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DISTRIBUTION OF SELECTED HEALTH FACILITIES AND RESOURCES IN SAUDI ARABIA A GRAPHICAL AND CARTOGRAPHICAL PRESENTATION

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ABSTRACT

Aim : Graphing and mapping of some of the healthcare facilities in Saudi Arabia are the prime aims of this paper. Displaying the progress of growth of these resources is important in visualizing how these resources progressed over a period of more than twenty years. One of the two previous published papers by the authors of this paper accomplished the task of discussing determinants of healthcare expenditures in the kingdom (El-Farouk, A. E., et. al., *EJPMR, 2016)*. The second paper studied and discussed the equality of the distribution of these facilities and resources using Lorenz curve and Gini Coefficient (El-Farouk, A. E., et. al. *EJEC, 2016*) Therefore, this paper is trying to portray in a visualized manner how these facilities are distributed over the plain of the thirteen administrative areas of the Kingdom and nationwide. **Material and Methods:** Many people consider visualization as one of the best ways to get your message across and to quickly draw attention to the key messages. By presenting data visually it's also possible to uncover surprising patterns and observations that wouldn't be seen from looking at numbers alone. Today, there's plenty of free graphic design software to help us do just that; either graphically or cartographically. Such software includes google developers, visualize, Easel.ly, infogr.am, and the most famous ArcGIS. By visualizing information, we turn it into a landscape that you can explore with your eyes, a sort of information map. And when you're lost in information, an information map is kind of useful. There are various types of statistical maps used by geographers and other scholars. These include choropleth (color shaded) maps, proportional symbol maps, and dots maps. The first type is suitable for showing standardized data such as rates, densities or percentages. A different color is used for each of a number of bands, allowing users to identify which areas have high, low or middling values. The second type, dot maps, suits where individual events or groups of events are marked with a dot, allowing users to geographic patterns such as clusters. The third type, which is used in this paper, is the proportional symbol map that uses symbols that are proportional in size to the values they represent, such that the biggest symbol will fall in the area with the highest value. Symbols can include **histograms**, circles, bars, or objects indicating what is being measured. **Sources of Variable Data under the Study:** A data matrix of the thirteen administrative areas by the four health resources mentioned below was constructed based on the available government data of the Central Department of Statistics and Information (CDSI). The type of health resources under the study (health center, hospital, hospital beds, and physicians). This data matrix is for 22 years starting from 1992 to 2013 for the health resources (Statistical Year Books) with the exception of the data for physicians. It's available for up to 2007, after which it has been produced at the level of the Kingdom. In order to obtain the relative share of an area of each health resource, the total number of, for example, health centers, is divided by the corresponding total population of the area and multiplied by k, which equals 100,000 (for health centers and hospitals), 1000 (for hospital beds) and 10,000 (for physicians). Looking at the absolute numbers, alone, of each area variable regardless of its corresponding population will lead to a faulty conclusion. Total populations, of administrative areas, were projected using the declared growth rates (by the CDSI) between censuses. Human population calculator was used to running the projection at this website (http://www.metamorphosisalpha.com/ias/population.php). Thus, relative shares are used instead of numbers because they provide a more realistic picture.

The presentation (of graphs and maps alike) is in two formats, the first of which is "comparison" of data by area for the starting and ending years. The second is a trend presentation for each variable of each administrative area for the whole period. Relatively few paragraphs of text have been used to explain some tables, and discussing the descriptive statistics of each variable; namely minimum, maximum, range, mean, standard deviation and coefficient of variation. The reader is left to browse the graphs and the proportional symbol maps to judge the facts. Numbered graphs and maps are all set beneath the research few text pages. Excel and ArcGIS are the main sources of tools that brought these figures to existence.

Results : In absolute numbers, the presented graphs and maps reveal that some areas stand head and shoulders on the lead, regarding variables of population, health centers, hospitals, and physicians. These top of the list administrative areas include Al-Riyadh, Makkah Al-Mukarramah, and the Eastern Region. On the other hand, the Northern Borders, Al-Jouf, Najran, and Al-Baha rest at the bottom of the list. This picture is depicted throughout the study period.

1. On the contrary, when it comes to ratios of health facilities mentioned in the study, the bottom listed areas enjoy much higher ratios than those on the top of the population list. This indicates that population growth rates are speedier in the populated areas than that rate prevailing in the least populous areas.
2. Comparisons made for the two start and end years of the study period showed an overall improvement of the study variables at both national and area levels (number and ratio wise). This reveals and testifies for the massive efforts exerted by the government to provide health services for its people, whoever they are and wherever they are in the Kingdom.

KEYWORDS: Ratios, Health centers, Hospitals, Hospital-beds, Physicians, Visual maps.

1. Differentials of Health Facilities

Graphical presentation – Aggregates of the Kingdom

Figure (1) below reveals the aggregate over time trend of health centers per 100000, hospitals per 100000, hospital beds per 10000 and physicians per 10000 populations for a period of 34 consecutive years (1979 – 2012). It depicts the overall trend of each variable aggregate of the whole Kingdom. The total number of each variable has been divided by the total corresponding number of the population projected for each single year.

In 1979, health center ratio was (9.032), reached its maximum of (10.463) in 1988, then started to decline until it reached its lowest by the year 2012 with a ratio of (7.836). As for hospital ratio, the trend was less variant than that of health centers. It started lower at a ratio of less than one (0.671) in 1979. It proceeded almost steadily up till it reached its top (1.013) in 1985, after which it went almost up flat and ended in 2012 with a ratio of (1.243).

Bed ratios' trend started with a figure of (1.216) in 1979, reached its maximum value of (1.783) in 1986 and ended low at (0.898) in 2012. This lowest end does reveal the fact that the overall population growth rate was higher than the beds' growth rate. In absolute terms, the number of beds has been steadily increasing but at a slower rate compared with population growth rate.

Physician density or ratio is another story. It showed a steadily increasing trend when it started with a ratio of (9.032) in 1979 and ended with a high ratio of (12.432) in 2012. This is a clear evidence that the pace of growth of physician was always greater than that of the population (see Figure (1)).

Graphical presentation – Administrative Areas

A. Population

Health centers are supposed to provide preventive and primary health care services in premises owned by a local authority (public). They provide health care for the local community and usually housing a group of practitioners, nursing staff, a child health clinic, X-ray facilities, etc. Thus, they resemble the base and foundation of the larger health care system of an area.

Because of the nature of the data matrix period prepared for administrative areas (22 years), and the number of areas included in the matrix (13 areas), the discussion will be confined to the two ends of the period; namely 1992 and 2012. First, we have to reveal the population total by area for each of the two years.

Comparing the two selected years in Figure 2, it is clear that the ranking of administrative areas in terms of total population is almost the same in 1992 and in 2012. In the 1st, 2nd, and 3rd places come Al-Riyadh, Makkah and the Eastern areas respectively, while in the 11th, 12th, and 13th places come Najran, Al-Jouf, and the Northern Borders respectively. This difference in population size has had its impact on the ratios values of all variables, including health centers, hospitals, hospital beds, and physicians.

B. Health centers

In other words, the largest population size areas have the lowest ratios of health centers, while the smallest ones enjoy the highest ratios in both of the years mentioned (see Figure 3 and Figure 4). This implies that growth of health facilities in the least populated areas is speedier, in relative terms than the case in the higher populated areas. A negative correlation between population size and health center ratios is obvious. A t-test of paired samples reveals a negative t value of (-15.17133), that is significant at all levels with ($p = 0.000$); i.e. the larger the population of the area, the lower is the number of health center's ratio (see Table 1 below). The rapidly growing population areas grow at rates usually speedier

than that of the health centers. The economic wellbeing and the wider opportunities of employment in the areas of larger populations attract more people from abroad and from areas with less economic and social endowment. But it could be argued that the most populated areas and cities enjoy much more health care services provided by the private sector. This may come to be true but the evidence of which is beyond the scope of this study.

C. Hospitals

According to the Wikipedia definition, a hospital is a health care institution providing patient treatment by specialized staff and equipment. The best-known type of hospital is the general hospital, which has an emergency department. A district hospital typically is the major health care facility in its region, with large numbers of beds for intensive care and long-term care. Specialized hospitals include trauma centers, hospitals, children's, seniors' (elderly) hospitals, and hospitals for dealing with specific medical needs such as psychiatric problems and certain disease categories. Specialized hospitals can help reduce health care costs compared to general hospitals. A teaching hospital combines assistance to people with teaching to medical students and nurses. The medical facility smaller than a hospital is generally called a clinic. Hospitals are usually funded by the public sector, by health organizations (for profit or nonprofit), by health insurance companies, or by charities.

It is clear that this ratio is also heterogeneous among the areas like its predecessor. The overall average of the Kingdom for this ratio was approximately 1.5 hospitals for every 100000 populations for the whole period. The disparity between areas is wide and can be checked from Figures (5 and 6). The maximum ratio registered was 5.09 (Jazan in 2001), while the lowest ration registered was 0.495 in Makkah in 2011. One can argue that these ratios are low because of the fact that greater population areas incorporate larger proportions of migrants than smaller ones. Most of those migrants resort to private health service providers, meaning that the real pressure on the public hospitals and health centers is far less than it appears here. Authenticated statistics regarding the total number of migrants enjoying the public health services is not within the reach of this research team. If reached, this could help the team to precisely measure the real pressure exerted on public health services provided in each area.

For the last year (2012) in the data matrix, Makkah, improving a little bit, reserved its bottom position as the last area in the ranking, with a hospital ratio of (0.5072), while Al-Baha enjoyed the first rank with a ratio of (2.4405), replacing Jazan. This implies an overall progress in the ratio through time, and that Al-Baha area has gained and enjoyed a more progressive trend in health service provision than other areas. A negative correlation between this variable (HOSP_PER_100000) and population, unsurprisingly, is typical in direction and values of the t-test between (HC_PER_100000) of health centers and population (see Table 1 below).

D. Hospital beds

The term "hospital beds" is set to mean all hospital beds which are regularly maintained and staffed and immediately available for the care of admitted patients. According to the Organization for Economic Co-operation and Development (OECD), beds in all hospitals, including general hospitals, mental health and substance abuse hospitals, and other specialty hospitals, occupied and unoccupied. The term excludes surgical tables, recovery trolleys, emergency stretchers, and beds for same-day care, Cots for healthy infants, beds in wards which were closed for any reason, provisional and temporary beds and beds in nursing and residential care facilities (OECD Health Data 2007: Statistics and Indicators for 30 Countries, OECD, Paris, 2007, Data sources, definitions and methods).

The data collected for this study show that the overall average of the bed's ratio for the Kingdom in 2012 was 1.9 beds per 1000 population. Commenting on this ratio of the Kingdom, the Vice-Minister of Health, Planning and Development, Dr. Muhammad Khushaim, expressed his dissatisfaction with this low ratio; "this ratio is low and all the sectors of the Ministry are working hard to correct and promote the figure" said the Vice-Minister (Alammary, A (January, 26, 2014). The highest ratio of beds in 2012 was (2.9) which was enjoyed by Northern Borders area, while the least ratio was (1.04) registered in Makkah area, preceded by Al-Riyadh area (1.06). The remaining areas' bed-ratios are shown in Figure (7). For the year 2012, the 13 administrative area ratios are grouped into three categories: The highest category comprises those areas with a ratio equal to or greater than the mean ratio plus one standard deviation (mean ratio + SD). The lowest category includes areas with ratios less than or equal to (mean – SD). The category in the middle contains areas with bed ratios between the highest and lowest groups. As is clear from Figure (8), the highest group grips the Northern Borders, Al-Baha and Al-Jouf. On the extreme bottom of the group appears Makkah and Al-Riyadh. The middle group, from lowest to highest, embraces the remaining seven administrative areas of Al-Qaseem, Najran, Hail, Aseer, Al-Madinah Al-Monawarah (observe the ratios).

E. Physicians

A physician, also known as a medical practitioner, medical doctor or simply doctor is a professional who practices medicine, which is concerned with promoting, maintaining, or restoring health through the study, diagnosis, and treatment of disease, injury, and other physical and mental impairments, https://en.wikipedia.org/ According to the WHO, available statistics shows that over 44% of its Member States report to have less than 1 physician per 1000 population, that is less than 10 physicians per 10,000 populations.

For the whole of Saudi Arabia, the historical trend of this variable shows that it fluctuates between 0.68 physicians per 1000 population in 2000, to the level of 0.94 in 2008. In between, the ratio was 0.63, 1.37 and 1.62 in the respective years of 2001, 2004, and 2007, https://wwwknoema.com. This fluctuation is indicative of the pace of immigration into KSA by citizens of foreign countries which leads to inflation of the denominator of the variable. For the purpose of elaboration, data collected for this paper uses physician ratio as per 10,000 population.

Dataset obtained for this variable by administrative area was available only for up to 1428. Since then the density of physician is calculated as aggregate for the whole of the Kingdom. Distribution of physicians across administrative areas, as revealed in Figures (9 and 10) below, provides a varying picture in the two comparison years of (1992 and 2007). In the year 1992h, Al-Qaseem, Al-Baha, Najran and Al-Jouf occupied the first top four ranks in terms of physician density. All of them enjoyed shares above 12 physicians per 10000 populations; exactly 15.62, 14.81, 14.32 and 12.75. From bottom rank and upwards, the lowest shares were for areas of Al-Riyadh (6.76), Eastern Region (7.13), Tabuk (7.28) and Makkah Al-Mukarramah (8.06). The range was 8.86.

In 1428, all of the thirteen areas enjoyed a much higher range of shares than that in 1992. The highest share was enjoyed by Al-Jouf (18.14), while the lowest by Al-Riyadh (7.93). The overall range was (10.21), indicating a wider dispersion, check Figure (10).

2. Trend of Healthcare Facilities over time by Area

- **Cartographical presentation**

In this study, we highlight the contribution of geographic information system (GIS) in the spatial distribution of infrastructures and services in the field of public health. This involves setting up a spatial and temporal database allowing the spatial management of services to facilitate decision-making in health planning.

The GIS software we used is ArcGIS 10. ArcGIS Desktop includes a suite of integrated applications: ArcMap, ArcCatalog, and ArcToolbox. ArcGIS is a complete system that allows everyone to use and apply geographic information. The way most people use geographic information is done through the power of maps. Using these three applications, you can perform all GIS tasks from the simplest to the most advanced, including mapping, data management, and analysis. In addition, thematic maps, synthesis products, and information layers have been created to help potential users of this geographic database to make the best use of available information. ArcGIS lets us stack different types of data to help readers of this article see relationships, patterns, and trends of our study variables. Maps are the most frequently used tools to visualize and understand spatial information. ArcMap allows us to work with all our geographic data in maps, regardless of the format or location of the underlying data.

The data collected in the form of excel tables have been reconfigured to be connected with the shapefiles of the KSA administrative. We were thus able to represent in a comparative way the temporal and spatial evolution of the health resources for all the regions over time. Two types of data were used: spatial and attribute data. Primary data are those collected from the General Authority for Statistics in the Kingdom. They are made up of spatial, statistical and attributive data on population and health resources.

Statistical treatments have been applied to the primary data obtained to extract other results such as ratios and percentages of health resources to facilitate comparison between administrative areas.

In the following pages, healthcare facilities, namely health centers, hospitals, hospital beds, and physicians, will be presented using maps to compare their absolute numbers and ratios by administrative area and to visualize their corresponding trends over time.

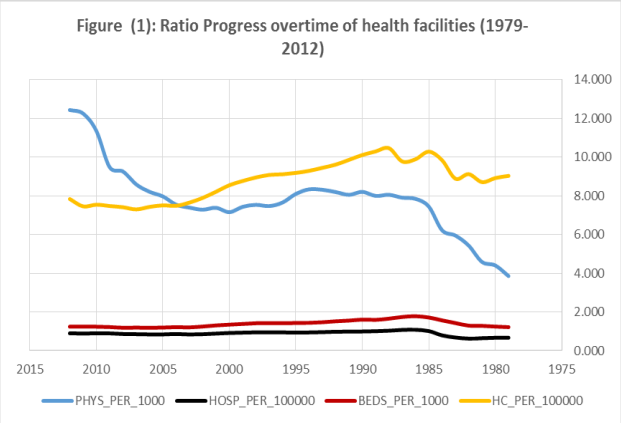
There are various types of statistical maps used by geographers and other scholars. These include choropleth (color shaded) maps, proportional symbol maps, and dots maps. The first type is suitable for showing standardized data such as rates, densities or percentages. A different color is used for each of a number of bands, allowing users to identify which areas have high, low or middling values. The second type, proportional symbol maps, uses symbols that are proportional in size to the values they represent, such that the biggest symbol will fall in the area with the highest value. Symbols can include circles, bars, or objects indicating what is being measured. The third type, dot maps, suits where individual events or groups of events are marked with a dot, allowing users to geographic patterns such as clusters, (Department for Communities and Local Government (2017).

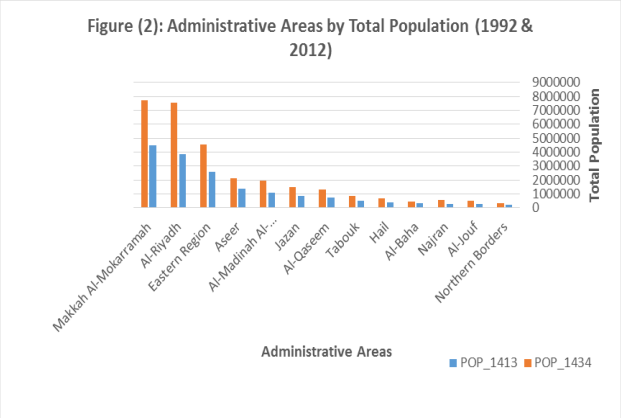
3. Table

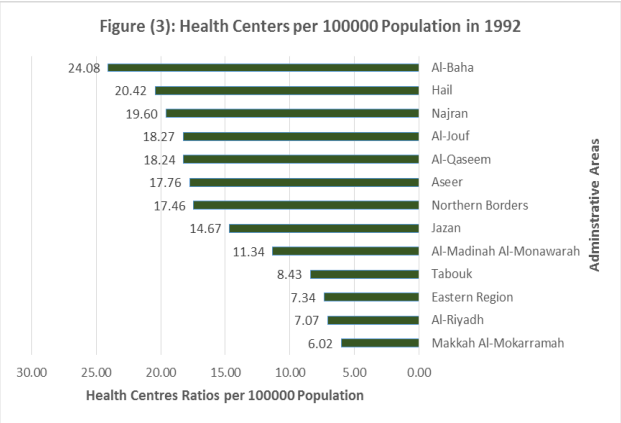
Table 1: Values of a Paired Sample t-test (HC_PER_100000 and Population) And (HOSP_PER_100000 and Population).

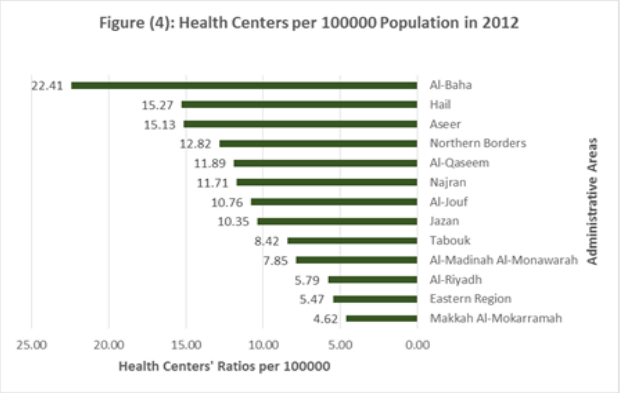
Variables	t	df	Sig. (2-tailed)
HC_PER_100000 - Population	-15.171-	285	.000
HOSP_PPER_100000 Population	-15.171-	285	.000

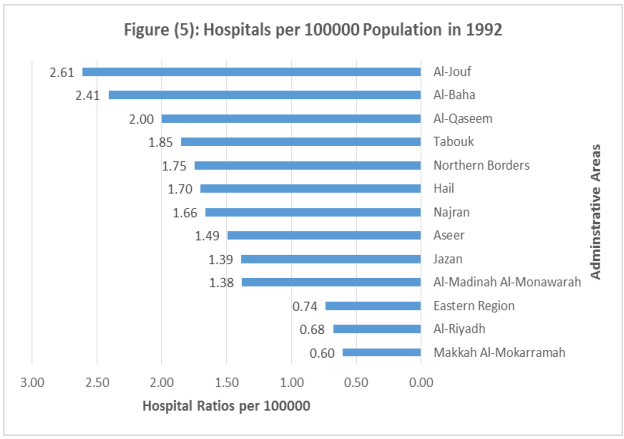
4. Graphs and Maps

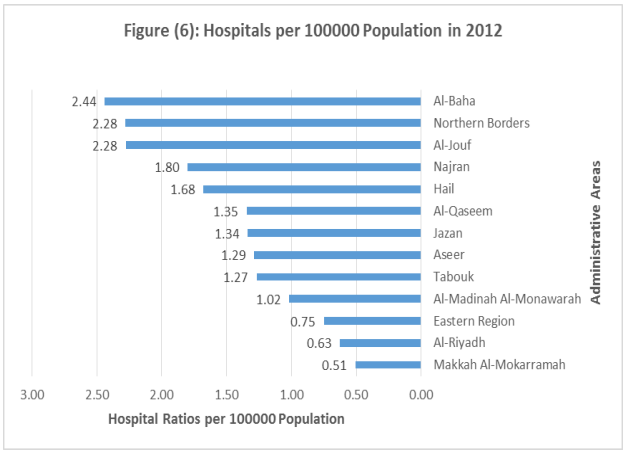


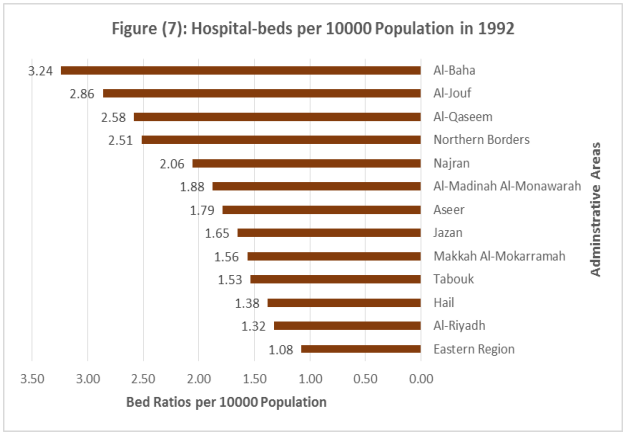


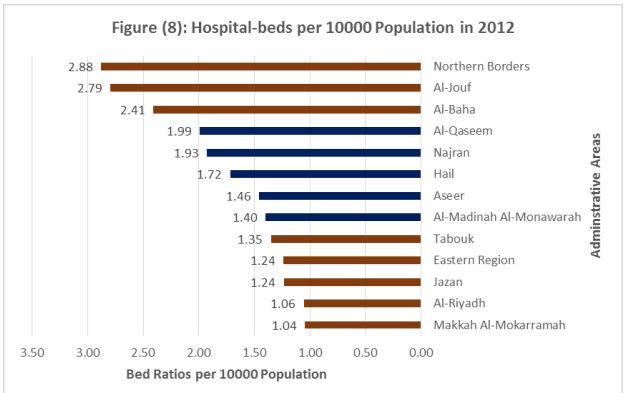


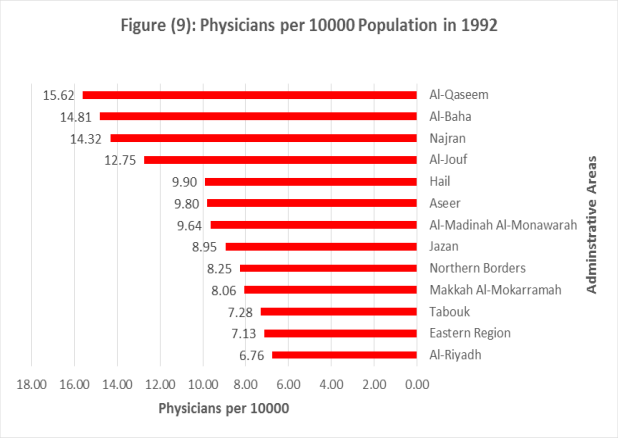


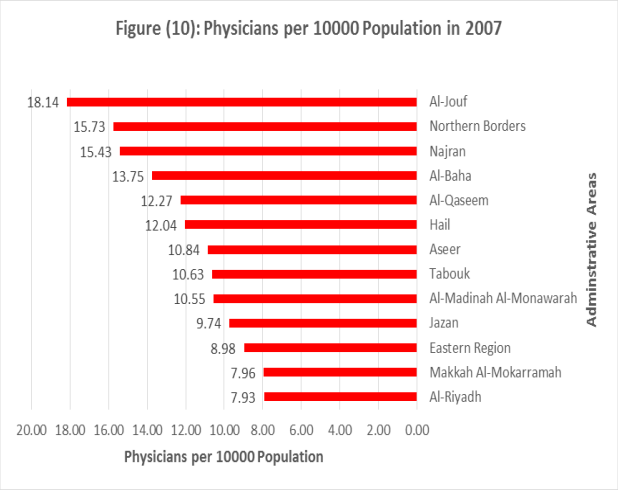












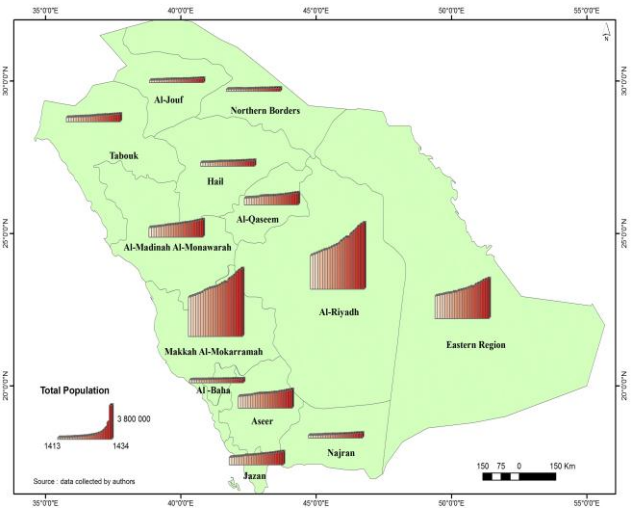


Figure 11: Total Population by administrative area (1992-2012).

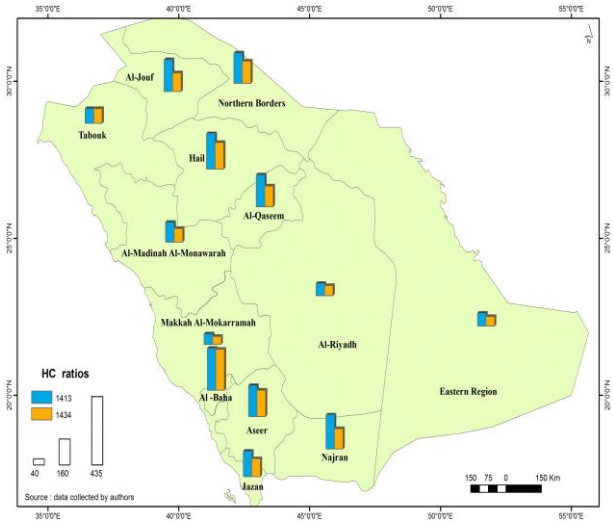


Figure 12: Health Center's ratios by administrative area in 1992 and 2012.

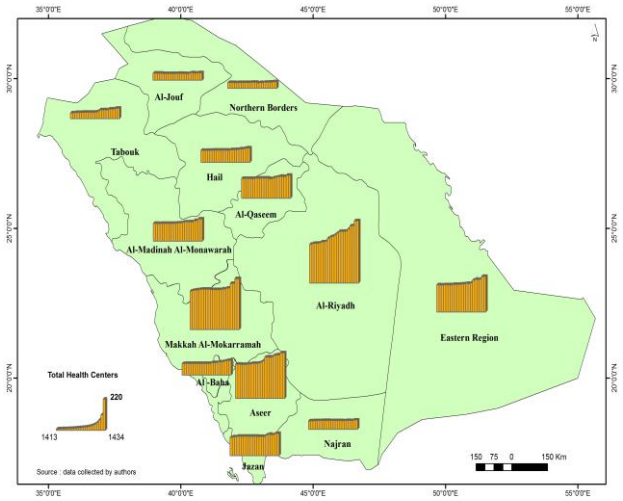


Figure 13: Health Centers by administrative area 1992 -2012.

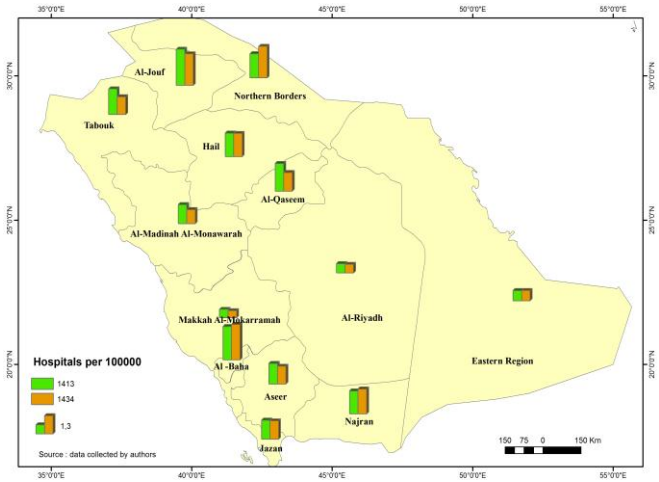


Figure 14: Hospitals ratios by administrative area in 1992 and 2012.

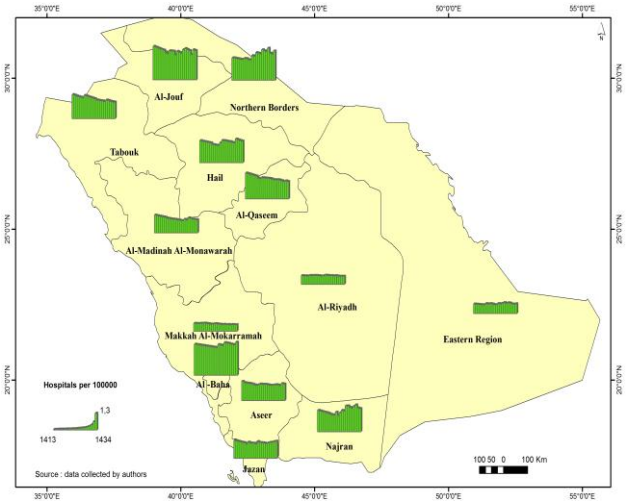


Figure 15: Hospital's ratios by administrative area 1992- 2012.

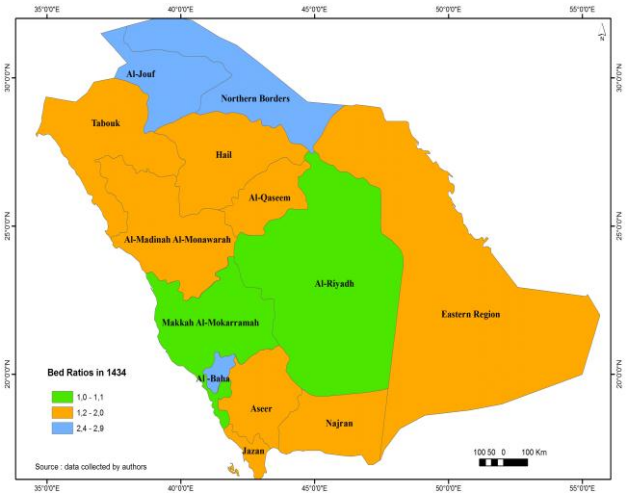


Figure 16: Bed ratios in 2012 by administrative area.

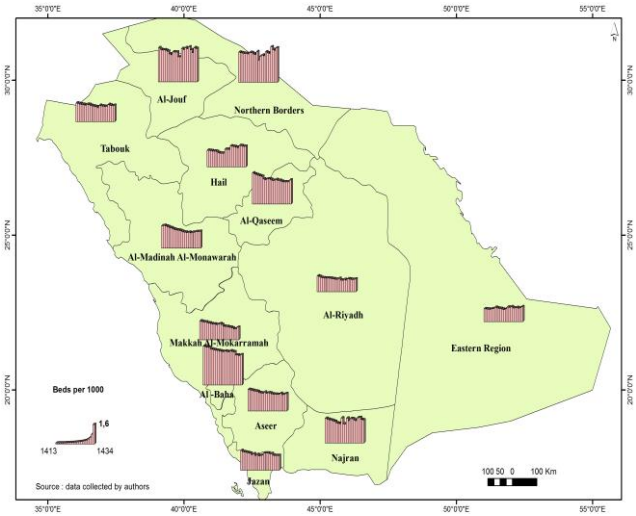


Figure 17: Bed's ratios by administrative area 1992 - 2012.

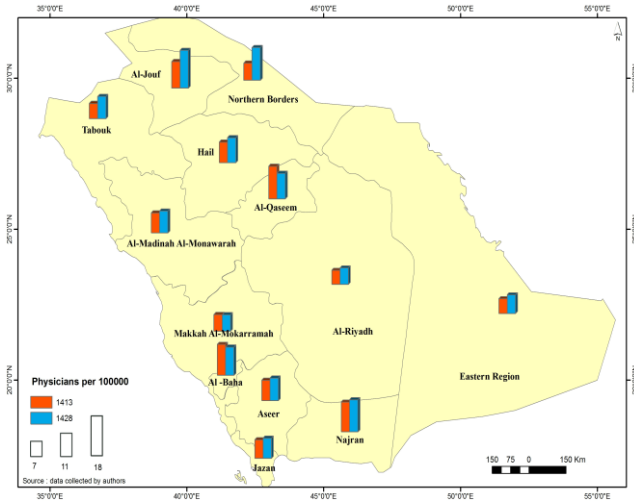


Figure 18: Physician's ratios by administrative area in 1992 and 2007.

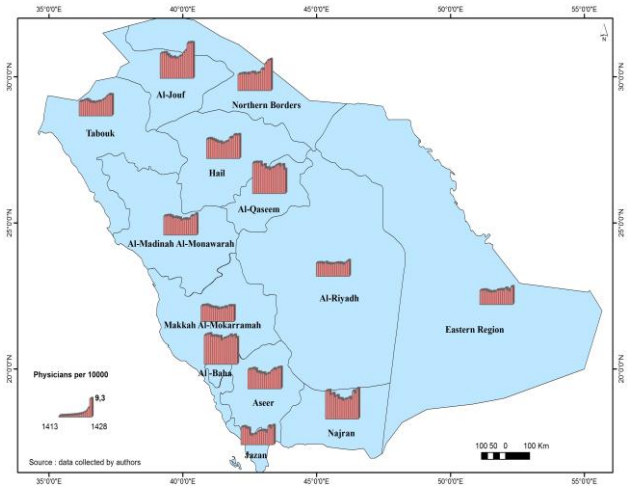


Figure (19): Physician's ratios by administrative area 1992 – 2007.

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