Change monitoring and assessment of health capacity of Iraq due to COVID-19 by application of GIS techniques

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Abstract. Infectious disease distribution is fundamentally a spatial process; thus, geospatial data, technology and analysis methods play an essential role in analysing and controlling the 2019 Coronavirus Disease (COVID-19) pandemic. As a result of this virus, there is a rapid increase in the number of infected and deaths distributed in different regions of Iraq. Social functioning, human health, life, human production, and also international relations are extremely threatened by COVID-19. To fight this virus, Geographic Information Systems (GIS) can play an important role in many aspects such as preventing the spread and the evaluating the required measures. GIS is an advanced technique which has a complete method for database, form construction, model construction, and map production geographical health gaps and social weaknesses review, and communicating illness state or return-to-normal operations in hospitals. The use of the GIS has the ability to improve the location and usability of personal security installations, ventilators, hospital beds and other objects. However, strengthen production of GIS to boost our ability to respond rapidly in the face of pandemics that are on the verge of spreading. This study summarizes the main uses of GIS technologies in the global health care sector, highlighting applications related to the modelling and analysis of parasitic diseases. It also allows investigators to connect health public and climate data so that relations of health-related variables and environmental risk factors at various geographical quantities can be analysed.

Keywords: GIS, Coronavirus in Iraq, COVID-19, Spatial analysis, Health capacity.

1. Introduction

On December 12, in Wuhan City, Hubei Province, China, there were cases of unexplained viral pneumonia, which had contributed to a rise in mortality rates. The remainder of Hubei Province and other parts of China subsequently became plagued by the COVID-19 epidemic. In the month of January from January 10 to January 24, 2020, the number of newly confirmed cases gradually rose, and the reported cases peaked and then leveled off during the first week of February. On February 12, the number of reported cases increased because a new system of recognizing and documenting cases in Hubei Province was introduced on the same day. There are 80,735 confirmed cases as of March 8, 2015. (PRC National Health Commission, 2020) [1]. In addition to the commercial and open-source GIS kits, which provide useful program solutions to discover and classify the emergence of a disease and report cases, several governmental agencies use open-source GIS software and public data sources to perform various tasks, particularly data collection (Lansley et al., 2019) [2]. Creating spatiotemporal algorithms helps to predict the outbreak of infectious
diseases. This visualizes the estimation of the effects of algorithmic improvement over time. [3]. As an approach, the evaluation tests the algorithmic time pattern and precision of reported outbreaks of disease, which then enables the choice of a suitable algorithm for the specific background of the observatory[4]. Additionally, the assessment approach also enables the algorithm parameters to be finely tuned to meet the diverse requirements of the applications listed [5].

This paper originated as a collaboration of ideas on the possible use of GIS for handling infectious disease and pandemics [6]. Following some thoughts on the sanitary and epidemiological aspects and effects of COVID-19, the current study provides data and analyses related to how GIS has been implemented in different stages of emergencies and ways that data can be incorporated and shared through dashboards that are constantly updated to be a reliable guide[7]. in particular, the need to develop robust GIS pandemic response systems is underscored, as several suggestions are given based on spatial and temporal diffusion in a GIS environment and on data monitoring[8] [9]. To this end, some thoughts on the importance of solving multiple problems are shared.

2. Case Study

The total area of Iraq is approximately 438320 km². Three provinces (Arbil, Dahuk, and Al-Sulaymaniyyah) are found in the north, while the remaining fifteen provinces are situated in central and southern Iraq, [10]. Iraq’s climate is continental, semi-arid subtropical in nature, with a Mediterranean climate present in the north and north-eastern mountains. Winters are cold and frosty, with an average daily temperature of around 16°C decreasing to 2°C at night and the risk of freezing. Summer months from July to August are dry and mild, with a temperature from 43°C to 46°C during the day and 26°C at night. Approximately 28.8 million people live in the total population, with 33% of them living in rural areas. At the present rate of population growth, the total population density is expected to be 66 people per square kilometer[12][13].

3. Methodology

The disease has high infectivity, lengthy incubation period, and is subject to regular re-emergence due to its highly transmissible characteristics. We additionally need scientific and technical assistance to keep track on the spread of the disease due to the fact that the disease has high infectivity, long incubation period, and exhibits highly transmissible characteristics. To that end, there is an urgent need for medical science and assistance to control and counteract the further spread of the disease because of its highly transmissible characteristics, its long incubation period, and the history of population movement. GIS and spatial big data technologies play an important role in the battle against the epidemic in the identification of the spatial propagation of the epidemic, the spatial avoidance and monitoring of the epidemic, the spatial distribution of resources, and, among other things, the spatial detection of social opinion[11].

GIS is useful for imaging the progress of disease progression, alterations in concentrations, or the expansion of threats over time (Tosepu et al., 2020). In addition to various mapmaking methods, including static map sequences, simulations, and related dynamic micromaps, there are numerous techniques that are utilized in this evaluation and visualization of imagery. To see much more precisely the cases of infection, a highly sophisticated technique uses geographic analysis and maps to create an animated and visualized epidemiology curve for the entire study field. In the maps used to visualize the phase, magnitude, and geographical spread of the outbreak, you can see both the magnitude and the direction of the curve.

The first step in this study is to collect data on all incidents, active cases, recoveries, and deaths from Coronavirus for all governorates of Iraq. This involves collecting data on new reported cases of COVID-19 in Iraq (as depicted in Figure 1) regular changes in these cases in Iraq from 24/02/2020 to 01/11/2020, along with data on each governorate and the number of hospitals within each governorate. This data is
then checked using satellite imagery and the ArcGIS program (version 10.9) in order to conduct modeling and data analysis.[10].

![Comparison between elements population of governorate with case, active case dead and recovers.](image)

**Figure 1.** Comparison between elements population of governorate with case, active case dead and recovers.

The second step is to conduct statistical analysis and spatial distribution to indicate the ratio of each of the cases, recovering and dead from the Coronavirus to the total number to clarify each case in each governorate in the form of geographical maps.

The third step is to calculate the health capacity for each governorate as follows:

Health capacity = (number of hospitals *100000) / population

The index of government hospital is calculated per 100,000 population in Iraqi standards.

4. Results and discussion

Some effective strategies for disseminating information include creating visualizations that help to visualize geographic data for regions, such as infrastructural, climatic, natural, and prevalence effects, as well as bring in detailed spatial information. The most effective and quickest way to disseminate current situational information is by creating visualizations that visualize geographic data like this. The graph in Figure 2 depicts data on cases, recoveries, and deaths caused by Coronavirus for all governorates of Iraq, along with the regular variations in newly reported cases of COVID-19 during the time period between February 24th, 2020, and November 1st, 2020.

These findings will support the field team to look at whether additional empirical analysis and a variety of advanced and existing geographical statistics are needed and to apply those methods to analyze spatial associations over time and in the event of suspected hazards.
Figure 2. Daily Changes in new active cases of COVID-19 in Iraq between 24/02/2020 to 01/11/2020. (Data source: World Health and Ministry of Health Iraq MOH. Daily briefing on novel coronavirus cases in Iraq

The results of the ratio of the actual active cases to the population revealed that the capital, Baghdad, reported it higher than Babil, Qadisiyah, Dhi Qar, Maysan, Wasit, Anbar, Diyala, Salah al-Din and Tamim, and it is considered a reasonable and acceptable percentage as it is the capital of Iraq. As for Karbala and Najaf, the rate of active cases was acceptable as the rest of the governorates, despite its religious and tourist characteristics.

In Sulaymaniyyah, Dohuk and Erbil governorates, the rates were high and clear, indicating a clear risk of active cases to the population of each governorate as shown in Figure 3.
The percentage of recovery active cases to the population is shown in Figure 4. The map showed that the highest percentage was in Wasit, then Dhi Qar, followed by other governorates, according to Mampin in Harita. Also, the largest percentage was observed in Dohuk.

Figure 3. Normalization between active case to population

Figure 4. Normalization between recovers to active case
As can be seen in Figure 5, the highest percentage of death to the population was observed in Sulaymaniyah governorate, followed by Karbala governorate, while the lowest percentage of death was observed in Anbar governorate in comparison with the rest of the governorates.

Figure 5. Normalization between dead to active case

Figure 6 shows the spatial and numerical distribution of hospitals in the Iraqi governorates, and the number of people according to the Central Bureau of Statistics, the government hospitals index is calculated for each (100) thousand people of the population according to the previously mentioned equation in Section 3, where the decrease in health capacity for some governorates and the increase in health capacity for others.
Figure 6. Distribution of hospitals for each governorate

Figure 7. Health capacity for each governorate
5. Conclusion
The goal of this research is to introduce a technology that allows for simulating disease outbreaks, which can produce realistic case distributions which can be conveniently extended to different locations and represent varying underlying population distributions. Using a technique that promotes comparisons of early detection algorithms, this analysis locates significant regions on a map to find anomalies. To make the program even better, it is intended to make changes so that more detailed disease distribution forms can be investigated, and combined case recognition and disease prevention mechanisms can be introduced. In addition to the fact that the used technique has some limitations, the application of the GIS environment provides significant benefits, which include access to a wide variety of spatial functions, and it is especially beneficial for accelerated growth and prototyping. This is an efficient technique for treating patients in a timely manner, but is better used when looking for new patients. As well as it is important in taking pre-emptive steps to avoid spreading of COVID-19 in a specific region.

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