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National Health-GIS Portal-
A conceptual framework for effective epidemic management and control in India

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Abstract
This short note proposes a national Geographic Information System (GIS) - based health infrastructure to deal with epidemics and pandemics. Currently, there is no pan-India health infrastructure available that can compile, update, and report the spread of epidemic diseases. It not only curtails the opportunity of finding the real-time data on the spatial distribution of a disease but prevents one to inquire into the causes of the disease through epidemiological analysis. The proposed infrastructure in this study is a pan-India one and can broadly be divided into two parts, hotspot mapping and accessibility to services. In the first part, hospitals are proposed to act as nodes of data collection, sending data to a national GIS portal. This portal shall have the capabilities of plotting the data using map rendering services such as Google and Bing Maps. This way, hotspots can be visualized in no time, benefitting the government and common citizenry alike. The second part deals with the accessibility of citizenry to a wide range of services, i.e., healthcare services, grocery outlets, emergency services, baby food, and many other essential services of the day to day life. In order to implement this, we propose that the government need to enforce a mandatory submission of locational coordinates of all Goods and Services Tax (GST) enrolled service providers. Once the coordinates are submitted, the government can effectively control the opening and closing of services and inform the citizenry at the same time. The proposed infrastructure is going to help deal with the extraordinary situations during epidemic and pandemics similar to what the world is currently facing in the form of Corona Virus Disease 2019 (COVID-19). Furthermore, the infrastructure can be scaled up or down as per the spread of a disease. The health-GIS platform proposed in this concept paper, shall help India in controlling and managing the epidemic more efficiently.

Keywords: GIS; health Infrastructure; National Portal; COVID-19; Hot-Spot mapping; Accessibility to services
**Background**

The use of mapping in studying public health was initiated by the efforts of Dr. John Snow in 1854, where he ended a Cholera epidemic by plotting the death rates on a cadastral map in a part of London city (Anamzui-Yam 2012). He is considered as the father of epidemiology, although the modern methods of studying public health had dramatically evolved since then, especially with the use of statistics and later with spatial sciences such as Geographic Information System (GIS) (Rushton 2003).

Use of GIS in public health concerns two significant areas, e.g., disease pattern studies and health care provider studies. Disease patterns studies include two kinds of approaches, i.e., point pattern analysis (Diggle 2003; Waller and Gotway 2004) and lattice-based analysis (Waller and Gotway 2004) on the other hand health care providers mainly includes evaluation of accessibility. Access, itself, generally described as the ability of people to use health services when and where they are needed (Aday and Andersen, 1974; McLafferty, 2003; Ranga and Panda, 2014). In India, the health infrastructure is divided into sub-centers, primary health centers (PHCs), and community health centers (CHCs) (Chokshi et al. 2016).

Today, the whole world is going through an unprecedented situation whereby a microscopic virus has taken a toll on human lives, which is so vast that the modern world has rarely seen it before (Merrin 2020). It all began when a pneumonia of unknown cause detected in Wuhan, China, was first reported to the World Health Organisation (WHO) country office in China on 31 Dec. ’19 (Phan 2020). The real fangs of the disease started appearing when it spread outside China. Consequently, the WHO declared the disease as a public health emergency of international concern on 30 Jan. ’20. The Corona Virus Disease (COVID-19) kept on increasing; this led the WHO to characterize the COVID-19 as Pandemic, i.e., a worldwide outbreak of a disease, on 11 March’20 (Zhang et al. 2020).

Till now, there is no medication or vaccine for COVID-19 disease (Casadevall and Pirofski 2020). Worldwide trials are underway for inventing a cure for it, but till now, as such, there is no full-fledged medication available (Zhang and Zhong 2020). COVID-19 has crossed all bounds of human existence. Beyond borders, cultures, and societies, currently, no one is safe from the contagion of this disease (Wang 2020). Though from observations, it has been found that specific age-groups and people that already have certain pulmonary and cardiovascular issues are particularly more vulnerable to the lethality of this virus (Santesmasses et al. 2020). Even the environmental factors such as temperature are not showing any significant role in restricting the spread of this virus in India (Meraj et al. 2020).

Worldwide, people dying from this disease as of 24 June 2020 are 480210, and confirmed positive cases have reached to 9,376,431. India, notably, witnessed as of this date, 14,490 deaths due to this virus, and the number of positive cases ascended to 456,926 (Worldometer 2020).

World health organization (WHO), since the onset of this pandemic, has issued advisories for restricting the spread of this disease through social distancing, isolation, and quarantining of the affected persons (Zhang et al. 2020). Almost all the countries followed this mechanism, and it yielded positive results (Lauer et al. 2020; Lee et al. 2020). Wuhan city of China from where the virus started spreading first was locked down entirely for almost 80 days. Due to the positive results from China, many European countries followed a similar mechanism and witnessed a considerable decline in the new COVID-19 cases (Fanelli and Piazza 2020).
India started lockdown strategy way too early than its other Southeast Asian neighbors such as Bangladesh, Pakistan, and Nepal. Initially, the lockdown strategy worked fine; however, due to some variety of region-specific factors such as labor migrations, poverty, and economic slowdown, relaxation in the lockdown strategy was administered by the governments. Although some workers had suggested flexible lockdown strategies (Kanga et al. 2020), but due to labor migrations, state governments and the central government were forced to provide relaxations. Due to these reasons, in India, even after 80 days of lockdown, seemingly, there is no stopping of coronavirus cases and the deaths taking place due to it (Ray and Subramanian 2020).

It has hence, necessitated at the country level to formulate confident policy frameworks that are beyond stringent lockdowns (Alfano and Ercolano 2020). In a country like India, lockdown strategy cannot work for long, and the government has to devise specific measures so that the pandemic such as COVID-19 is managed more effectively, and the public at large is provided a means of respite from being severely affected by this disease both healthwise and economically (Ray and Roy 2020). In this context, we in this paper have put forth a policy framework suggestion to the Government of India to establish a National GIS-based health framework to map pandemics such as COVID-19 as a long term strategy to deal with any future epidemics in India. We have discussed how this can be implemented as well as the advantages of the commissioning of this strategy.

**Health-GIS portal**

*The concept – Accurate geocoding of the affected persons*

The key to active management of an epidemic is the precise locational data of the patients that we propose to involve in this framework. Our conceptual framework revolves around the hospitals that shall act as the central nodes in the Health-GIS portal. When an epidemic such as COVID-19, SARS, MERS, and Ebola takes place, hospitals are the centers where patients first approach. We propose that the hospital staff, in addition to asking for the essential patient details, also ask essential address information such as prominent landmarks of the patients so that such address details could be converted into locational coordinate information, a process known as geocoding, when uploading such data in the Health-GIS portal.

*Mechanism of implementation.*

In India, there is already a mechanism in place where the patient information is incorporated into a national health portal. If such information is supplemented with the location data, we shall be able to transform our already existing health portal into a GIS-based epidemic mapping portal. One of the first-hand benefits of using location data is the spatial understanding of the pandemic. By plotting the location data on any map rendering services, such as Google and Bing Maps, epidemiologists and statisticians can rapidly analyze the data to find out where the epidemic started and where is the possibility for its spread (fig. 1).

The integrated hands-on geospatial modeling tools in the portal shall further help the disease analysts to intervene in the policy decisions of the government at the times of an epidemic effectively. It can be achieved by incorporating GIS information layers that are critical in determining the contagion of the epidemic into the GIS portal. Such layers include population density, total population, poverty index, urban, rural, and water bodies.
The primary task of this framework is the establishment of the national health-GIS portal, encompassing all hospitals in the country and can be effectively achieved by passing a law by the parliament or issuing an ordinance by the President of India.

**Advantages of Health GIS portal**

**Mapping of pandemic hotspots**

Once the health GIS portal is established, the direct benefits shall be in two main ways. First is the hotspot identification in no time, and second is the spatial data dissemination to various institutes that monitor and frame policies for epidemic control in India. In the case of pandemics such as the current COVID-19, mapping hotspots in no time shall serve immediate intervention in stopping the contagion of this disease (Van Bavel et al. 2020).

**Essential Service Control**

Accessibility to a service is the reach-ability to a service. If services are within reach, accessibility is termed to be useful (Doetsch et al. 2017). In cases of pandemics (COVID-19), timely and efficient accessibility to not only hospitals but also to all other goods such as grocery, milk, vegetable, and pharmacies and services such as banking, education, insurance, transportation, and medical treatment within and outside hotspots is essential (Smith et al. 2020).

In order to control these services during the pandemic, we propose that all GST (Goods and Services Tax) enrolled service providers to register their location coordinates to the government. It shall be another GIS information layer within the health GIS portal. The government, in turn, shall use these locations to control their services in extraordinary circumstances. For example, which grocery shop or pharmacy to be opened in which hours can easily be regulated through the health GIS portal (fig. 2).

Further, with the help of a mobile app, all such locations can be shared with the public at large. In this way, opening and closing can be controlled through government, and the public will be informed in one go (using the app). This shall save time and energy of the public and
bringing transparency in the management of the pandemic. Additionally, the data and information will empower the government to have more control over the resources of the nation and will be better prepared to tackle the epidemic or pandemic situations.

**Fig. 2** A graphical representation of how the service providers can be geo-located and put in an App.

Hence after the establishment of the health GIS portal, wherever the infection happens, it will be marked quickly over the map. Moreover, GIS will help in buffering the extent of the spread, e.g., an infected person can go to 300-500 meter and can spread infection, but if the area is designated as a hotspot with different zones for limiting the activities in the area, the pandemic can be effectively managed (Kanga et al. 2020). Additionally, which service providers are nearest or safest can be judged, and the same information can be communicated to the public. This strategy can help designate different areas into red, orange, and green zones based on the evidence-based spatial modeling approaches (Kanga et al. 2020).

**Discussion and conclusions**

Geographic information system (GIS) has since long helped the epidemiologists working in the field of spatial epidemiology to understand flow patterns during the spread of an epidemic such as SARS and COVID-19 (Kraemer et al. 2020). The role of GIS is not limited to epidemiology alone, rather foundational fields of medicine such as oncology and environmental epidemiology have used it for understanding the disparities and several other factors that form the basis for the widespread occurrence of diseases (Calvert et al. 2010; Walker 2016).

The spread of epidemics like COVID-19 can be modeled for its contagion in GIS using techniques such as proximity analysis, spatial aggregation, interpolation, and regression (Auchincloss et al. 2012; Leslie 2020). During the current pandemic of COVID-19, once the health GIS is setup, authorities can identify the pandemic clusters, i.e., the spatial distributions of COVID-19 cases to evaluate its incidence and prevalence in areas that are not infected yet with this disease. Based on the scale of infection and other environmental factors (global, local, and focal), GIS can further use different clustering techniques to perform the analysis (Unwin 1996; Clennon et al. 2004; Yeshiwondim et al. 2009).

In recent years the surveillance and intervention monitoring mechanisms of the health sector in all the developing and developed countries are being executed using GIS technology (Boulos et al. 2004; Eisen et al. 2011). World bank has particularly invested heavily in various under-developed countries of Africa to restrict the spread of epidemic diseases such as...
trypanosomiasis, malaria, and onchocerciasis. Disease mapping is an efficient tool to optimize the efforts of governments for containing the spread of an epidemic since it helps in the identification of disease distribution irrespective of the local boundaries and helps in the observation of the control measures employed (Carroll et al. 2014; Caprarelli and Fletcher 2014; Alimi et al. 2015).

One of the crucial strategies in controlling the current epidemic in India and elsewhere in the world is restricting the number of new infections of COVID-19. Though lockdowns have substantially stopped its spread, but its efficiency has not been outstanding in a densely populated country like India, Bangladesh, and Pakistan (Dhama et al. 2020; Tröster, 2020). We have observed that the R0 (R-Naught) has shown peak and dips throughout the lockdown period in India. In order to reduce the R0, GIS can help in advocating scientific means to restrict the flow of the super spreaders from the hotspots of disease (Kanga et al. 2020).

Health GIS portal, once successfully implemented in India, shall serve as a link between medical science and the geographical factors associated with the disease outbreak (Curtis et al. 2000; Asheim and Gertler 2005; Arcury et al. 2005). India being geographically diverse, health-related issues, when mapped using GIS, shall help in tracing the susceptible populations, outcomes of health interventions, and evaluation of the risk factors associated with any current and future epidemic using GIS-based spatial modeling approaches and the relationships between them (Sadler et al. 2001; Chacko 2004). Already organizations such as National Remote Sensing Centre (NRSC) through the Bhuvan portal have all the environmental information mapped for pan India, and once such a system is integrated with the Health GIS, a new realm of progression in the Indian healthcare system will commence. Additionally, it has even been made mandatory by the United Nations through the SDG-3 to set up the specialized health care system for promoting the health and well-being of the people. India being at the forefront of development, has introduced several initiatives in the health sector to promote reduced inequalities and better healthcare for one and all (WHO 2015; Campbell 2017; Hall et al. 2018). The health GIS concept for epidemic control shall supplement India’s efforts in this direction.

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