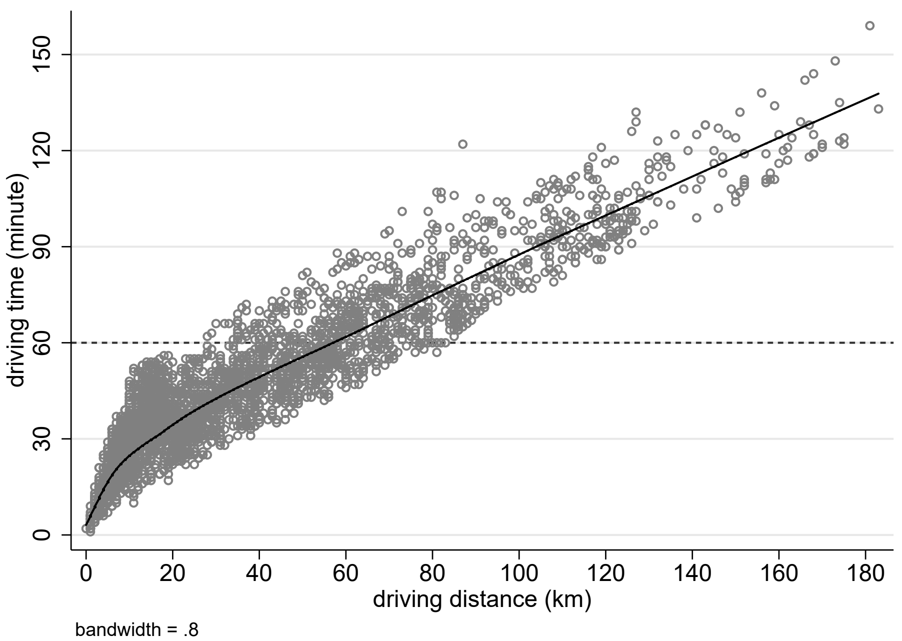
Note: This scatter plot compares the linear distance (km) of each township to the nearest trauma center and the driving distance (km) for the same origin-destination pair. The solid line is the 45 degree line. The dashed line represents the linear fit. Due to the variation in road network and geography, driving distance is about 38% longer than linear distance on average. In terms of the estimated regression coefficients, $\textit{predicted driving distance} = -1.17 + 1.42 \times \textit{linear distance}$.

Figure 6: Linear distance and driving time



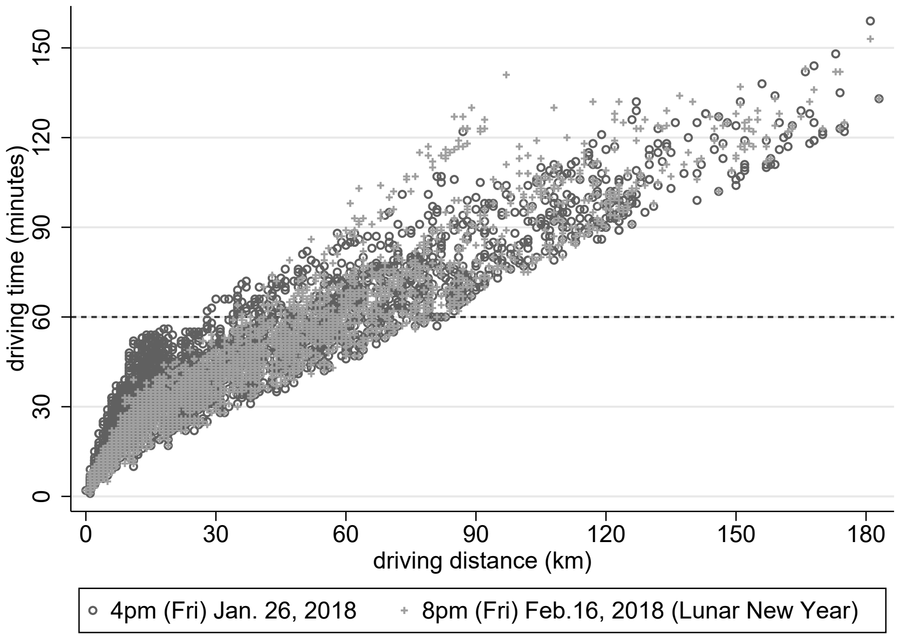
Note: This scatter plot compares the linear distance (km) of each township to the nearest trauma center and the driving time (minutes) for the same origin-destination pair. The solid line is the locally weighted scatterplot smoother. The horizontal dashed line represents the golden hour (60 minutes).

Figure 7: Driving distance and driving time



Note: This scatter plot compares the driving distance (km) of each township to the nearest trauma center and the driving time (minutes) for the same origin-destination pair. The solid line is the locally weighted scatterplot smoother. The horizontal dashed line represents the golden hour (60 minutes).

Figure 8: Comparison of driving time in different dates (SCATTER)



Note: This scatter plot compares how driving time varies depending on when the driving time is measured, given the same driving distance in our sample. Our main data, which was collected at 4 pm on January 26th (darker colored open circle) is compared with another batch of collection at 8 pm, February 16th (light colored +). January 26th was a regular Friday afternoon. February 16th was the Lunar New Year's Holiday, with a large volume of car traffic on many roads for family visits. The horizontal dashed line represents the golden hour (60 minutes).

Figure 9: Comparison of driving time in different dates (LOWESS)