Rapid Assessment of Access to Primary Care in Remote Parts of the Developing World

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Physical access to primary care is poorly understood in most remote and underserved populations, although technology exists that can quickly help bridge this information gap. To improve health care delivery in these regions, it is essential to understand the factors that enable or inhibit health care use. One key factor is that of distance from residence to health facility. Assessment of the effect distance has on health facility use provides a clearer picture of how access can be attained. This article focuses on understanding the geographic character of access to care and the expediency of data collection using global positioning system technology. It shows how to quantify geographic access for a given health facility. This procedure can be performed within a relatively short period of time with the assistance of modern technology and some knowledge of geographic techniques.

Keywords: *access; health; developing; rural; geographic*

Access to health care is an important part of an overall health system and has a direct impact on the burden of disease that affects many countries in the developing world. Unfortunately, health care, like many public services, is not equally accessible to all people (Joseph and Phillips 1984), and limited physical access to primary health care continues to be a major impediment to achieving the goal of health care for all (Perry and Gesler 2000). Access

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to primary care services has been clearly shown to positively affect health systems and health in populations (Starfield, Shi, and Macinko 2005), but measuring the geographic component of access to care in rural parts of the developing world has been difficult using the traditional procedures and methods of medical geography.

To improve access to health care, it is essential to monitor how access varies across geographies and subpopulations (Knickman 1998). However, it can be difficult to compare access across communities (Halfon et al. 1999). Global positioning systems (GPS) and their related mapping software can help by enabling the creation of accurate maps. Maps are very useful tools for involving stakeholders in regional public health planning and policy development because they can visually represent and simplify large amounts of complex information. When produced with widely available GPS technology and in digital format, maps can accurately represent distances from health facilities to the homes of patients in a targeted catchment area. When combined with health facility usage data, these maps are an efficient way of estimating the effect that distance has on the actual use of health facilities.

The proliferation and increasing affordability of geographic information systems (GIS) and global positioning technologies have rejuvenated studies of the accessibility and utilization of health facilities, particularly in medically underserved regions such as the rural developing world. Perry and Gesler (2000) and Black and colleagues (2004) have recently developed methods for comparing the spatial distribution of health service provision relative to the Latin American populations being served. These studies use GIS to analyze physical accessibility to health care but lack an understanding of actual use patterns. Noor et al. (2003) evaluate several measures of spatial access (including Euclidean distance, road distance, and estimated travel time) to medical facilities in rural Kenya and suggest that a modified travel time variable simulates the best fit to the actual distance/utilization relationship. Tsoka and le Sueur (2004) use GIS as a way to measure accessibility, delineating catchment areas based on distance and usage patterns and conclude that many people do not have adequate access to primary health care in rural South Africa.

Many other places in the developing world present possible health service access challenges, and where health facilities *are* available, little is known about the geographic character of actual utilization patterns. Nevertheless, simple geographic methods and basic clinical archival fieldwork can provide a rapid and helpful geographic snapshot of how use varies with distance in a service population. This article presents a simple and efficient way of quantifying the effect of distance from home on actual utilization patterns in remote and poorly understood locations.

ACCESSIBILITY, UTILIZATION, AND DISTANCE

In general terms, health care accessibility concerns the ability and willingness of the population of a given area to bridge the physical gap between home and the location of a health facility. Accessibility is determined in part by geographic barriers, including distance, transportation costs, and travel time (Cromley and McLafferty 2002). It is also influenced by many social, behavioral, and economic factors (Habib and Vaughan 1986; Curtis and Taket 1996; Müller et al. 1998; Buor 2002). Physical geographic accessibility is only one of the dimensions shaping health services use in rural areas with considerable health needs and limited transportation, but distance to care is viewed as a key factor in utilization of service (Phillips 1979; Egunjobi 1983; Stock 1983; Habib and Vaughan 1986; Noor et al. 2003; Buor 2004).

A number of researchers have cited distance as the primary factor that determines health facility utilization in the developing world (Fredericksen 1964; Stock 1983; Müller et al. 1998; Buor 2002, 2003; Noor et al. 2003). Sometimes called the *distance decay effect*, the rate of interaction between a person's home village and a health facility varies inversely with distance. This simple model has been used frequently in studies of health care behavior (Stock 1983), but because of variations in terrain, climate, population distribution, and other factors, the rate of decay can vary across settings. In more developed and urban regions of the world with good public transportation systems, the shape of the distance decay curve within a given catchment area may have a more gradual downward slope compared with areas offering no mass-transport alternatives or where footpaths on steep terrain are the usual route. For the strategic development of an effective health care system, therefore, it is critical for policy makers and health system planners allocating health care resources to understand distance decay and related geographic concepts as they apply to their targeted service populations.

Today's field researcher has at his or her disposal several tools to aid in field-based research. A primary data collection tool for the modern geographer is a handheld GPS that can accurately and efficiently map travel routes and specific geographic features such as bridges, town centers, houses, or health facilities. Geographic data captured by the GPS unit are easily transferred into commercial mapping software such as MapSource (Garmin 2004) or freeware/shareware products such as GPS Utility (2007). Both of these GPS mapping products can be used to download trackpoints (locational points along a route) and waypoints (user-defined locational points such as town centers) data. They can be used to estimate travel distances, create maps, and manage data (Garmin 2004). The handheld GPS units, in combination with mapping software, work well together and greatly facilitate spatial analysis of access to care.[1]

GPS has become a common and increasingly important tool in health-related field research (Gibbs and Emmanuel 2004). As noted, Perry and Gesler (2000) have demonstrated the use of GPS in geographical studies of service provision in Andean Bolivia. Their results indicate significant variation in physical access to primary health care across three mountainous study areas. Based on their findings, Perry and Gesler suggest an alternative model of health care personnel distribution that can better meet the needs of those being served. GPS was used effectively to identify the spatial framework for an Indian village, enabling an analysis of socioeconomic, demographic, and spatial factors related to a dengue fever outbreak (Pratt 2003). GPS was also used in field research as an easy and effective way of collecting primary data for health care research (Bernheisel, Bazemore, and Baker 2003; Brane et al. 2004).

RESEARCH OBJECTIVES

The primary purpose of this article is to describe a rapid and simple procedure for better understanding the geographic character of access to health services in rural parts of the developing world. Particularly aimed at rural health service providers and policy makers who have ready access to attendance records and who seek a better grasp of the impact of spatial and physical barriers to care, the methods described here can also be applied by health services and social science researchers interested in health care accessibility and utilization in remote underserved areas. Requiring a short period of fieldwork, local transportation, a local guide, a handheld GPS unit, and mapping software, these procedures can be readily adapted for a variety of contexts and research questions.

SETTING

Clínica Hombro á Hombro is a nonprofit NGO legally registered in Honduras since 1998; it has been operating under the sister U.S. organization Shoulder-to-Shoulder since 1990. It represents a successful partnership between the University of Cincinnati College of Medicine, the Honduran Ministry of Health, and the Community Health Board in Santa Lucia, Intibucá (http://www.shouldertoshoulder.org). The Hombro á Hombro clinic and the Santa Lucia service area offered an opportunity for a micro-level study of access to care in a poor rural part of southern Honduras. Many similar rural health facilities in the developing world can benefit from better understanding physical access as related to the reach of the services they provide.

METHOD

This article suggests a method by which access to care can be assessed in an accurate and timely manner. There are four key steps necessary in such an assessment:

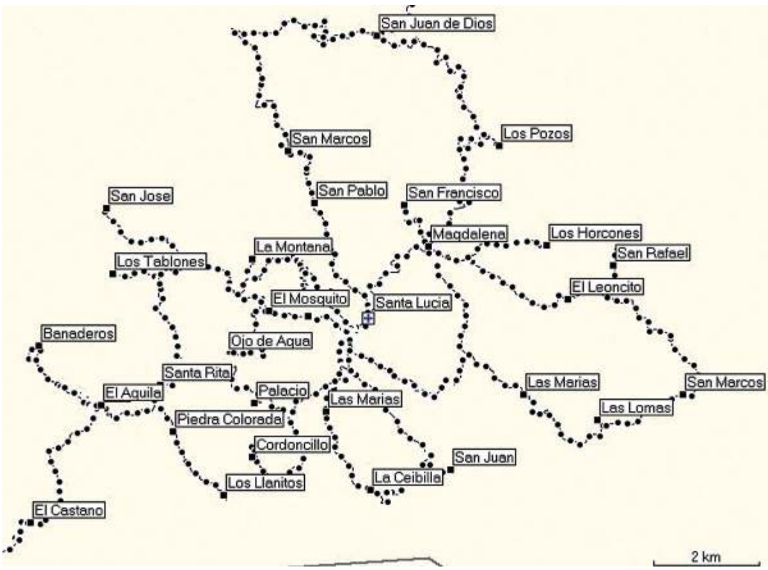
1. geographic data collection and base map development
2. estimation of travel cost
3. clinic attendance sample and population data, and
4. compilation and graphing of data

An appropriate scale must be determined at an early stage of the assessment. For this analysis, an appropriate and efficient spatial scale is that of the village. The village is a hypothetical spatial unit where attendance and population data are aggregated to the village or hamlet closest to the patient's home residence. It is not necessary for each household location to be individually identified, only each village. Although there are some obvious limitations to this approach, this scale was primarily chosen for its efficiency in data collection. Locational data collection was reduced from 477 points (the sample size) to thirty-two (the number of villages). With the exception of Santa Lucia, which can be traversed by foot on its main cobblestone road in about 10 minutes, most of the surrounding villages were comparatively small (fewer than twenty households) and could be traversed in less than 5 minutes. The village, therefore, is the unit of analysis in this study, and utilization rate and distance to clinic are the units of measure.

Step 1: Geographic Data Collection and Base Map Development

The collection of geographic data using a handheld GPS unit is an efficient and accurate way to map a primary care service area in a region where few other health care resources are available. In a short two-week field trip, an entire primary health care service area was mapped in a rural mountainous part of Central America (Figure 1) using a Garmin eTrex series handheld GPS receiver (Garmin Ltd., Olathe, Kansas, U.S.).

FIGURE 1
GPS-Derived Base-Map of Santa Lucia (Center) Service Area



In this study, a handheld GPS unit was used to map villages, travel routes, and other user-defined "waypoints." Each of the travel routes was traversed, allowing a GPS unit to periodically and automatically sample locations (or trackpoints) along the road or trail. A GPS such as a Garmin eTrex will selectively place each trackpoint. Selectively means that the GPS unit does not place a trackpoint every second, but at some less frequent interval to save memory in the GPS unit. Straighter routes are sampled less frequently than sinuous ones. When the unit detects a curve in the route, trackpoints are made more frequently (http://www.gpsmap.net/; http://www.motionbased.com). In this study, the sampled points varied in frequency between 1 and 25 seconds. The output of the GPS unit is a log of geographic coordinates (latitudes and longitudes), altitudes, and time stamps for each location (trackpoint) sampled by the unit. When extracted from the GPS unit, this information is organized into rows and columns of data, with each record (row) being a discrete location sample. These discrete trackpoints form a "cookie crumb" trail that appears as dots on the map.

To ensure accuracy of the geographic data collected, it is important that the GPS unit be functioning correctly. If the unit is not able to receive data transmissions from its reference satellites, then its accuracy will decline. Common causes for interference are steep mountain features near the trail or overhead tree cover. Monitoring the GPS unit for indications of reduced geographic accuracy is suggested, and notations on areas of reduced accuracy should be made. The level of accuracy for the handheld units used in this study was 30 feet.

To improve the quality and usefulness of the collected data, villages and major geographical features such as a river or mountains should be labeled. The GPS unit enables the explicit marking or labeling of a location in the field (waypoints). In the field, the location and identity of all villages and travel routes were determined with the help of a local guide. A four-wheel drive pick-up truck was used for much of the route mapping, but some of the remote villages required access by foot. The data from the GPS unit were easily transferred to a computer loaded with mapping software that was used to create a digital base map. This map can be used in the estimation of distance from village to clinic, which, in turn, is an estimation of travel impedance or cost.

Step 2: Estimation of Travel Cost

When loaded into a microcomputer-based mapping software product such as Garmin's MapSource, the GPS village and route location data can be easily used to estimate travel cost between villages and health facilities. The mapping application allows storage, editing, and printing of base maps. Furthermore, the mapping program has the capability to estimate travel route distances from beginning to end. The travel route distance calculation is used to estimate the level of access to health care services for each of the villages in a study area.

Guagliardo (2004) reviewed several different estimates of spatial accessibility including travel cost. He notes that travel cost is often measured in units of Euclidean (straight line) travel distance from patients' homes to the health facility. The method of measuring travel distance suggested here involves estimating the distance along a walking path or roadway. Geographers often call this *surface distance*. Surface distance may be a more accurate estimation of utilization patterns than simple Euclidean distance that has been employed in past research such as Oppong and Hodgson's (1994) study on accessibility in Ghana or Ayeni, Rushton, and McNulty's (1987) study of accessibility in Nigeria. Surface distance recognizes that people often cannot go directly from one place to another but must follow established paths or roads that follow the topography and consider obstacles such as rivers or mountains.

Another method for estimating travel cost would be to use travel time. Research conducted in rural Honduras suggests most people travel to the NGO health facility by foot (Kurak 2003). This is consistent with Tanser, Gijsbertsen, and Herbst's (2006) findings in a rural part of South Africa and Noor et al.'s (2006) findings in rural Kenya. Walking time may be a more accurate measure of travel cost, but accurately estimating this factor may be difficult. This method is intuitively appealing but has several inherent problems. A sampling of clinic patients may offer a variety of walk times for a given village because of differences in the perception of time, the effort of movement over varied terrain, and the age and health status of the patient. Additionally, using travel time as an estimate of travel cost may require a greater time commitment during the data collection phase. Given the limitations of the estimates of travel time described above and the limited time and resources for our data collection, we chose surface distance as the best estimate of travel cost.

Step 3: Attendance Sample and Population Data

We reviewed attendance data from the Hombro á Hombro clinic in a systematic 10% sample of the clinic's logbooks during a twelve-month period (January–December 2004). This involved sampling every tenth record during a review of the entire year's attendance records. The records in the logbook were organized in chronological order, one record for each patient visit. Before this data collection process, we met with members of the local Santa Lucia Community Health Board, including the chairperson and the health facility's head clinician to discuss the anonymous and confidential nature of the data to be collected and to obtain permission to collect data. No identifying information was collected; only the patient's home village was recorded. Requiring less than two days, location data were sampled from 477 records representing thirty-two different villages.

Step 4: Compilation of Data

The next stage in this analysis includes the compilation of data into discrete distance bands, the calculation of a utilization rate for each band, and the creation of an access graph. After the location of the villages and the travel distances are determined, villages are ordered by distance from the health facility and grouped at 2 km intervals. Although the 2 km interval chosen was arbitrary, it nevertheless enabled a systematic way to assess varying levels of access to the clinic for the various villages in the catchment area. Utilization rates are calculated by multiplying the clinic attendance count by 10 (10% sample) and summing this number for all villages within a distance band. This figure is then divided by the sum of the population for the same villages within the distance band. Population counts for the villages were acquired from the 2001 Honduran national census (Instituto Nacional de Estadística [INE] 2003). The resulting utilization rate thus represents the attendances per person per year for each distance band. These data were then graphed using Microsoft Excel for the final access graph (Table 1, Figure 2).

The creation of a graph describing access to care uses distances from the clinic along the *X* axis and utilization rates along the *Y* axis. This graph displays variations in the levels of utilization through the segmentation of the service area into different levels of access. The graph can be used to estimate the effective size of the service area and the distance people are willing to travel to receive this service.

CONCLUSIONS

This article describes a rapid method for estimating the effects of distance on physical access to primary health care in a remote mountainous health catchment area of about 12,000 persons in Central America near the border between Honduras and El Salvador. The population distribution, terrain, and road quality of this region resemble that of innumerable rural low-income communities throughout Latin America, Africa, and Asia. Our findings suggest that the health clinic effectively services only a small area near the clinic, and other interventions may be needed to reach the entire catchment area. These results indicate that almost 50% of potential attendances were lost at a distance of 4 km. These results are consistent with distance decay findings of several studies of health services in other parts of the rural developing world (Stock 1983; Müller et al. 1998).

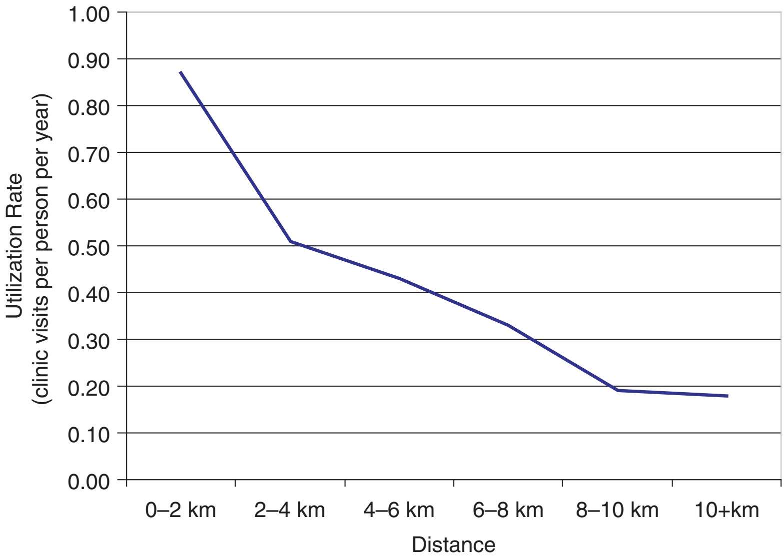
Several limitations in the methods and analysis should be noted. First, although the Hombro á Hombro clinic is the principal source of primary health care in the region, a fuller understanding of physical access to such care requires consideration of patient choice and the dimensions of access to traditional care resources (e.g., folk healers, government nursing stations, and small "pharmacies"). The government clinics operating in the region have a primarily public health mission of providing vaccines, immunizations, and prenatal care and are severely limited in the ability to provide other kinds of health services. For these reasons, the government clinics are not directly comparable to the service offered by the single NGO health clinic

TABLE 1
Calculating Utilization Rate for Six Distance Bands Within the Clinic Catchment Area

Distance Band	*Village*	*Number of Attendances (10% Sample)*	*Population*	*Utilization Rate for Distance Band*	*Distance (100m)*
0–2 km	Santa Lucia	850	917		4.0
	Barriel	70	129		14.0
	Espino	70	98	0.87	16.3
2–4 km	San Pablo	90	84		28.6
	Las Marías, Santa Lucia	60	217		29.7
	Magdelena	690	1054		30.7
	Las Aradas	40	171		35.2
	La Montana	70	337	0.51	37.0
4–6 km	Junquillo	70	136		40.2
	Palácio	110	431		41.2
	San Marcos, S. L.	50	137		43.5
	San Francisco	230	636		44.7
	San Juan	510	990		46.2
	Talquezal	60	130		49.2
	La Ceibilla	230	311		49.9
	San Lorenzo	70	127		55.9
	Los Horcones	50	161		56.4
	Cordoncillo	50	251	0.43	58.7
6–8 km	Leoncito	50	126		63.4
	Las Marías, Magdelena	90	300		67.5
	Santa Rita	140	399		69.9
	San José	230	701		72.0
	Tablones	130	354		73.0
	Los Pozos	70	243	0.33	74.9
8–10 km	San Rafael-Mag	140	719		83.9
	Aguila	120	197		91.9
	Las Lomas	50	754	0.19	99.5
10+ km	Llanitos	40	390		103.2
	Banaderos	180	254		111.3
	San Marcos, Colomon.	0	562		113.8
	El Castano	40	99		124.6
	San Antonio[2]	120	828	0.18	N/A

and are not considered in this analysis; second, the spatial aggregation approach used here prevents us from understanding the possible role of differences in ages or demographics (e.g., income) across distance bands or communities. The goals of this method, however, are rapid rather than comprehensive assessment.

FIGURE 2
The Relationship Between Increasing Distance to Health Center and Decay in Utilization Rate of the Clinic



Notwithstanding the limitations, the rapid assessment methods described here can provide a useful picture of regional health care access and can be easily duplicated in similar communities elsewhere—or within the same community for different sources of care. On a short two-week field trip to a remote mountainous area, two people working with a local guide collected a substantial volume of geographic and clinical data. Data collection and analyses performed during this period included sampling of attendance records at a primary health care facility and collecting village locations and route information using GPS followed by a straightforward and duplicable analysis of access to care. This and related analyses are informing strategic planning by local municipal officials and NGO staff who are exploring regional sites for future clinical activities (Baker and Liu 2006). Our experience with these methods suggests that without great cost or expertise they could be used in similar rural settings around the world where limited primary care and public health resources must be efficiently distributed.

NOTES

1. There is a range of GPS units on the market that can be distinguished by a price/accuracy relationship. At the low end of the range are the consumer-grade units, which are about \$200–\$300 and have an accuracy of roughly 10 m. Garmin and Magellan are two popular brands in this category. At the high end of the range, there are commercial-grade GPS units with sub 1 m accuracies. These units cost about \$6,000 and a popular brand is Trimble. The scale of the study is the most appropriate way of determining the necessary level of accuracy. For health care service areas with a radius from the clinic of 10–20 km, consumer-grade GPS units should offer a sufficient level of accuracy.

A range of software products is available to create maps and estimate distances. The proprietary software product associated with Garmin GPS units is MapSource and costs about \$200. MapSource is simple to use and easy to learn. Researchers can learn to use MapSource in less than one hour. At the other end of the spectrum for mapping software is a GIS. A popular brand is ESRI's ArcGIS. This software is complex and costly, with fully configured packages costing close to \$2,000. An uninitiated researcher might need several months or a college-level GIS course to develop competency with this product.

2. Several patients sampled came from the distant town of San Antonio. Because San Antonio was not in the expected catchment area, no GPS route data were collected. This research assumed that San Antonio was more than 10 km from the Santa Lucia clinic and thereby added it to the 10+ km band in the utilization table and graph.

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