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Physical accessibility to health facilities in Costa Rica

by

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This paper estimates physical accessibility to health services in Costa Rican communities and identifies target geographic areas for opening new health facilities. The analyses use geographic information system (GIS) methods and relies on the concept of population potential. The paper aims at illustrating the use of simple GIS techniques for solving an important problem with demographic connotations.

Measuring physical access of individuals and populations to health or other public services is crucial in planning the opening of new facilities, evaluating program's impact, and understanding changes in fertility and mortality. Besides, displaying accessibility information on maps is essential to describe a situation, to have a feeling of topological relationships, and to facilitate the use of information by decision makers.

Research and evaluation of health and family planning programs have approached the issue of measuring accessibility in a casual way, coming out with common-sense solutions that are far from satisfactory. Some of these common-sense measures of accessibility is the distance to the nearest outlet, the presence of outlets in a community or area, density of services in an area, and the services available in a determined radius. All of these measures have drawbacks that have hampered the inquiries about the relationship between physical access and health and contraceptive behaviour. This paper addresses the following research issues involved in measuring access (National Research Council, 1991):

- **Contamination across communities:** Often people use services located in communities or administrative divisions other than those in which they live. The lack of services in their communities, or convenience considerations, are causes for this behaviour. Access measures of the type "density of services in an area" do not reflect this contamination effect and can be seriously biased.

- **Overlapping services:** Different organizations may offer similar or related services in a community (e.g., ministry of health, social security, ONGs). This situation -- which is frequent in health services in Latin America -- presents aggregation problems and it is not properly handled by "the nearest outlet" approach.

- **Competition for services:** Access to a clinic will be substantially different if this is the only facility in a big city than it is in a small town. Competition for services in heavily populated areas reduces the access to them. This circumstance is not considered by only-distance measures of accessibility.

Methods

The procedure for estimating physical accessibility relied on distance-dependent calculations of potential access and potential population, which are concepts widely used by geographers. The concept of potential is as follows: the potential number of elements (clinics, people, and so) in a point *i* is the sum of the elements existing in all locations *j* weighted by the inverse of the distance between *i* and *j*. The calculation is usually limited to locations within a determined radius from *i*.

Thus, a simple formula for computing potential physical accessibility A_i to health facilities *H* is:

$$A_i = \sum_j \frac{H_j}{d_{ji}^b} \quad [1]$$

where H_j = number of health facilities in location *j*;
dji = distance between locations *j* and *i*;
b = distance decay exponent, which was set equal to 1 for the present application.

This formula has been used to measure accessibility to workplaces (Duncan, 1964) and to health practitioners (Thouez et al., 1988). Along with caring for cross-communities contamination threats, this formula permits to aggregate services from different providers. However, it does not take care of the aforementioned threat of competition for, or relative scarcity of, services. To correct this problem, Joseph and Bantock (1982) suggest a formula that considers the quantity of services H_j relative to the magnitude of served populations C_j in the service's catchment area:where C_j

$$A_i = \sum_j \frac{H_j / C_j}{d_{ji}^b} \quad [2]$$

is estimated by the population potential for location *j*:

$$C_j = \sum_h \frac{P_h}{d_{jh}^b} \quad [3]$$

with P_h representing population in all places *h* within the catchment area of a clinic in location *j*.

Computations of formulae 1 to 3 were performed using the GIS package "OSU MAP-for-the-PC" (Marble, 1989). The command SCAN-TOTAL of this package counts the number of elements within a circle with a given diameter and it assigns the result to the central cell of the circle. The package repeats this operation for each cell of a map as a "roving window". The difference between two SCAN outputs gave a count for a ring. For example, the difference between 11 and 9-cell diameters produced a count for a ring with 5-cell radius. These ring-counts are the elements inside the summations in formulae 1 to 3. The end result came from adding up these elements weighted by the inverse of the ring's radius. Distances were computed as straight lines and the maximum radius considered was only 10 km.

Data

The GIS data consisted of three OSU MAP-for-the-PC layers:

1) A population layer, i.e. a map showing the population of the 420 districts of Costa Rica, according to the 1984 census. Population was assumed concentrated in the main city, town or village of the district, whose geographic coordinates were entered the computer.

2) A layer with the location of health facilities on Costa Rican territory. Only government facilities providing outpatient medical consultations were considered, namely health centers of the Ministry of Health, and hospitals and clinics of the Social Security System, for a total of 221 facilities. Excluding the private sector does not introduce meaningful biases since it comprises only a small fraction of health services in Costa Rica (e.g., only 3% of hospital deliveries take place in private hospitals). The geographic coordinates of these facilities had to be entered the computer.

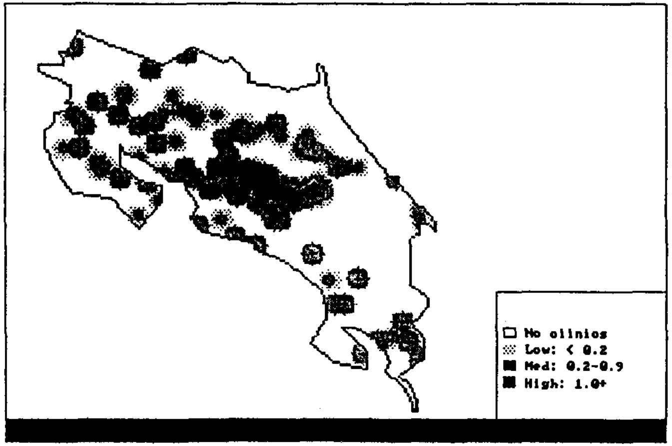
3) A boundary map of Costa Rica, which was entered into the computer as a unique polygon.

The geographic coordinates for population and clinic points and for the boundaries were projected assuming 111 km per degree of latitude and 109 km per degree of longitude, which corresponds to distances at 10º N latitude: the mean latitude for Costa Rica. The OSU-Map layers were created with the command PLPMAP in a 190 by 180 cell grid. Each cell in this grid represented an area of 2 by 2 km.

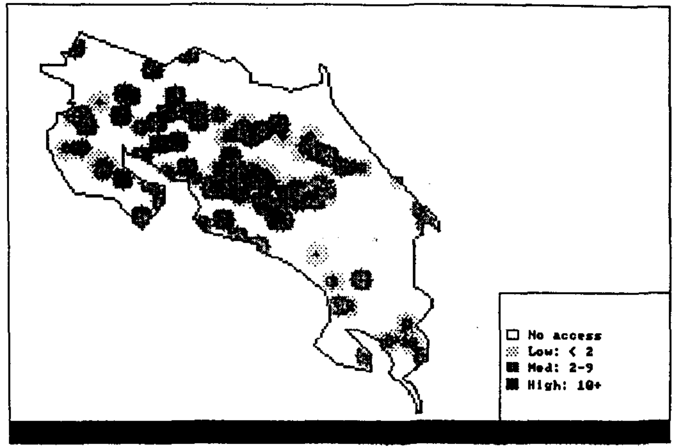
Results

Map 1 shows the results for the simplest measure of physical accessibility (formula 1). As expected, health services appear heavily concentrated in the central plateau, which is the location of the capital city and of two thirds of Costa Rican population. This map, a pure representation of health service supply, gives only a partial description of accessibility. For example, areas with low or no potential access to clinics could be so because they are unpopulated or have a low demographic density. This picture of supply must be complemented with information on the location of demand (population).

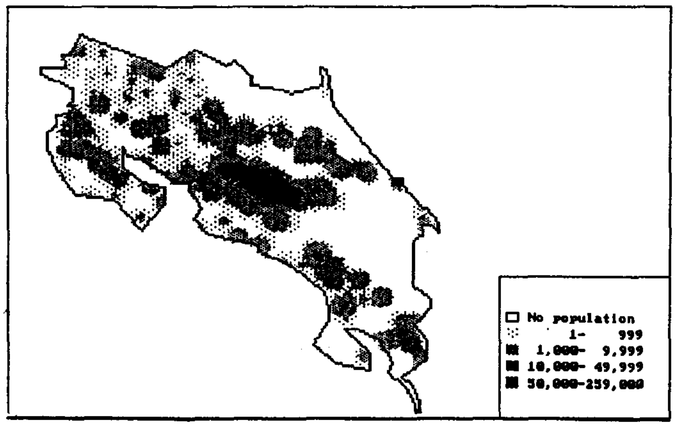
Map 1. Costa Rica: Physical Accessibility (Formula 1) to Health Facilities.



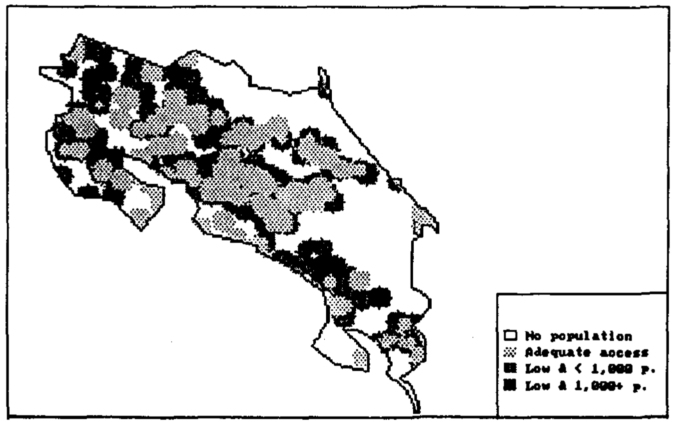
Map 3. Costa Rica: Physical Accessibility (Formula 2) to Health Facilities.



Map 2. Costa Rica: Population Potential according to the 1984 Census



Map 4. Costa Rica: Areas with Low Physical Accessibility (Formula 2) to Health Facilities by Population Potential.



Map 2 depicts the geographic distribution of Costa Rican population as measured by the population potential computed with formula 3. This map resembles closely the geographic distribution of health facilities presented before: population appears heavily concentrated in the Central Valley.

How evenly distributed are health facilities relative to population? Map 3 shows the results of applying formula 2, which combines the data on potential clinic's supply with population location data (the figures in the map's legend indicate number of clinics per 100,000 people). Even though the central plateau still presents somewhat high levels of physical accessibility, the highest levels are not any more in the capital city and its vicinity (center of the Valley), but they are now in several sites over the territory, even in the low lands.

Areas where population has low or no access should have priority for opening new clinics. However, the demographic development of these areas has to be also considered before make any recommendation. An area with low accessibility is not the same if it has a few hundred population than it has several thousand inhabitants. Map 4 cross-classifies the areas with low or no access (less than 2 clinics per 100,000 people) depending on whether they have a population potential of less than 1,000 or more than 1,000 inhabitants. This map also identifies the inhabited areas, which obviously should not be considered for opening new clinics. The highest priority areas would thus be those with low accessibility and more than 1,000 population. The map shows that one of these priority areas is particularly important: a southern zone, in the regions of San Isidro and Buenos Aires, is clearly in need of new health delivery points. In turn, the areas that the map identifies as with a low accessibility and a scarce population potential might be considered for opening small health posts to serve disperse population.

Summary and conclusion

Using OSU Map-for-the-PC, an inexpensive GIS package, and readily available data on population and location of services, this paper estimates the accessibility of health services for the Costa Rican population. This estimate addresses the problems of contamination across communities, competition for services, and the existence of several providers in the same community, which have hampered accessibility studies. The results are presented in maps, which facilitates their interpretation. By the reading these maps, the paper makes clear-cut recommendations regarding the opening of new facilities. The results in this paper illustrate a practical and straightforward use of GIS and demography for solving a problem of planning and evaluation of health services. Further developments to present estimates would include the use of more geographically disaggregated information (e.g., census tracts instead of districts); incorporating characteristics about the size and type of health services, as well as private providers, in the estimates; considering roads and transportation networks for computing distances; calibrating distance decay exponents; moving beyond the 10-km radius used here; and considering data about the mean information field of each community. These developments would obviously require to use more powerful GIS packages than the one used here.

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