GIS for public health: A study of Andhra Pradesh

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Abstract. Geographic information systems and remote sensing have capabilities that are ideally suited for use in infectious disease surveillance and control, particularly for the many vector-borne neglected diseases that are often found in poor populations in remote rural areas. They are also highly relevant to meet the demands of outbreak investigation and response, where prompt location of cases, rapid communication of information, and quick mapping of the epidemic’s dynamics are vital. The situation has changed dramatically over the past few years. GIS helps in determining geographic distribution of diseases, analysing spatial and temporal trends, Mapping populations at risk, Stratifying risk factors, Assessing resource allocation, Planning and targeting interventions, Monitoring diseases and interventions over time. There are vast disparities in people’s health even among the different districts across the state of Andhra Pradesh largely attributed to the resource allocation by the state government. Despite having centers of excellence in healthcare delivery, these facilities are limited and are inadequate in meeting the current healthcare demands. The main objectives are to study the prevalent diseases in Andhra Pradesh, to study the infrastructural facilities available in A.P. The methodology includes the Spatial Database, which will be mostly in the form of digitized format. The Non-Spatial Database includes both secondary data as well as the primary data.

1. Introduction
Geoinformatics technology can aid in epidemiological investigation and outbreak response thereby reducing the health hazards in the communities before, during and after epidemic episodes. GIS enhances the quality of spatial and non spatial data for analysis and decision making by providing, integrated approach to disease control and surveillance at local, regional and national levels. Effective response requires considerable commitment to preparedness, risk reduction, prevention and control, and timely economical support. Advance planning in terms of health education, warning and evacuation, emergency health care provision and infrastructure protection can be effectively prepared and implemented and GIS can be a key tool in this regard. Health care is a large, 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. Currently the use of health informatics is in its infancy and...
the data is manual and nonintegrated. Geographic information systems has the capabilities that are ideally suited for use in infectious disease surveillance and control, particularly for the many vector-borne neglected diseases that are often found in poor populations in remote rural areas.[1-3] They are also highly relevant to meet the demands of outbreak investigation and response, where prompt location of cases, rapid communication of information, and quick mapping of the epidemic’s dynamics are vital. The situation has changed dramatically over the past few years. GIS helps in determining geographic distribution of diseases, analyzing spatial and temporal trends, Mapping populations at risk, Stratifying risk factors, Assessing resource allocation, Planning and targeting interventions, Monitoring diseases and interventions over time. The analysis functions use the spatial and non-spatial attributes in the database to answer questions about the real world. e.g., composite map could be created from exposure information, combined with the knowledge of health/ disease status (e.g. water borne diseases) by house location or water sources could be included in the study to investigate relation between polluted water and disease risk. Data on potential confounding or modifying factors (e.g. age, gender, sex, income, settlement type) could also be incorporated into data analyses. Health professionals have used maps when analyzing associations between location, environment and diseases.GIS in public health is used for basic mapping and involves spatial analysis of disease occurrences and contributing environmental factors.GIS helps us in visual analysis and exploratory analysis along with estimation of relationship between measures of disease incidence [5]. Health research using GIS includes demographic, political, environmental, ecological, topographical, hydrological, and climactic, land use, public infrastructure, transportation, health infrastructure and epidemiological data[6-7]. A GIS is an information system designed to work with data referenced by spatial / geographical coordinates [4].

There are vast disparities in people’s health even among the different districts across the state of Andhra Pradesh largely attributed to the resource allocation by the state government. Despite having centers of excellence in healthcare delivery, these facilities are limited and are inadequate in meeting the current healthcare demands. Most public health facilities lack efficiency, are understaffed and have poorly maintained or outdated medical equipment. Andhra Pradesh faces a huge need gap in terms of availability of number of hospital beds per 1000 population. Moreover, Andhra Pradesh faces a shortage of doctors, nurses and paramedics that are needed to propel the growing healthcare industry.

1.1 Objectives
The objective of the paper is to carryout a health mapping of Andhra Pradesh through GIS that would bring in an interactive spatial analysis tool enabling the concerned departments to perform re-districting, re-locating health jurisdictions for effective utilization of health infrastructure. Such an automated facility to generate proposals at the district level and review at the State level were lacking as a system. In a state-wide implementation of Health Information System, sharing health related information with other districts is one of the primary goals, so that consistent and current data is available with the districts. The main objectives are to study the prevalent diseases in Andhra Pradesh, to study the infrastructural facilities available in A.P.

1.2 Methodology
The methodology includes the Spatial Database, which will be mostly in the form of digitized format. The non-spatial Database includes secondary data from various govt. sources.

2. Uses of GIS in Public Health Studies
This includes: 1. Identifying areas where a particular disease is prevalent; 2. Identifying vulnerable population; 3. Identify factors responsible for diseases; 4. Incidences of each disease; 5. Identify health care centres; 6. To determine morbidity and mortality rates; 7. Water polluting sources; 8. Diseases zonation mapping; 9. Target and plan the remedial measures.
Representation of disease incidences data can be displayed as dot maps to show health event, choropleth maps to display death and illness rates in geographical area, and diagram maps to present quantitative data within map.

2.1 Study Area
Andhra Pradesh is the fifth largest State with an area of 2,76,754 km², accounting for 8.4% of India’s territory. The State has the longest coastline (972 km) among all the States in India. Andhra Pradesh is endowed with a variety of physiographic features ranging from high hills, undulating plains to a coastal deltaic environment. As per the graph, it shows the health indicators for the state of Andhra Pradesh since 1961. The total population of the state is 8,46,65,533 with 50.2% of male population and 49.8% of female population, with a density of 308 persons/sq.km, The sex ratio for 2011 was 992 which is higher compared to the last census.

Figure 1. Health indicators of Andhra Pradesh.
Source: AP Statistical Data

The Crude Birth Rate per 1,000 Population is 18.4% for the year 2011 in the State. The Crude Death Rate per 1,000 Population is 7.5 for the year 2011. The Infant Mortality Rate is 43 for the year 2011 per 1,000 live births.

Figure 2. Key indicators of health, marriage and fertility indicators.
Source: AP Statistical Data
The graph above shows the key indicators of Andhra Pradesh under marriage and fertility variables. 54.7% of women get married by the age of 18 years and 34.8% of men get married by the age of 21 years. The total fertility rate of women has come to 1.79% in 2006 from 2.25% in the year 1999.

3. State of Health

Diseases caused by poor water supply and sanitation are the source of most of the illnesses attributed to poor environment. According to a study by the World Bank (2001), environmental factors account for about 20% of all the diseases in Andhra Pradesh. More than 90% of this is associated with traditional environmental problems such as lack of access to protected water supply and sanitation, and indoor air pollution resulting from the use of biomass fuels. Environmental factors account for 22-23% of diseases in rural areas, and for 18-19% of diseases in urban areas (World Bank, 2011). Children are most vulnerable to illnesses due to poor household environment and deaths of children under five accounts for nearly two-thirds of such cases. The next vulnerable group is rural women who are particularly affected by exposure to smoke from dirty cooking fuels, in addition to the impact of unsafe water and poor sanitation. Bacterial contamination presents the highest and most immediate health risk affecting 65% of those depending on dangerously contaminated water. It accounts for 11.3% of the total diseases in the state. Within the state, there are wide variations in access to tap water across districts. In a few districts like Hyderabad, West Godavari, Chittoor, Anantapur and Ranga Reddy more than 60% of the total households have access to tap water. Overall, access to tap water is poorer in the districts of Coastal Andhra region than in districts in both Telangana and Rayalaseema.

In Srikakulam and Vizianagaram only 10 and 18% of the total households respectively have access to tap water. Hand pump is the second most important source of drinking water in almost all districts in Andhra Pradesh. There is a rural-urban gap in the coverage of households with access to tap water and the coverage in rural areas is much lower than the urban levels. While nearly 70% of urban households (3.0 m households) have access to tap water, only 40% in rural (5.1 m households) areas are covered. Only in West Godavari and Chittoor districts do more than 60 per cent of the rural households have access to tap water followed by Nizamabad, Ranga Reddy, Medak, Nalgonda and Anantapur with more than 50% of the total households. The National Habitation Survey of drinking water status in rural habitations reports that only 43% of the habitations are fully provided with drinking water. Except Chittoor, in almost all other districts the majority of habitations are only partially covered. In Vishakhapatnam, a considerable number of habitations do not have proper supply of drinking water. The National Habitation Survey 2003 also points out that the water quality in over 70% of the total habitations in Nalgonda is affected by fluoride. The percentage of fluoride-affected habitations is also very high in Anantapur (23%), Karimnagar (20%), Prakasam (17%) and Guntur (14%) districts.

The below table shows the health infrastructure facilities in Andhra Pradesh. In Andhra Pradesh, the availability of Primary Health Centres (PHC) Sub – Centres (SC) and Child Healthcare Centres (CHC) is relatively better than the all-India average and many states in India, except the south Indian states of Kerala and Tamilnadu.

There are 1,709, 12,476 and 292 PHC, SC and CHCs respectively serving around 60 million rural population in Andhra Pradesh. Since the inception of mandals, a sub-administrative division in the district, the State had made it mandatory that there should be one PHC in each mandal. The number of PHCs is more than the number of mandals (i.e.1,126). This seems to be inadequate in terms of population norm14 (1 PHC per 30,000 persons) according to which 60 million rural population should be served by 2,000 PHCs, which means that 291 more PHCs are required. Similarly, an additional 172 CHCs are required. But in terms of sub-centres (existing 12,476), AP seems to have 524 more SCs than the norm (12,000). However, people located in rural areas continue to be the most disadvantaged in terms of access to health care facilities. There are a number of villages.
where there may not be any basic medical facility available. Even where facilities are available, their functioning’s dismal in rural areas. Many villages do not have any qualified medical practitioners.

Figure 3. Map showing sex ratio and gastroenteritis.

Source: A.P Health department.

Table 1. Health infrastructure facilities.

Source: AP Statistical Data.

| S N | District      | No. of Sub-centres | No. of PHCs | No. of CHCs | No. of Area Hosp. | No. of Dist. Hosp. | No. of 24x7 PHCs | No. of Ambulances | No. of MHUs |
|-----|---------------|-------------------|-------------|-------------|-------------------|-------------------|------------------|-----------------|-------------|
| 1   | Srikakulam    | 478               | 76          | 14          | 2                 | 1                 | 36               | 26              | 20          |
| 2   | Vizianagaram  | 442               | 66          | 10          | 2                 | 1                 | 33               | 26              | 17          |
| 3   | Visakhapatnam | 584               | 85          | 13          | 7                 | 1                 | 35               | 40              | 20          |
| 4   | East Godavari | 809               | 103         | 20          | 7                 | 1                 | 33               | 36              | 24          |
| 5   | West Godavari | 627               | 73          | 16          | 7                 | 1                 | 31               | 34              | 21          |
| 6   | Krishna       | 620               | 78          | 9           | 5                 | 1                 | 28               | 35              | 20          |
| 7   | Guntur        | 696               | 77          | 16          | 3                 | 1                 | 32               | 37              | 24          |
| 8   | Prakasam      | 559               | 85          | 14          | 3                 | 1                 | 37               | 32              | 20          |
| 9   | Nellore       | 483               | 74          | 15          | 2                 | 1                 | 28               | 26              | 20          |
| 10  | Chittoor      | 651               | 92          | 9           | 1                 | 1                 | 37               | 40              | 24          |
| 11  | Kadapa        | 462               | 68          | 12          | 1                 | 1                 | 34               | 28              | 22          |
| 12  | Anantapur     | 609               | 80          | 11          | 6                 | 1                 | 44               | 39              | 23          |
| 13  | Kurnool       | 555               | 83          | 18          | 1                 | 1                 | 45               | 29              | 20          |
| 14  | Mahabubnagar  | 681               | 84          | 14          | 4                 | 1                 | 62               | 33              | 32          |
| 15  | Rangareddy    | 397               | 48          | 9           | 4                 | 1                 | 28               | 41              | 14          |
| 16  | Hyderabad     | 53                | 85          | 10          | 3                 | 1                 | 10               | 24              | --          |
| 17  | Medak         | 596               | 88          | 8           | 4                 | 1                 | 36               | 27              | 21          |
| 18  | Nizamabad     | 416               | 42          | 14          | 2                 | 1                 | 29               | 27              | 14          |
| 19  | Adilabad      | 469               | 68          | 13          | 6                 | --                | 34               | 31              | 24          |
| 20  | Karimnagar    | 576               | 73          | 16          | 3                 | 1                 | 35               | 32              | 23          |
| 21  | Warangal      | 608               | 64          | 14          | 4                 | 1                 | 36               | 40              | 20          |
| 22  | Khammam       | 583               | 66          | 13          | 5                 | 1                 | 35               | 31              | 27          |
| 23  | Nalgonda      | 582               | 71          | 4           | 7                 | 1                 | 37               | 37              | 26          |
| Total|               | 12476             | 1709        | 292         | 91               | 19                | 800              | 752             | 475         |
4. Conclusion

The performance of Andhra Pradesh has been relatively better in the all-India context in terms of a few demographic indicators particularly with respect to demographic transition because of a dramatic reduction in total fertility rate (TFR) and decline in the growth of population. Primary health care services should be accountable to the local governments and ensure better services for the money spent. Due to lack of adequate resources, there was stagnation in the size of hospitals at secondary and tertiary levels, while the primary level services, especially PHCs and sub-centres, are underutilized mainly due to non-availability of doctors at these health centers, especially in rural areas. These primary health centers account for around 5% of out-patients (OP) and in-patients (IP) in rural Andhra Pradesh.

While the hospitals at secondary and tertiary levels are over-utilized, the primary level services, especially PHCs and sub-centres, are underutilized mainly due to non-availability of doctors at these health centers, especially in rural areas. These primary health centers account for around 5% of out-patients (OP) and in-patients (IP) in rural Andhra Pradesh.
and degeneration in the quality of care at the public hospitals. There is overcrowding and more than full capacity utilization of public hospitals, particularly at the secondary and the tertiary levels. There is still widespread unmet demand for medical care among the poor and the government should expand facilities in the public sector to meet this demand. The recent investments in the secondary level hospitals and perceptible improvement in the quality of care attracted more and more patients particularly from the poorer sections. Thus public hospitals at present are self-targeted, i.e., used mostly by the poor. The bed and doctor population ratios are abysmally low even after taking private facilities into account. The lack of control on the cost and quality of care is another major problem in introducing the social insurance. Encouragement should also be given to not-for-profit hospitals. There should be regulation of private medical care and no partnership with private hospitals. The government should promote institutions to regulate the private sector. Third, there is a need to promote community health insurance schemes (e.g. SEWA’s scheme) in order to provide health services at low cost to the poor in rural areas. A.P. has introduced Arogyasri programme. The effectiveness of this scheme can be judged only in the future. Fourth, health sector development has to be integrated with the overall process of development. For example, there is no synergy between the processes directed at improving drinking water facilities, sanitation and public hygiene, access to elementary education, nutrition and poverty alleviation and the processes that improve access to public health and medical services. An integrated approach is important to improve the performance of the health sector. Therefore, it is suggested that the current public policy of encouraging corporate hospitals and public-private partnership in health care needs to be reviewed given their far-reaching implications and the public health care system needs to be further strengthened and extended.

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