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Review Article

GIS in Health: A Sustenance Less Explored

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ABSTRACT:

GIS in Health informatics was conceived long back but from the conception stage, it has taken baby steps to move forward to infancy stage in developing countries as the data is still manually integrated. The medical or health geographical information has become extremely useful in understanding the bigger picture of public health. The whole scenario of past, present and future can be understood and analysed with the help of GIS. Aims & Objective: This review examines how geographic methods have been evolved and used over the time to address public health issues, what is its current status and what path forward has been projected among the SEAR countries. Material & Methods: Peer-reviewed literature published between January 2010 and January 2021; on prominent research platforms were explored to develop a synthesis of literature available on the internet regarding how the SEAR countries have been incorporating the significant discoveries in GIS in their health system and how is it beneficial for development in health sector. Discussion: The mapping technology and computer aided database management serves as the source of multipurpose information on patterns, associations, correlations etc. The visual representation of data makes GIS the most accountable tool for provision of undeniable health facilities which can save time and money. The SEAR countries have shown variable use of data base in GIS for their health statistics. Conclusion: Although GIS in developing countries is at a stage of infancy at large, but in countries like Sri Lanka and Nepal, the health services and system have been making progressive changes with additional remote sensing tools- taken a fast pace at data management.

Introduction:

Health-related information in health planning and programs increasingly require elaborate and accurate analysis; most of these are linked in some way to geography and are emerging more important over the time for health. The healthcare professionals and concerned people need to create systems that empower them to usefully utilize this and other different types of countless information about population that is available on health issues and program management. Despite such a technology was originated way back, by John Snow, one of the founding fathers of modern epidemiology, during a major cholera epidemic in 1854 in London on collected and mapped data on the locations. His detailed analysis was laborious and slow, but ultimately informative that led to the identification of the epidemic's source-a contaminated public water source.

GIS, a phenomenal informative science is systematically designed to work with data referenced by geographical coordinates for identification, collection, storage, management and visual interpretation of data according to location. This technology is classified into three major parts namely, geographic information system (GIS), global positioning system (GPS), and remote sensing. The momentous potential of GIS and other geospatial technologies in benefiting the health care industry is just now beginning to be identified. [1] John Snow's study on cholera outbreak is a classic example which showed the importance of mapping as the cause of outbreak that came to be known after the epidemiological maps were created. While the sophisticated technology that we have now was not used in those times, but today computer software, hardware and satellite imagery have changed the whole scenario of understanding of disease outbreak and its spatial and temporal trends. [2] New diseases, outbreaks, endemics and even pandemics (e.g. current COVID-19 scenario) are common to spread globally every year or every alternative year which enhances the value of GIS in delivery of care under dire and uncalled for circumstances, which is only possible if efficient information is available in less time.

Although Health technology is a vastly growing and complex sector of economies around the world, India, because of its diverse culture and practices, faces many complex challenges in providing the best health care for its people and at the lowest possible cost. GIS in such scenarios helps in conceptualizing the frame which increases the ability to monitor these diseases and identify their causes. Additionally, health organizations imperatively analyses and display multifaceted geo-location data through the use of GIS tools. [3] Presentation of data on maps is relatively quicker and can provide more insight than a table of the same data which enables the system to make assessments of trends quickly. Providing competency in

provision of minimum health services is a particular challenge in developing countries where there is mismatch of existing health resources and infrastructure. They majorly help in connecting to the problems of access to health services which is a primary area of concern when it comes to utilisation of health services. [4]

Factors that Make GIS a Boon:

It's a known fact that health mapping is one of the most striking features of GIS and is an invaluable gem created to enhance the human power and reach where manual approach fails and technology takes over. It identifies and maps vulnerable populations, health outcomes, risk factors and the associating factors among them. Identifying prevalence of disease in specific areas, their pattern, crisis caused by disease, vulnerable population, factors responsible for diseases, incidence of each disease, identify health care centres, determine morbidity and mortality rates, source of disease, disease zonation mapping like quantities, densities, profiling, disease surveillance, distribution and spread of disease across geographic regions, target and plan the remedial measures, optimize planning of intervention and monitor their effectiveness. Public Health GIS is a link between biomedical and social sciences. It has now become the hub of usage of a wide variety of health science applications. Epidemiologists use GIS to proximally assess the aggregates, clusters, spatial smoothing and interpolation. [3, 5, 6,7]

Beyond this, the system has numerous capabilities that makes it one of most valuable and versatile tools in the recent times such as; layering the map with information, such as level of pollution, literacy levels, reduce health hazards during and after epidemic episodes, integration of GIS and GPS enhancing the quality of spatial and non-spatial data, Spot mapping with regard to endemicity, epidemicity and pandemicity of diseases, Geotagging, preparedness, risk reduction, prevention and control, and timely economical support, Infectious disease surveillance for instance COVID-19 pandemic, tracing potential confounding or modifying factors between location, environment and diseases, Health research, [8,9,5,10] defining the density of population, boundaries, healthcare provision location and road network transport for accessing the health facilities, [11] databases, management information systems (MIS), information transfer and online connectivity.[12]

The inter-pooling of health planning & policy making with GIS are the major advances that would make the spatial data available, [13] advanced navigation system can help in forecasting of infectious and non-infectious diseases thereby opening up the scope of telemedicine.[14]

Materials & Methods:

The current review focused on assessment of how public health has been approached from a geographic perspective. Peer-reviewed literature published between January 2010 and January 2020 available on prominent research platforms was comprehensively perused and deliberated on. The idea was to develop a synthesis of available literature on the internet regarding how the SEAR countries have been incorporating the significant discoveries in GIS in their health system and how is it beneficial for development in health sector. Which countries are moving at a faster pace in terms of technology driven health information and utility of the available information, and what subsequent improvement in the health status of the countries will occur in future? Learning about the progress with obstacles in the use of geographical approaches may help improve public health conditions in India.

From our initial search, 118 titles on geographic informatics that were found out on basis of many terms - SEAR, India, application of Geographic Information System, health technology, spatial epidemiology, health mapping, community health and public health, were reviewed. Of those, we eliminated 91 papers after their review of the content and its association with our theme of interest. The papers that were eliminated lacked availability of the adequate information, focus on health perspectives, the determinants of the study and the geographic techniques to merge and manoeuvre with the health field. The 27 remaining articles were subjected to a full text review. While this was not a big number but for clarity of objective only relevant and precise information was concentrated upon.

Discussion:

The implementation of geospatial technologies and methods for improving health has become widespread in many nations, but India's adoption of these approaches has been fairly slow. Through the evaluation of pertinent scientific research, it was evident that current geospatial approaches to health research in India are fairly descriptive in nature but the use of more complex models and statistics is increasing. There has been increasing adoption in diverse health related domains in national settings in this context with the goal of improved response to public health problems. This reveals that complexities in understanding public health issues require interdisciplinary and coordinated efforts and the spatial perspective can be of particular importance because the spatial patterns of distribution of diseases, both infectious and non-infectious, help us understand the dynamics of the diseases. About 17.7% of the world's population resides in India, and public health challenges are commensurate with its size. India is among one of the world's largest burden of non-communicable diseases with high potential for emerging infectious diseases and continues to face significant problem in disease indicators. Chronic conditions such as cancer and diabetes that increasingly affect people are closely related to environmental conditions and spatial parameters. As for the current scenario, COVID-19 poses a serious threat and puts the countries in a fix on the solution to deal with pandemics. In the past, descriptive geographical epidemiology of diseases was restricted to describing their state-wise or regional prevalence, and detailed integrative

analysis of epidemiological data at a local level was rarely carried out. Historically, these types of observations were satisfying achievements of medical geography and field epidemiology, but with the increased availability of spatial data and technologies advanced target intervention is possible. [15]

Various studies carried out in the past reflect the status of efficient use of GIS and how it has changed the picture over time in context of Public Health.

A study carried out in Indonesia reveals free and simple GIS health applications, without reliance on access to the internet, were deemed appropriate for low resource settings such as rural eastern Indonesia. District and clinic health staff demonstrated ready uptake of health GIS and instigated and implemented a range of new health mapping applications, independent of external expertise. Maps were also being used by district health departments. It provided information on the surveys of the trainees indicated that, before the training, half the trainees had no prior GIS experience. Some trainees had received training in GIS using more complex software but had not used this complex software in their work because they encountered problems and were not given follow up support. It also reveals 2010 figures for internet users as a percent of population; 11% for Africa and 12.3% for Indonesia, compared to 58% and 77% for Europe and North America respectively. However new opportunities for the more widespread use of GIS in low resource settings are emerging out of recent developments in GIS software and associated hardware. It addressed issues related to the prohibitive expense and complexity in GIS by exploring the possibilities presented by free or open source GIS software not reliant on internet access, decreasing hardware co-stand the increasing availability of spatial data and spatial data collection tools (e.g. GPS enabled mobile phones and laptops).[4]

A project concerning risk evaluations and health planning against influenza in Taiwan demonstrated the value of GIS in public health planning and potential disease prevention. Data were then used to simulate a pandemic flu outbreak and to determine which areas within the county required additional facilities. [3]

A study carried out in Bangladesh reveals that Ministry of Health and Family Welfare (MOHFW) recently began using spatial tools in health policy decision-making demographic and health surveys. Furthermore, countries like Kenya, Ghana, Rwanda and Malaysia have applied this technology to data-driven health decision-making. Canada have used it to monitor the spread of West Nile virus. Kenya used health facility mapping for planning, and Indonesia used it for regular monitoring of its heath programmes. Additionally, Bangladesh addresses the challenges of access to healthcare. The findings from this study informed a national tactical plan for GIS use in health analysis, including national guidelines for standard acquiring, processing, inter-operability, and quality control of GIS data.[16]

Further, a study done in Nepal describes about the implementation of GIS as one of the monitoring, decision making, and documentation tool. With a limited resource in terms of manpower cost and other resources, it is still managed by providing training to various partner organisation providing help and support in technical part. With the GPS coupled with GIS various analysis of health service adequacy and accessibility mapping were performed. Linking the tabular database with spatial data and classifying according to needs has attracted the health professionals and has successfully conveyed information through such visual means. Various organisations in Nepal have already been applying GIS in various fields but only few in health sectors. Health GIS over the years have successfully developed various spatial data like districts/VDC/municipalities etc. It is to be noted that efforts were taken by the Nepal government to train staff in both theoretical as well as practical knowledge for using ArcView GIS software. [7]

The Maldivian government published a paper that presented the approaches used to overcome the many hurdles that were forced to develop the strategic framework and implementation plan. While the many challenges of designing an enterprise GIS to meet the real needs of small islands nations have been reviewed in previous papers, this project faced additional issues. To the challenges of dealing with national as well as local issues and operating with limited budgets, the situation in the Maldives was further complicated by general lack of expertise in GIS, limited education in field, virtually no system capability in the field and a user community that generally lacked practical expertise. Also, island nations and states face different needs and issues from the larger countries, issues of climate change and rising sea levels, monitoring, policying and managing extensive ocean resources is a huge responsibility. It should come to no surprise that the only GIS routinely used by the Maldivian Govt is being used in the coast guard. [17]

A study was carried out in Srilanka presents that the chronologic and geographic shifts in notifiable disease patterns can be identified through the application of modern Geographic Information Systems. It examined the data for notifiable diseases for the 7 reported years (from 2005-2011) to identify geographic trends in disease outbreaks and to document any indicators that may assist in predicting future outbreaks. The notification system in Sri Lanka is well established with 20 notifiable diseases with periodic updates. However, it is predominantly paper-based and often requires 15-30 days for data communication and the central Epidemiology unit to process it. A real time bio-surveillance pilot project has been introduced in this regard. The mapping of incidence from month to month clearly highlights the opportunity to get early warning of outbreaks and the ability to target preventive amelioration to hot-spots. The application of GIS technology to the near real-time national reporting of data provides an opportunity for the health system of Sri Lanka to be prepared for outbreaks. The key is the application of technology to display the data in a form that immediately highlights the areas of growing risk. [18] Furthermore, Sri Lanka boasts of a well-developed public health infrastructure as a developing country with some kind of public health care facility available within a 5 km radius. Public health care services in Sri Lanka are provided “free-of-charge” at the point of delivery. The spatial approach provides a useful decision- support tool in health informatics with a substantial potential to harness in planning public

health care services not only in Sri Lanka but in other developing countries as well. Moreover, formulating web-based, open source- health care facility locations with exact street addresses is imperative to many developing countries such as Sri Lanka where such information systems are underdeveloped. Spatial approach provides an innovative decision- support tool in health informatics with a substantial potential to harness in planning, monitoring and evaluation of public health care services. [19]

Additionally, study done in Bhutan demonstrated that spatial accessibility indices can be used for identifying medically under-served and over-served regions, for measuring the equality of distribution of health resources across the regions and for studying spatial and temporal changes in the distribution of the health resources in the country. The spatial accessibility results of Bhutan for 2013 show that there is a huge disparity in the distribution of the health resources. The Bhutanese health system does not have a systematic approach to conducting spatial planning for distribution of health resources in the country, which has possibly affected the decision-making process, as evidenced from this study where there are huge disparities in the equity of spatial access to primary health care services in the country. The proposed spatial accessibility measurement system can be used to develop a spatial decision support system to facilitate evidence-based spatial planning for equitable distribution of health resources across the country Data collection using this was simple but limited to those with reasonable IT literacy. [20] The study done in Myanmar depicts that the spatial analysis functions of ArcGIS Desktop have been used to conduct a rapid impact assessment of the disasters therefore illustrate how emergency management can be supported. It reveals that the use of geospatial data and technologies but also demonstrated the benefits gained through geo-enabling. [21] Another study done in Korea reveals a new method named, Seoul Enhanced 2-Step Floating Catchment Area (SE2SFCA), which is customized for the city of Seoul, where population density is higher and the average distance between healthcare-service locations tends to be shorter than the typical North American or European cities. The proposed method of SE2SFCA is found to be realistic and effective in determining the weak accessibility regions. It resolves the over-estimation issues of the past, arising from the assignment of high healthcare accessibility for the regions with large hospitals and high density of population and hospitals. [22] Studies indicated that an unfair health system, an uneven distribution of human resources within the health care system, inappropriate health policies. Determining the areas that need health care services can help health care authorities provide adequate facilities to improve patients' health. [23]

A study done in Chennai revealed that satellite data has the unique capability to detect the changes in land use quickly and accurately. From the analysis it has been found that the satellite data is very useful and effective for getting the results of temporal changes. This will help in maintaining the ecological balance and improving microenvironment of the region. [24]

A study done in Pondicherry revealed that satellite data has the unique capability and humongous competency to detect the changes in land-use quickly and accurately. From the analysis it was found that the satellite data is very useful and effective for getting the results of temporal changes, haphazard growth of plantation and settlements to understand the extent to which a disaster if happens can harm up to what extent. [25] Another study done in Pondicherry, 2014 deals with the issues of integrating qualitative and quantitative methods of analysis. The study concludes that the application of remote sensing and GIS to public health epidemiology and essentially prioritising public health for mapping the geographical aspects of the prevalence of disease. The integrated hybrid remote sensing and GIS techniques must be used to map the potential areas vulnerable to risk of disease transmission and could provide the possible information on reliable estimates. [26] Universal coverage of health is an important concern for developing countries and access to healthcare is a significant factor that contributes to a healthy population. In response to this, the WHO integrates the methods and models to encompass several layers for measuring accessibility to health care which is integrated in GIS. The results of these methods are used for cost effectiveness analysis and population coverage estimates as well as for resourceful planning and monitoring within countries. [27]

Conclusion:

GIS as a technology makes multiple data handling less cumbersome, prominent and provide highest degree of accurate information at a less time. Largely, in SEAR nations, health GIS remains unknown or ignored or underutilized in health systems even after almost two decades after it was first realised as one of the major advances having immense potential benefits and as the source which has the sole purpose of digitalisation of data records right from collection to compilation and analysis. While it is a known fact that GIS has a full-fledged working module in other sectors like geography, disaster management and environmental science but not in health sector. There are many implementation difficulties, national security concerns, lack of trained manpower, access to geographical, expensive software, etc.

Further, GIS in public health with lack of published data on explicit use of GIS indicates its scarce use. In countries like Sri Lanka and Nepal, the health services and system have been making progressive changes with additional remote sensing tools, taking a fast pace at data management. Others are lacking behind- they need to take away lesson and incorporate changes in their health system to merge GIS to significantly improve upon health system and public health.

Recommendation:

Some SEAR countries have taken a fast pace at data management, but others need to take away lesson and incorporate changes in their health system to merge GIS to improve upon Public Health.

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