The Development of Barriadas & Access to Medical Services in Lima, Peru

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Introduction

Squatter developments (barriadas) are largely unstructured, unplanned developments which appear on the outskirts of a city or in areas that have been avoided for formal development. Although these densely populated areas are substandard in many ways, they are what one third of the urban population in developing countries call home (Pérez et al. 2008). The barriadas outside of Lima’s suburbs emerged in the late 1950s. These developments known as The Cones (seen in figure 1) have progressively developed into more sophisticated settlements eventually becoming a part of Lima’s urban fabric and an integral part of the city proper. The central part of Lima has always been home to higher income residents and these people have good infrastructure and facilities in place (Fernández-Maldonado, 2006). The purpose of this analysis is to find if as the barriadas develop and become integrated as a part of the city, do they have similar access to hospital services or are these areas overlooked in the process of planning the locations of medical facilities?

The social and geographic dimensions of health care are examined in this study. Spatial access is a measure of access to facilities using geographic features such as barriers to travel and pathways or roads on which people can travel. Aspatial access considers non-geographic factors such as socioeconomic class. When health facilities are being planned an optimal location would take both of these access factors as considerations (Wang and Luo 2005). Many studies focus on the distance or travel time to the nearest facility for a population without considering the population that is being served. Socioeconomic data representing the social dimension is used in conjunction with the distance to a hospital facility to find what populations have better access to those facilities. Considering both of these dimensions can lead to a spatially equal epidemiological profile for a city.

The expansive cones display homogenous socioeconomic characteristics whereas the city centre has more fragmented smaller areas where wealthy and urban poor are often in close proximity. Galea and Vlahov (2004) have noted that even though different socioeconomic groups live in close
proximity to each other, there are still disparities between these different classes of people and their access to health care. Not only do lower income urbanites often lack health care, they are more likely to use emergency facilities and in the end receive poorer quality care (Galea and Vlahov 2004).

Due to the aspatial barriers to healthcare experienced by lower socioeconomic classes, policy experts are increasingly promoting health policies and developments explicitly directed at lower socioeconomic classes. This may reverse the regressive nature of health care in developing countries by analyzing the whole population and how the demand dynamic fits with the supply of health care (Kruk and Freedman 2008). Health services should benefit those needing the services the most. The analysis presented here enables a health care facility planner to find areas with lower levels of access to medical services and plan a new facility or facilities. As a part of this study, a hypothetical new facility will be located in an area with low access and a comparison to the existing access will be made as a demonstration of the impact a new addition can have.

Related Work

Most studies of spatial inequality relating to healthcare measure access based on either straight line distance or travel time distances between health services and demand points (Kohli et al 1995; Rushton 1999; Phillips, Kinman, and Lindbloom 2000). Manhattan distances (the kind used here) are distances that do not follow straight lines, but follow pathways such as roads around city blocks. These distances are generally longer than a Euclidean distance but are more accurate as the road networks more realistically emulate a real journey (Christie and Fone 2003).

The use of cost path models has been less common than Euclidean distance (Brabyn and Skelly 2002; Christie and Fone 2003). In a large urban centre such as Lima, Peru there are overpasses and bridges and presumably one way streets which impact the accessibility to services. A raster cost path model (used here) does not easily take these factors into account which could make a vector road network more appropriate in urban centres where these features are present. There also may be areas where vehicle access is prohibited or impossible. In these instances a cost path raster analysis can account for traveling over areas on foot or through open areas where no formal route exists.
Methods

A distance measure will be calculated instead of driving times to quantify accessibility to hospitals. The road and building footprint data (supplied by the University of Calgary's Latin America Research Centre (LARC)) does not have speed limit data associated with it so driving times could not be calculated. This was accomplished through calculations of the areas around the urban footprints using Spatial Analyst. High data detail has been used to accommodate some small pathways in the road network.

The roads and block footprints were all buffered by 25m to create a study area of paths that travel to a hospital could occur on. The urban land use blocks on which buildings and other non-traversable areas exist were then used to eliminate those barriers to travel from the travel surface. Essentially the urban block footprints punched holes in the background census areas creating the travel surface.

Hospital locations were digitized from locations on Google Earth and Wikimapia. These two sources were used to verify the locations of hospitals because their content is largely user generated and can therefore be prone to errors. The definition of “hospitals” for Lima, Peru was also the one used by Wikimapia so the facilities are both regional primary care facilities and secondary care facilities. These hospital locations are plotted in figure 2. The outskirts of the city demonstrate lower levels of access. This is one reason for proposing the hospital in the northern cone. This hypothetical proposal should demonstrate enhanced access to a hospital in an area with higher needs.

The socioeconomic data for Lima is from the Peruvian 1993 Census (also provided by LARC). Socioeconomic classes are already defined in the dataset but that data was aggregated and normalized to find the mean socioeconomic class in each respective census area. Populations defined by a census area can be represented in a number of ways. In order to define where that population actually resides, and is therefore traveling from, a more specific
location needs to be defined. Populations are not evenly distributed throughout the polygons that represent them in census data. A single representative point (centroid) could be used to represent the whole area. If the polygon area is quite large the centroid point could be quite inaccurate. Many points could be evenly distributed throughout the area, each representing an equal proportion of the population. This would intuitively be more accurate than the centroid point but is still not realistically representative.

Langford and Higgs (2006) used dasymetric modeling to redistribute population variables into relatively homogenous sub zones using the actual tabulation zones the data was collected at. This takes the aggregated population data and spatially refines it to be more realistically representative. This should provide the most detailed and best estimates of potential demand on services when compared to the centroid or distributed points. The three methods described here can be seen in figure 3. The data in this analysis has urban block footprints present which represent areas where the populations are most likely to reside and so the census information has been distributed dasymetrically for the analysis here. Each of the multiple blocks is used as a location the distance was calculated from. For cartographic representation, and simpler display of the results the population densities are averaged and shown as even across individual census areas.

![Figure 3](image-url)  
**Figure 3.** Methods of representing a population by (left to right) centroid, evenly distributed points, and dasymetric modeling.
Results

The results of the socioeconomic classification are displayed in figure 4. Central Lima clearly has the highest socioeconomic class rating as depicted in figure 4 with progressively lower classes radiating outwards. It is also evident that the Southern Cone is the lowest ranking in terms of average socioeconomic class, with the Eastern and Northern Cones coming in with the next lowest average class levels. Population densities are higher in the centre of Lima, as seen in figure 5 and the highest densities appear to correlate well in the central regions with lower socioeconomic classes in figure 4.

Figures 6 and 7 display the results of the two path distance calculations. Figure 6 shows current accessibility to hospitals and figure 7 displays the results when the new hospital is placed in the Northern Cone. The differences between figures 6 and 7 exist in the Northern Cone as the new facility will only affect areas where there is no other closer facility. Only a small portion of the overall population is impacted.
Figure 6. Results of the path distance analysis with the current hospital facilities.

Figure 7. Results of the path distance analysis with the current and proposed hospital facilities.
The proposed location in the Northern Cone improves access to about 4% of the total population. The results can be seen in the histogram in Figure 8. The low and middle-low socioeconomically ranked populations are the groups which show meaningful differences in their access with the new hospital. The low socioeconomic group's average distance to a hospital improves from 13.5 km to 8.5 km. The middle-low class' average distance is improved by over a kilometre from 8.9 to 7.7km. The improved access in middle and middle-high classes is marginal. What is quite striking is the difference in access to hospitals between the highest class and the lowest class. The histogram demonstrates an inverse relationship between socioeconomic class and access to hospitals. The highest socioeconomically classed groups have an average distance of 1.5 km to a hospital increasing to 3.9km for middle classed populations, 8.9 km for middle-low classes and an average for low socioeconomic classes of 13.5 km. The middle-low class is also by far the most populous group with over 4.2 million people representing more than two thirds of Lima’s population, but poor access to hospitals.

**Figure 8. Average distance to a hospital by socioeconomic class and the corresponding population**

Results displayed by region are found in figure 9. The city centre has the most facilities and also the best access in terms of distance from the hospital facilities. The northern cone stands out with the highest population and is the farthest average distance to a hospital. Adding the new facility brings the access to a more comparable level with Callao and the other Cones. The Northern Cone still has the highest average distance to a hospital.
Discussion and Conclusions

The proposed hospital was located based on a community in need in the northern portion of Lima and affects 4% of Lima’s population increasing accessibility to hospitals in approximately a 7.5 km radius around the proposed location. This region of Lima demonstrates a clear demand for a hospital (a socioeconomically vulnerable population with less access to existing facilities) and the impact was expected to be greatest in this location. 46% of the population is more than 4 km away from a hospital and that population is largely classified in the Low socioeconomic group. The lowest socioeconomic class is clearly the farthest away with average distances to a hospital currently of 13.5km. The impact of the new hospital would help towards attaining equal access to hospitals for all socioeconomic populations. Even so, as seen in figure 9 the northern cone still has the farthest average distance to a facility and the highest population with a new facility. The northern cone shows a demonstrable need and the ideal supply of health care should more representatively reflect that demand.

Looking back at the socioeconomic distribution in figure 4 the hospital locations appear to be trickling outwards to the mainly middle-low class inhabited areas, but the hospitals are located largely in the higher socioeconomic class populated areas of the city. These are also the most densely populated areas of Lima as seen in figure 5. Although quite intermingled, as can be seen in figure 4 higher socioeconomic classes generally exist in the older central regions of the city and the lower classes generally can be found on the outskirts. There is merit in having close access for dense populations. Although densely populated, the histogram in figure 8 still shows an
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inverse relationship favouring higher socioeconomic classes for higher levels of access to hospitals. Many of the barriadas established in the last fifty years have developed into improved settlements but because policy makers are influenced by the wealthy, the middle and lower class populations are not influencing urban development and infrastructure upgrades (Peters and Skop 2007). It appears that even as the old barriadas develop, access to health care services does not develop concurrently.

Accessibility to hospitals in Lima varies considerably throughout the city and cones. There is a clear bias. The hospitals are located largely in the higher socioeconomic class populated areas of the city. One possible explanation is a lag in medical development and as the city develops the services lag behind the population growth on the outskirts. Lima has seen dramatic growth since the 1950s and as such the extents of the city are always being pushed farther away from the metropolitan center. This means that when facilities have been planned in the past the city has had a less sprawling profile. Now facilities will appear to have a less spatially equal service because of this fast growth and outward expansion in areas outside of the original city’s jurisdiction. Facility locations are often planned according to a number of factors including site availability and often other locational factors are neglected (Gar-On Yeh and Chow 1996). It is not unreasonable to observe that the fiscal perspective was an influence on the planning of hospital facilities as they are currently near to each other and are therefore able to share costs and facilities making the system less expensive to run. Considering both aspatial and spatial access there is an imbalance on both counts. Those geographically near the hospitals are also populations with fewer aspatial barriers to health care. When health facilities are being planned an optimal location would take both of these access factors as considerations (Wang and Luo 2005). Integrating the two perspectives can aid in defining areas with health care shortages which is helpful when planning new healthcare facilities or expanding operations.

An assumption of this analysis is that a person requiring hospital care would visit the nearest facility. People may prefer certain facilities or may only be aware of some. There could be certain services provided at specific locations so more data reflecting preferences or what services are available at which locations would be necessary to overturn this assumption. Additionally, the analysis here considers a more realistic way to analyze a road network without a more commonly used vector road centreline data set. This is highly applicable to urban poor as they reside more often in rugged terrain or areas with only walking access. Three levels of roads are classified in the data used here but the roads that are classified are fragmented so highways, for example, have
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gaps. Although no speed limit or travel time data is present assumptions could be made based on the hierarchy in the data to create travel time catchments for each facility. Accessibility to services is sensitive to the speeds on the roads. The speeds on the roads is not available in the data set used here. The data provided also has very limited attributes associated with it so even if some hefty assumptions about the speed of travel were to be put forth, driving times would likely be quite inaccurate. The shortest travel time and shortest travel distance to a facility could potentially take entirely different routes which would impact the results.

Geostatistical methods should be implemented in future work finding spatial autocorrelation with a measure such as Moran’s I to quantify if the locations of hospitals in fact are correlated spatially with attributes associated with near populations. Other variables could be used to find if spatial inequality exists among populations ranked by political preference or education level. Chung, Yang, and Bell (2004) note that many geographic analyses applied to health applications visualize the results that are described, but the statistical descriptions of the relationships in the data are not addressed in a way that does more than suggest relationships in well mapped analyses. That is certainly the case here. Solid statistical analysis would add validity and significance measures to this study.

Acknowledgements

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