Exploring access to Maternal Health Services and Infant Mortality Regional Differentials

Peru 1996-2000[1]

Lissette Aliaga Linares

Department of Sociology

University of Texas at Austin

Thomas W. Pullum

Department of Sociology

University of Texas at Austin

March 15th, 2007

Paper Presentation

PAA 2007

For an updated version of this paper, please contact lissette@prc.utexas.edu

Exploring access to Maternal Health Services and Infant Mortality Differentials

Peru 1996-2000

Abstract

This paper explores a new methodology to calculate sub-regional estimates of the relationship between access to maternal health services, mainly the use of prenatal care, and infant mortality rates. Using geographic weighted regression and point-spatial autocorrelation techniques on DHS geo-referenced data for Peru 1996-2000, the strength of this relationship is tested when controlling for social factors such as the proportion of rural, poor and low-educated women. The results show significant regional variations of the impact of public health policy even within regions inside the South Andean, Coast and Jungle part of Peru that are not captured when using non-spatial statistical modeling methods based on survey data. An argument is made to the contribution of spatial techniques to analyze inter and intra-regional variations.

I. Introduction

The use and access of health services has been an important determinant accounting for infant mortality reduction in developed (Gotmaker & Wise 1997) and developing countries (Turner1991, International Family Planning Perspectives 1986). In Latin America, major policies are currently focused on increasing maternal-child health program coverage. Particularly, in Peru, after the economic adjustment of 1992, a context in which socioeconomic conditions of the population deteriorated, health reforms targeting the poor accompanied with administrative and budget decentralization have promoted the increase of the coverage of delivery of medical assistance and prenatal care with relatively high success. In this respect, the study of public investment in those maternal health programs in recent years has been focused on understanding the general trends mediating public policy effects. Since data quality has improved since the application of health and demographic surveys, most research has drawn theoretical models based on how institutional and other social factors affects the probability of infant mortality at the individual level. Nevertheless most public expenditure is made at a regional level[2]. In this sense, more research on this level is required to evaluate how effective these policies are in the reduction of infant mortality. Using sub-regional geo-referenced cluster data for the Demographic Health Survey for Peru, this paper proposes to analyze regional patterns of infant mortality in Peru for 1996-2000. First, spatial autocorrelation using G* is used to analyze the pattern of clusterization of the indicators of maternal services coverage and infant deaths. Second, using geographic weighted regression modeling, a spatial autoregressive method that allows calculating coefficients, standard errors and significance levels per unit of analysis, the relationship between infant mortality and medical assistance at the moment of delivery is estimated at the sub-regional level. Adding to the model variables such as proportion of rural population and women with low education, our aim is to identify the differentials between and within regions in terms of the effect of public health investment on infant mortality rates.

---

[2] Although Peru has eight altitude levels, it is generally divided in three natural regions: Coast, Highlands (Los Andes or Sierra) and Jungle. In terms of public policy, the relevant administrative regions are 24 departments, from which social expenditures are assigned. However, the division reaches the provincial and municipal level as minor units, which are not in budget assignations but remain important in terms of internal distribution.

II. Background

The economic adjustment and the structural reforms applied in Peru in the last decade enabled the economic stabilization and incorporation of the country into the international finance market. This economic improvement has moved along with the progressive reduction of infant mortality rates. In the previous context of economic crisis before the reforms, a report of the World Bank elaborated by Baxton & Schady (2005) estimated an increase of about 2.5 percentage points in the infant mortality rate for children born during the crisis of the late 1980s, which implies that about 17,000 more children would have live in the absence of the crisis. Beginning the nineties, the economic reforms did not have a large positive effect on maternal and child health as well, proving that the economic growth initially experienced can not explain solely the steady decrease of infant mortality rates. According to Vicuña (2002:11), in the period of 1991-1996, the maternal and infant mortality rate experienced just a minor decrease of 11% and 17% respectively. Even with the steady decrease of infant mortality rates, factors such as infectious diseases, chronic malnutrition, and low access to health services and general adverse conditions for reproductive health still persist as obstacles for the improvement of maternal and child health.

Figure No. 1: Evolution of Infant Mortality Rates Peru 1956-2000
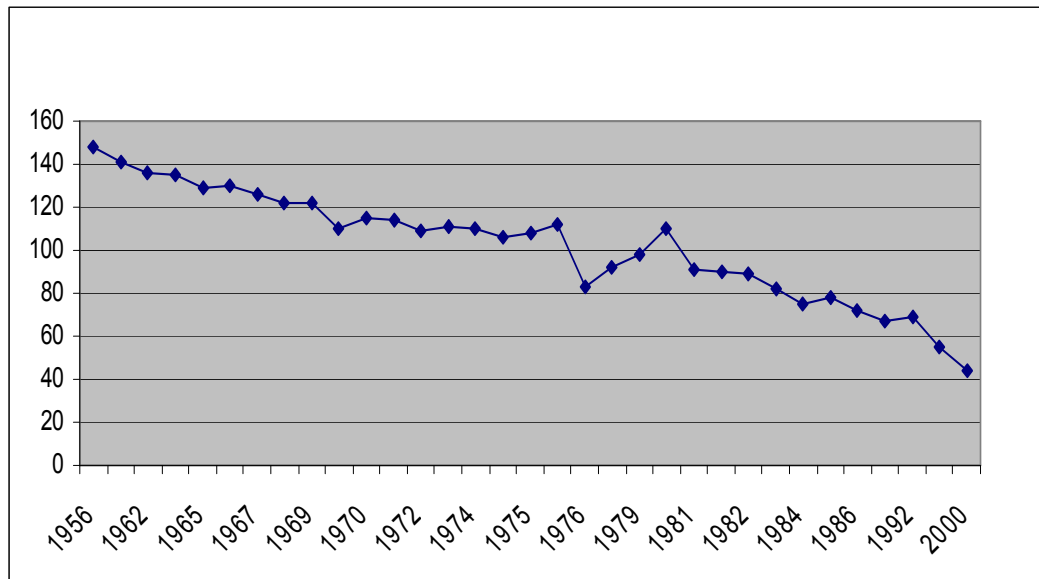
Source: ENDES-INEI

After the economic reforms, a major reform in health policy was achieved. Nowadays, health policy is characterized by social protection that combines a public and a private system. In this model, the State gives priority to collective health such as the vaccination and prevention of diseases in universal campaigns but also covers particular cases of high risk diseases. The public system covers people that with their wage make contributions to the Social Security System, but more importantly, supports cost-free high risk and vulnerable population. The private sector has also been promoted to ease the access for companies to provide health services to workers with short and medium-term contracts, particularly for common diseases. In this sense, health coverage has increased by either the private or the public system. Nevertheless, the increase of the participation of the private sector has not reduced the importance of the role of public health policy. The State has the responsibility to subsidize serious health problems for the population in conditions of poverty. The new health system also adopts the criteria of budget decentralization and targeting in some emergency programs.

Relevant policies in the case of access to maternal and child health services were implemented between 1994 and 2000. Most of the regional offices of Health (DIRESA, in Spanish Acronyms) complemented their coverage with specialized programs such as: Program of Shared Administration, Project 2000, Basic Nutrition and Health Project and Infant-Maternal Social Security. Most of these programs were targeting maternal and infant health and were oriented toward increasing the access to health services, and lowering economic, geographic and cultural barriers. For instance, it has been estimated, three years after 1994, the availability of maternal health services has increased in two thirds. Nevertheless, although home medical assistance has been enforced to target poor population, among the most vulnerable maternal population there is a gap between prenatal care and assistance at delivery; suggesting there are still certain obstacles to achieving wider health coverage for maternal population (Dammert, 2004:5). Additionally, this gap shows a significant natural regional variation. While in the Coastal natural region the coverage of prenatal care and medical assistance at birth demonstrate a reduction in the gap from 7.4 to 5.9, the Highlands or the Andes have increased this gap from 21.6% to 36.2% in 1992 and 2000; even higher than that the gap of the Jungle which increased from 13.0% to 20.7% (Ibid. 48).

III. Literature Review

The empirical relationship between infant mortality and socio-demographic variables has been widely analyzed in the literature, for developed as well developing nations. In general terms the mortality decline has been explained by the rising living standard of the population and the general improvement of health services within others. Preston (1980) demonstrated that both socioeconomic development and improved technology played major roles in the decline of infant mortality rates. In the case of Latin America Behm (1979) notes mortality declines have occurred in a context of modernization and industrialization. Also, in developing countries, a major factor explaining not only mortality but also fertility decline has been women education (Caldwell 1979).

With the identification of these social factors, many researchers developed integrative models that can account for how certain socioeconomic characteristics of women and the population mediate the achievement of health policy. Mosley and Chen (1981) propose a broader framework unifying biological, environmental, social and economic determinants of child mortality. Caldwell (1981) also has made significant contributions to the idea that contextual characteristics of social organizations and medical services have joint effects on health. By investigating countries and regions that have succeeded in producing low mortality, he argues that health care systems precipitate declines in mortality but provision of these services is most effective in particular contexts, depending upon the improvement of females living conditions.

Yet beyond these initial studies, few researchers have investigated which socioeconomic conditions and health care organizational characteristics are relevant and how they interact to produce low or high infant mortality in Latin America. Andes (1989) in a study of Peru, highlights the importance of the community as unit of analysis when understanding infant mortality decline. She compares two provinces, Pisco and Ilo, which have an equal number of health facilities but two different outcomes, being infant mortality greater in Ilo. Her results suggest that the effectiveness of health care programs is influenced by the larger socioeconomic context of the community. She concludes by stating that "If health care system operates in a harsher, less equitable economic environment, its ability to overcome the effects of these structural constraints may be impaired" (Andes 1989:395).

Research on Peruvian infant mortality has moved from the general interest of improving aggregated regional and national estimations (Hobbs & Arriaga 1982, Ferrando 1993) to more

explanatory models at the individual level, due to the improvement of survey data. Moreover, the reasons for this interest is a general concern with targeting health policy especially since education and urbanization has increased over time, infant mortality rates are assumed to be more dependent on access to health services. Ferrando (1993) pointed out that 72% of childbearing women had at least 11 years of education. She also estimated that from 1986 to 1991, the proportion of childbearing women without formal education diminished from 11% to 6%. Moreover, today Peru is predominantly urban, reaching around 70% of the population. Even cities with lower urbanization trends in the Jungle have grown at a faster rate from 5% to 7% in the period from 1981 to 1993. In this sense, it is believed that health coverage make much more of a difference in these contexts.

Accounting for the relationship between infant mortality and access to health services, there are three main studies performed using the Encuesta Nacional de Demografía Social (ENDES in Spanish Acronyms) for 1992, 1996 and 2000. Murillo (2002) studied the effect of health intervention on the determinants of infant mortality, using the Mosley & Chen analytical framework. Relevant variables that reduced children's probability of dying in his study were number of family members, having other children under age 5, breastfeeding, fertility, as well as prenatal care and birth attended by a physician. He concentrates on studying child survival under age 5 since data quality is not sufficient to estimate infant mortality under age 1 (few cases). He argues that the importance of these factors have varied over time. In 1992, he demonstrated that the over-representation of urban population explains why the number of births attended by a physician appears as a strong significant predictor, which is not compatible with the low coverage of those times. However, in 1996, the access to prenatal care also has a significant association in the rural areas. By 2000, both indicators had increased in significance for rural and urban areas. It is estimated that the absence of prenatal care increases by five times the risk of infant death and the absence of medical assistance at birth increases 10 times that risk (2002:38). Murillo suggests that since they represent increasing important factors determining infant mortality outcomes, health coverage is still low and that targeting needs to be reinforced. Other factors that are important to emphasize are education and the presence of other children under 5 years-old. Education has also increased its significance in rural areas. And, overall the presence of children under 5 years old is an important determinant since households tend to be more

vulnerable to mortality risk if they face adverse socioeconomic conditions and resources are scarce to take care of a higher number of children.

A second study developed by Vicuña (2002) has focused on the changes in the use of maternal health services in Peru from 1991 to 2000. Compared to prenatal care, she found that institutional births (or births at health services) have showed lower increase in coverage. From 1992 to 2000, use of prenatal care has increased its coverage by 12.4%, and is more evident in rural than in urban areas. In rural areas the increase is around 25% while in urban areas it is 18.8%. In terms of natural regions, Los Andes has shown a higher increase in coverage compared to the Coast and the Jungle. In contrast, 41% of births continue to occur at women's houses and 39.2% in hospitals, although the former has decreased significantly in the last years. This practice is most popular in los Andes and among the rural population. From 1992 to 2000, the coverage of medical assistance at delivery has increased only 4.5%.

Vicuña also found that there is a direct association between the use of health services in terms of prenatal care and births that occurred at a health service and the level of urbanization, which is consistent and strongly significant over time. This is also relevant for poverty and education. Interestingly, the marital status of women has paradoxical effects. While being married or in a union increases the probability of giving birth at a health service, it also diminishes the probability of prenatal care. Also, the younger the mother, the more likely she is to use prenatal care but less likely to give birth at a health service. Relevant to my research, she distinguished the effects among rural and urban areas in use of health services and mortality outcomes. In both, education, marital status, poverty and prenatal care are important, but poverty interacting with language spoken is more relevant in rural areas. By natural regions, among women living in the Jungle, the factors described before are not significant. Rather, prenatal care and service quality are the only significant predictors. Therefore, it might be the case that infant mortality outcomes are more determined by health coverage in this zone than anywhere else.

A third study, was developed by Dammert (2004) and focuses on the access to health services in determining infant mortality outcomes. According to Dammert, the research on infant mortality has considered access to health services as an exogenous variable, even when this factor is part of the decision making process inside a household. She tries to capture this effect by using duration models to explain infant mortality using ENDES. Following the general findings of both of the previous mentioned studies; she found that the access to health services,

prenatal control and birth at health service, increased from 1992 to 2000 but that this does not necessarily explained the change within that period. Nevertheless, access increases importance in each year, having a larger significant effect when individual variables, such education, interact with this access.

All these studies have made important contributions to the relationship between access to health services and infant mortality. However, administrative regional disparities cannot be capture using this disaggregated level of analysis, which are relevant for policy assessment and budgeting decisions.

IV. Problem description

One of the central consequences of the increasing efficacy of maternal-child health services is an increasing burden on society to provide these services equitably. Favorable conditions, such urbanization and the increase of women education, could ease public health access and use if we account for an efficient distribution of public health resources. In this sense, the increase of coverage in those programs elevates the importance of access in the determination of disparities in infant mortality.

Despite rising coverage of health programs, the worries about targeting are also associated with inequality and regional disparities. From 1985 to 1986, a study by Bazan (1991) proved that the public expenditure did not reach the poor, as targeting policies announced. A second study performed by Francke (1998), indicates that 61% reaches to the poor, indicating a more efficient delivery. Looking at the regional trends, when assessing the targeting of public expenditure, he suggests that "the health expenditure funded by regional budgets is greater in the regions where there is less poverty and less health needs" (1998:49). For instance, he quotes that in 1995 in Cajamarca 6 dollars[3] was spent per person with no insurance, while in the Callao[4] it was 42 dollars. The funds of the Program Basic Health for Everyone does not show the same problem, and are not concentrated in the poorest regions. Using the same example, this program designated 2 dollars per person not covered by insurance to Cajamarca and 3 dollars to Callao. Considering that the target population is not necessarily the uninsured population but mainly the poor, the analysis does not vary.

---

[3] Peruvian currency, 1 dollar is roughly equivalent to 3.5 soles.
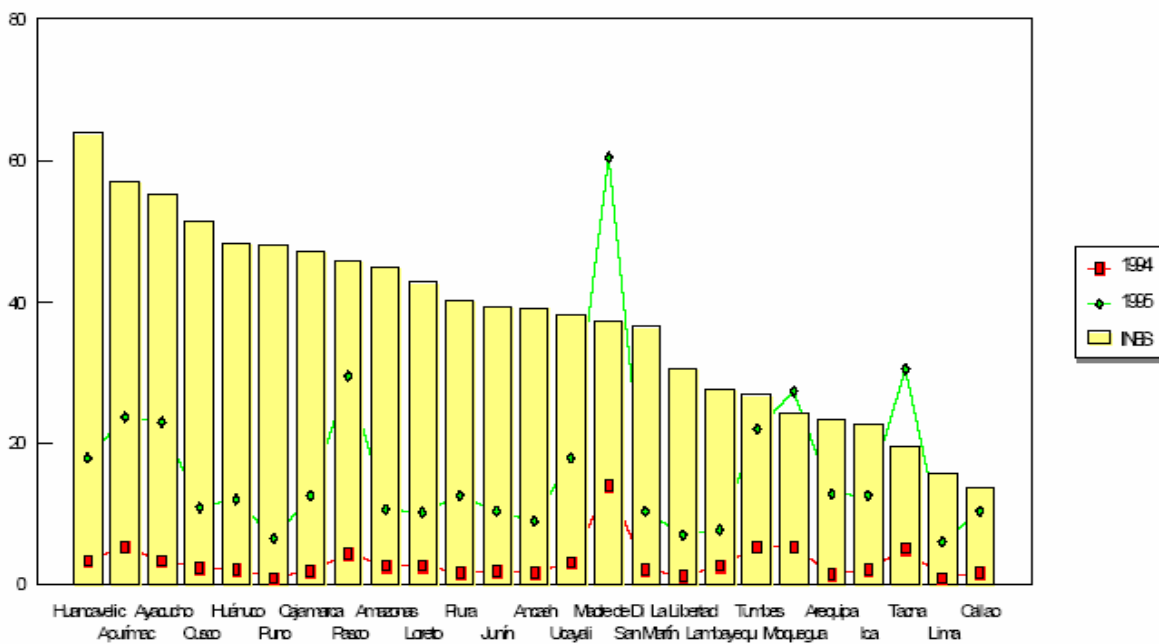[4] This is a province located in the Department or region of Lima.

Figure No. 2: Total Expenditure (In Soles) in Health and Health Needs (NBS in Spanish acronyms)
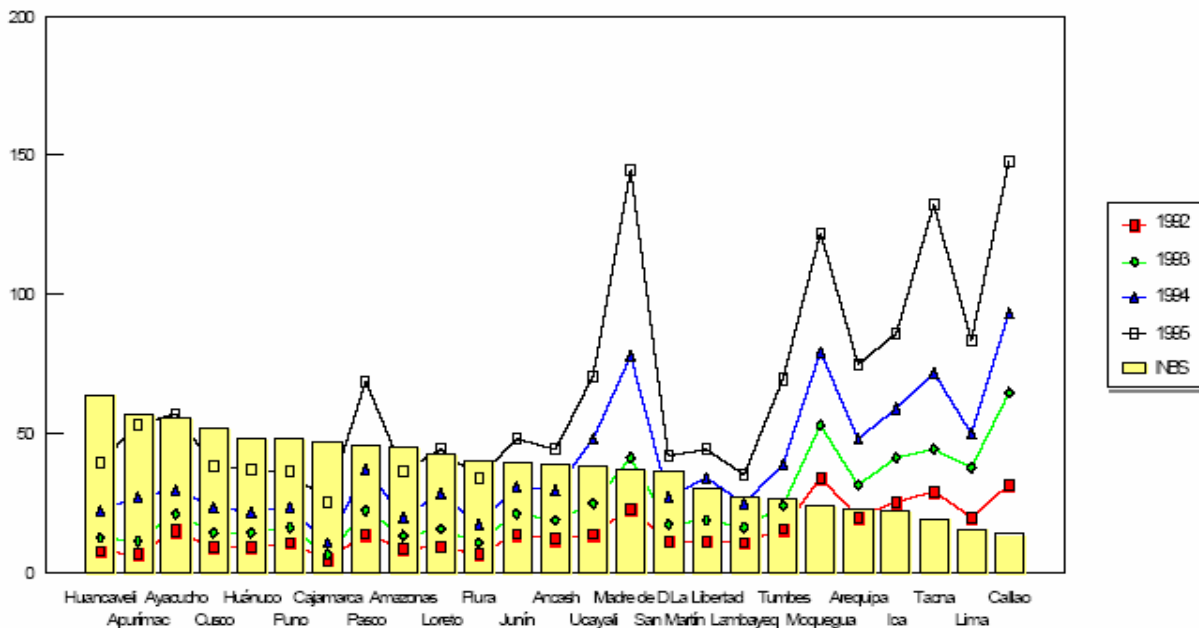
Source: Francke 1998.

Figure No. 3: Total Expenditure in the Program Basic Health for Everyone and Health Needs (NBS in Spanish Acronyms)

Source: Francke 1998.

Comparing Figure No. 2 and No.3, it is noticeable that both total and targeted public health expenditure has simultaneously increased inequality across regions from 1992 to 1995. In 1992, although disparities existed, just Tumbes, Tacna, Lima and Callao demonstrate that total public expenditure surpassed health needs. Moving from 1994 to 1995, this situation is manifested in more regions. Although, the mismatch is less in the case of targeted expenditure, compared to 1994, in 1995 three regions, Madre de Dios, Tacna and Ancash, are noticeable for being targeted despite their comparative lower health needs.

Interestingly, none of these regions demonstrates a high reduction of IMR in the period 1996-2000. Although investment is higher in Huancavelica, Apurimac and Ayacucho, they also have higher health needs that are financially less covered particularly in the targeted programs. These trends suggest that even a small increase of public investment in general as well as targeted programs have greater impact on IMR.

Despite the inequalities of public investment, it can be argued that the comparative less investment have produced greater impact on infant mortality reduction. Huancavelica, Moquegua, Puno and Ayacucho started with a relatively high infant mortality rate than regions such as Lima and Tacna. As shown in Table No.1, Southern Andean regions such as Huancavelica, Puno and Ayacucho still demonstrate high infant mortality rates in 2000, but they also account for most of the reduction between 1996 and 2000. Conversely, regions with lower infant mortality rates account for less in the reduction and are mostly located along the central and South Coast. There are several regions whose relative contribution to the infant mortality rates varies from 4 to 6%, these regions are located in the central highlands and in the Jungle part of Peru. Although, it seems that the levels of the reduction are spatially clustered in certain areas, there are still some variations in specific sectors that deserve greater attention as in the case of Huancavelica in the Southern Andean region and large qualitative variations in the Jungle zone. In absolute and relative terms, Huancavelica has the highest reduction but the reduction is not enough to refrain this region for showing the highest IMR within the Southern Andean neighbors such as Cuzco, Apurimac, and Ayacucho. Even though, Madre de Dios relative contribution is equivalent to Ucayali, its IMR decreased more dramatically. Furthermore, some regions, mainly located at in the northern coast (La Libertad, Ancash), north central Andes (Huánuco) and jungle (San Martín, Loreto) have shown an increase of IMR.

Table No. 1: Regional Infant Mortality Rates, Absolute and Relative Changes from 1996-2000

| Regions	IMR 1996	IMR 2000	Absolute Change	Relative Change
Huancavelica	109	70	-39.0	19.4
Moquegua	52	28	-24.0	11.9
Puno	82	59	-23.0	11.4
Ayacucho	69	50	-19.0	9.5
Piura	56	37	-19.0	9.5
Ica	39	21	-18.0	9.0
Junín	57	43	-14.0	7.0
Madre de Dios	40	28	-12.0	6.0
Ucayali	64	52	-12.0	6.0
Tumbes	47	36	-11.0	5.5
Arequipa	50	40	-10.0	5.0
Pasco	67	58	-9.0	4.5
Cajamarca	58	51	-7.0	3.5
Lima	26	20	-6.0	3.0
Amazonas	51	47	-4.0	2.0
Apurimac	73	71	-2.0	1.0
Tacna	26	24	-2.0	1.0
La Libertad	43	45	2.0	-1.0
San Martín	47	49	2.0	-1.0
Loreto	50	53	3.0	-1.5
Huánuco	59	63	4.0	-2.0
Lambayeque	34	38	4.0	-2.0
Cusco	78	84	6.0	-3.0
Ancash	41	50	9.0	-4.5

Source: DHS
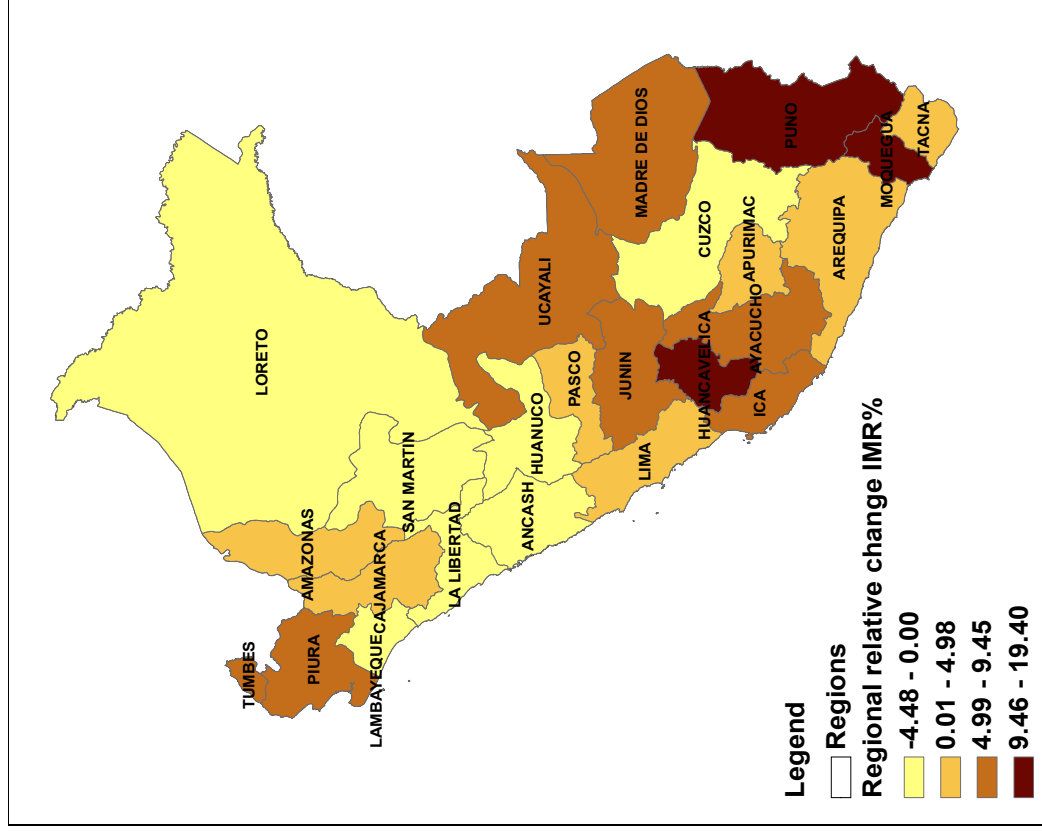
Illustration No.1: Absolute Change of Infant Mortality Rates 1996 2000

The mapping of these differentials does not follow the general path of the natural regional division; that is, Andes, Coast or Jungle, manifesting administrative regional differences as well. This suggests a spatially variable pattern that may be affecting the relative regional contribution to infant mortality reduction. The larger impact can be due to the social characteristics of the population composition in which reduction can be achieved. For instance, most of the literature on Peru has demonstrated that the Andean region which concentrates the higher proportion of rural and indigenous population is the one with more adverse factors for child survival and less access to health services (Deemer et al. 1993, Andes 1992, Behm & Primate 1978, Edmonston & Andes 1982). The large reduction experienced in this area Andes may reach a ceiling effect in the following years if the same social conditions persist. Also, due to the rapid urbanization of the Jungle part, it is necessary to observe whether or not this tendency is accompanied with the improvements of social conditions guaranteeing access, and conversely, contributing to IMR reduction. Therefore, it could be expected that the determinants of these regional IMR as relating to access to health services at an aggregate level may show a differential effect accounting for the social composition of its population, varying also at the sub-regional level.

V. Methodology

5.1 Research Questions

- How does the socio-demographic composition of the population mediate the impact of maternal health services coverage on IMR decrease at the regional level?

- Taking into account this variable population composition, where are the relevant regional differences in the relationship between IMR and maternal health services coverage located?

5.2 Methods

For this project, the unit of analysis is the sub-regions, or provinces. The GPS data set from DHS is composed by 1414 clusters, from with their latitude and longitude coordinates are e geo-referenced[5]. In order to account for the sub-regional level, we aggregated this clusters, resulting in 164 polygons with no missing data. We converted these polygons into centroid data points with a

---

[5] The DHS clusters do not hold unique latitude and longitude coordinates. Therefore, there is a significant overlapping in the data points. Also, when adding data for 1996 and 2000, not all the clusters were sampled resulting in a high proportion of missing data. This is the reason why we opted to aggregate data in the next administrative level in order to capture local variations, avoiding issues of missing cases and large variations of sample sizes.

twofold purpose: to use some point pattern analysis techniques and to reproduce a grid surface to represent geographically weighted regression results.

To this cartographic data set, we attached selected variables reported in the children and women files of the Demographic Health Survey for Peru 1996-2000. The dependent variable is the infant mortality rate approximated by dividing the number of deaths to infants under 1 by the total person-months lived in the interval or the total exposure (as an approximation of total live births). The main independent variable is the use of prenatal care, using as an indicator the percentage of t women that use prenatal care while pregnant. The relationship between prenatal care and infant deaths occurrence will be assessed by using selected socio-demographic intervening factors, which are proportion of poor[6] and low-educated women, and whether or not the cluster is located in a rural area.

As an initial step for the analysis, spatial G* is used to identify clusters of low and high incidence of infant deaths, prenatal health coverage, rural, poor and low educated women. This technique tests for spatial and statistical significance in the distribution of cluster variables. In order to identify a more accurate pattern that can be assessed visually, we performed a Bayesian adjustment for the data-point estimates that could account for 1996-2000 period. The Bayesian approach permits us to keep our interest in deriving a local estimate adjusted to reflect the differing contributions of 'true' variation and the component of overall variation due to random chance.

The Bayes estimator (θ) is calculated based on a weight (W) derived from the prior and observed distributions parameters, in which $\overline{X}_i$ is the mean rate for each data point between 1996 and 2000 and μ is the population mean for the 1996-2000 rate.

$$\theta_{eb} = W_i \overline{X}_i + (1 - W_i)\mu$$

The weight is calculated by the ratio of the prior variance σ_0^2 and the observed variance for each cluster σ^2 / n.

$$W_i = \frac{\sigma_0^2}{\sigma_0^2 + \sigma^2 / n}$$

The advantage of this approach is that the method can be used to show variations on a very fine scale, correcting for small sample areas, and thus pinpoint the areas where the rates are

---

[6] Poverty is measured by using as an indicator the lack of access to piped water.

significant. The bandwidth, or the distance range of frequencies beyond which the frequency function is zero, used to perform the mean distance within data points which is 5,859 meters.

As a second stage, we use a Poisson Geographic Weighted Regression (PGWR), suitable for count or integer variables. Using this technique, we measure the influence of the selected variables on the baseline expected infant deaths for 1996-2000 and can spatially represent them. The advantages of GWR are that it permits to model nonlinearly the local coefficient estimates and also provides adjusted measures for the global pattern. In GWR an observation is weighted in accordance with its proximity to point i so that the weighting of an observation close to i are weighted more than data from observations farther away. For the Poisson regression model GLM provides a basis for PGWR. PGWR, or geographically weighted generalizes linear model, can be specified by allowing the linear coefficients to be arbitrary functions of location points. The calibration method is based on iteratively reweighted least squares, also known as the Fischer scoring procedure. It implies the use on an adaptative kernel which iteratively estimates the expected values of y at each location, adjusting it until convergence.

By this technique, local parameters can be calculated, including coefficients, standard errors and t-values significance level for each point. In the case of logistic GWR, the calibration method is an iteratively reweighted least squares. The modeling is computed using GWR3, a software package designed specifically for this type of analysis. For the Poisson GWR, the software does not provide a Monte Carlo test, to check for local variability. Therefore, we informally test for non-stationarity in the local parameters by comparing 2*standard error with the Interquartile range[7].

We assess the relationship between the use of prenatal care on IMR by comparing two models. Model 1 shows the initial relationship between use of prenatal care and IMR. Model 2 adds the effect of the proportions of poverty, rural the proportions of low-educated women. The logistic GWR results are presented in three outputs for each model, the global model which is equivalent to the general statistical model, the local variability informal test and local parameters summaries for each model. For presentational purposes, we used inverse distance interpolation to represent the variability of cluster coefficients.

---

[7] For more details on this technique, see Fotherington, S.; Brunsdon C. & Charlton, M. (2002).
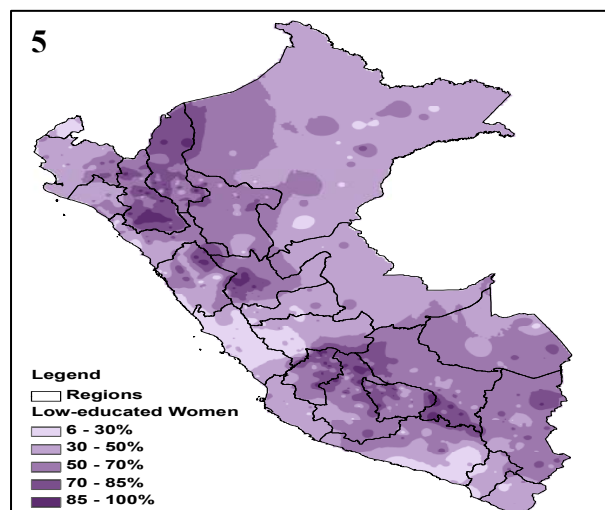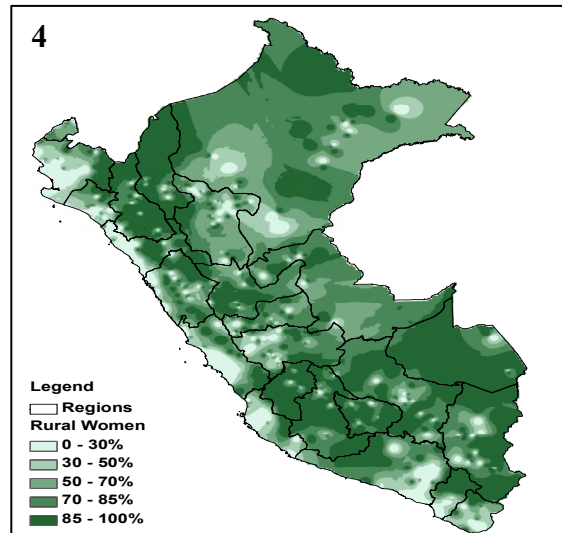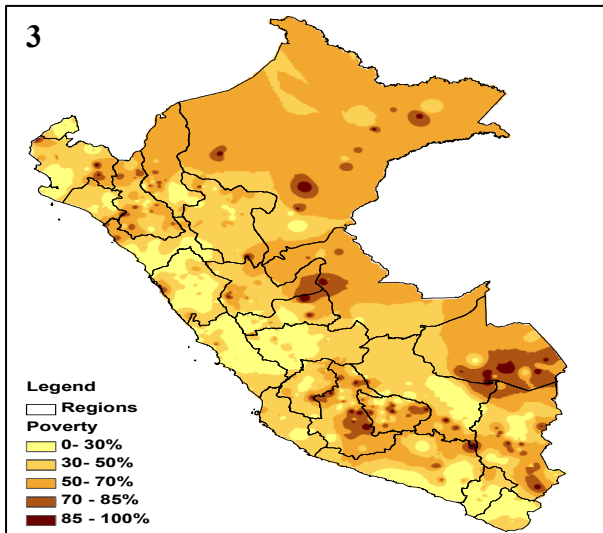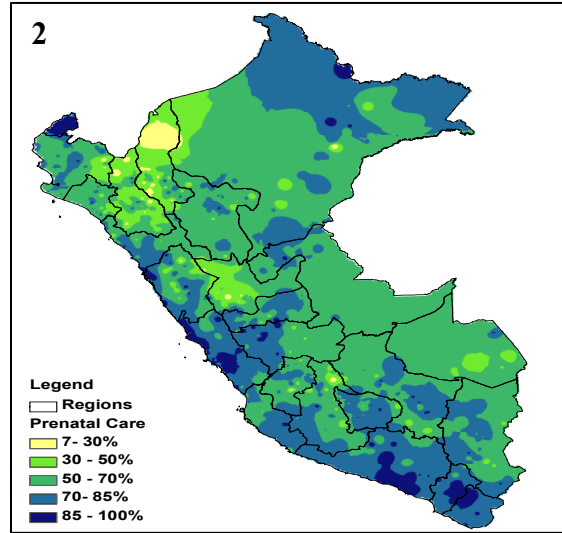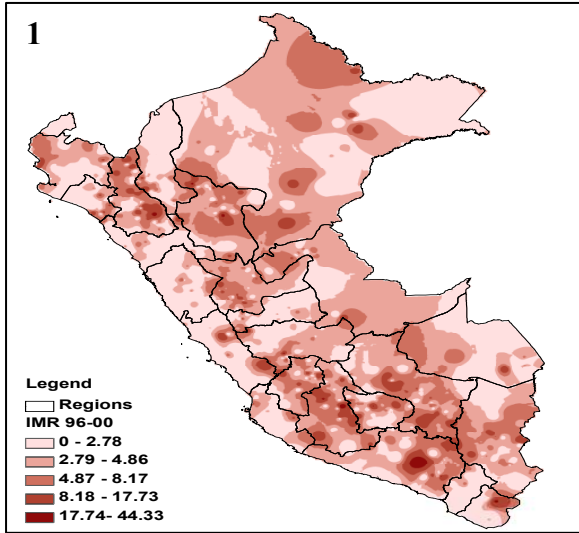
5.3 Hypothesis

- The access to prenatal care is a strong predictor of IMR in the period of 1996-2000.

- High IMRs tend to be negatively clustered in regions with greater access to prenatal care and positively clustered in regions with lower coverage.

- The areas with lower IMRs are the ones in which the proportion of rural, poor and women with low education are low.

- The estimated effect of prenatal care coverage on IMR is larger within non-rural areas in which the proportions of poor, rural and low-educated women are high.

5.4. Data Description

The following maps shown in general patterns the distribution of the variables that will be explored using spatial autocorrelation G* and the logistic GWR. The main characteristics are:

1. The Bayesian adjusted IMR for 1996-2000 demonstrates several areas of high infant mortality rates along the Andes and northern side of the jungle region.

2. The Bayesian adjusted percentage of women that use prenatal care while pregnant for 1996-2000 shows a higher proportion mainly along the Coast and in some areas in the Jungle and Andes in which cities are located. The lowest proportion of prenatal care coverage is located in the Amazon border, located in the upper north. In the south Andes the rate ranges from 60 to 70% of prenatal care use.

3. The Bayesian adjusted proportion of women living in poverty, using as an indicator the lack of access to drinking water, shows a spread pattern between the areas with the highest concentration of poverty. These areas are mainly located along the South Andes, southern Loreto, in the intersections of Ucayali , Huánuco and Junín, and the Northern area including Cajamarca and Amazonas.

4. The Bayesian adjusted percentage of women living in rural areas, as expected, show a higher concentration along the Andes. The central Andes shows large areas with low concentration of rural women and some spots in South Andes.

5. The Bayesian adjusted percentage of women with low education (less than secondary education) shows a more concentrated pattern in the South and North while the central Andes demonstrate lower rate areas.

Illustration 2: Distribution of selected variables

1

Legend
Regions
IMR 96-00
0 - 2.78
2.79 - 4.86
4.87 - 8.17
8.18 - 17.73
17.74 - 44.33

2

Legend
Regions
Prenatal Care
7 - 30%
30 - 50%
50 - 70%
70 - 85%
85 - 100%

3

Legend
Regions
Poverty
0 - 30%
30 - 50%
50 - 70%
70 - 85%
85 - 100%

4

Legend
Regions
Rural Women
0 - 30%
30 - 50%
50 - 70%
70 - 85%
85 - 100%

5

Legend
Regions
Low-educated Women
6 - 30%
30 - 50%
50 - 70%
70 - 85%
85 - 100%

16

VI. Results

6.1 Spatial Autocorrelation

Figures A, B, C and D below show significant clusters in terms of high values (red/pink) and low values (blue/light blue). IMR clusters are represented with bold dots while selected variables are represented by shadowed dots.

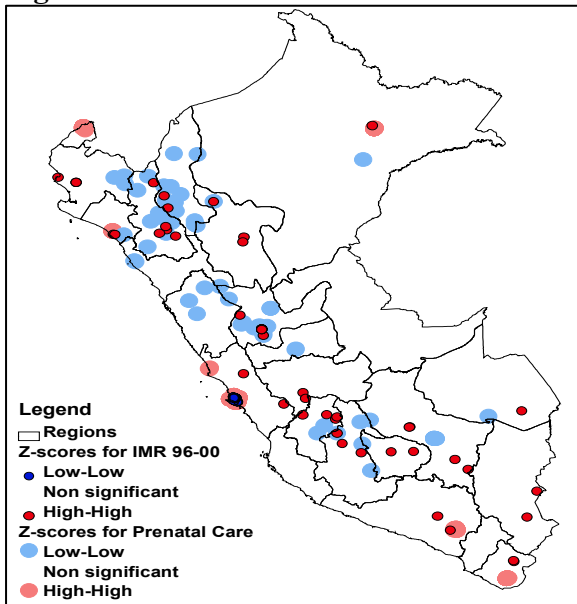**Illustration No.3: Spatial autocorrelation for selected variables**
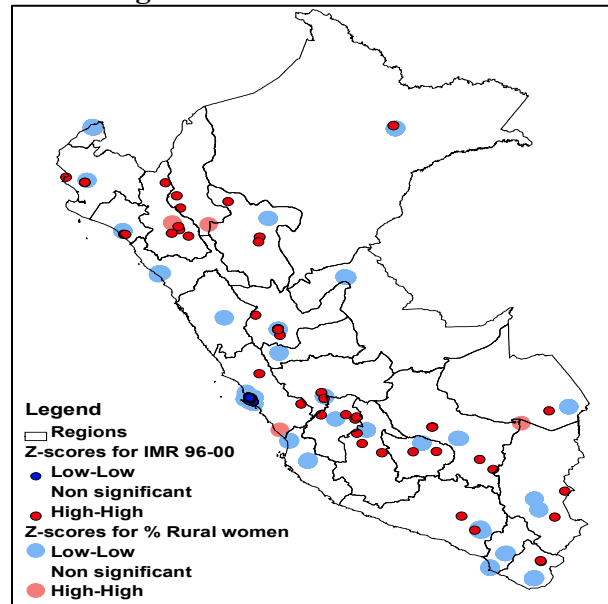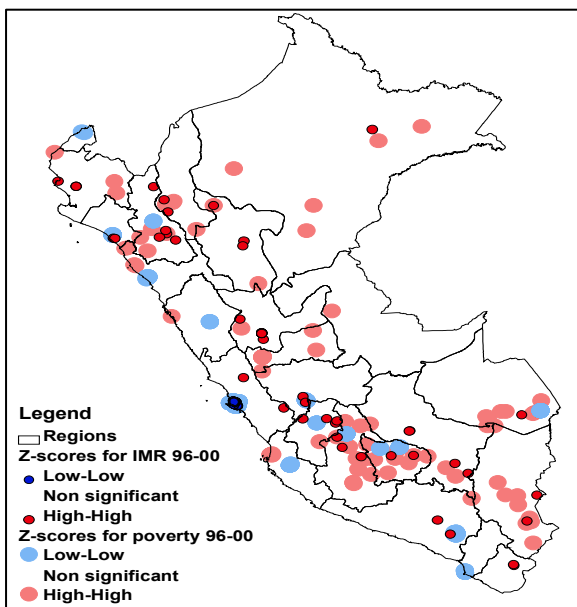
Figure A

Figure B
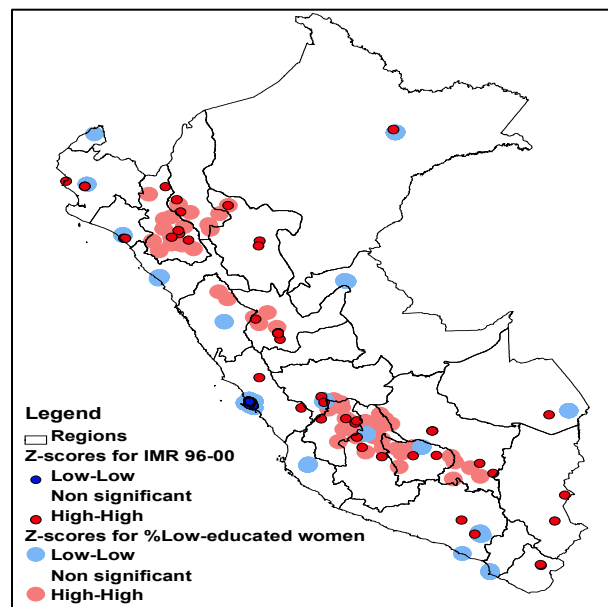

Figure C

Figure D

Figure A shows how IMR clusters overlap with prenatal care clusters. We can observe that both prenatal care and infant mortality suggest a variable spatial process. Generally, it will be expected that locations with low infant mortality are located in areas with high concentration of prenatal coverage. This prediction holds true in the Center Coast, particularly in Lima. Conversely, in the north side the high infant mortality rates are overlapping areas with low prenatal use clusters. Also, some high value IMR clusters in the South Andes also match areas with low prenatal coverage. The deviant cases are located in Loreto in which clusters with high prenatal coverage are matching clusters with high values of IMR.

Figure B contrast IMR clusters with proportion of rural women clusters. Along the coast, there are several low value clusters of the proportion of rural women. However, just in Lima these low clusters match low-value IMR clusters. High value cluster of IMR are matching high value clusters of rural population in the North Andes, specifically inside Cajamarca. Within the South Andes, low value rural women clusters are not matching but are located close to high-value clusters of IMR.

The patterns of clusterization shown in Figure C and D seem to be more related to high values of IMR. Figure C illustrates the proportion of poor women clusters compared to IMR clusters. Most high values poverty clusters are concentrated along the South Andes, matching high values of IMR. The same pattern is observed at the north coast, inside the bordering areas of La Libertad, Lambayeque and Cajamarca. Lima shows a predictable match between low value IMR and low values of poverty. Figure D compares the proportion of low-educated women clusters with IMR clusters. Low value clusters of women with low education are matching high value IMR clusters within the South and North Andes. Along the Coast, Lima demonstrates an overlapping of low IMR clusters with low value clusters of low educated women. Some deviant cases in the Coast are located in Piura and Southern Arequipa.

As stated in the hypothesis, it is expected that clusters with low values of infant mortality are located in areas showing high value clusters of prenatal coverage, low value clusters of women with low education as well as rural and poor women. This prediction holds true in the Center Coast, particularly in Lima. However, in the far southern coast, the clusters of low infant deaths are just related to high prenatal care coverage and low clusters of low-educated women. Except from Lima, low value clusters of the proportion of rural women do not seem to be associated with low infant mortality. In the case of high value clusters of infant mortality, it would be expected

that they tend to be located within areas in which there are clusters of low prenatal care, high low educated, poor and rural women. In the north Andes, high clusters follow the clusterization of high values of low educated, poor and rural women. Low values of prenatal care appear significantly clustered in this zone. Nevertheless, not all high infant mortality clusters are matching areas with those expected characteristics. In the South Andes, clusters of high values of infant mortality are not uniformly located in low prenatal coverage clusters or low rural population clusters. In contrast, they are uniformly distributed along high value clusters of high proportion of less educated and indigenous women. Consequently, we can expect that the relationship between prenatal care and IMR reduction may follow a variable and divergent pattern along these zones.

6.2 Geographic Weighted Regression

This G* spatial autocorrelation suggests a divergent pattern that varies over space while explaining infant mortality outcomes. The impact of prenatal care on IMR is not constant within regions. And, the mediating effect of socio-demographic characteristic is not uniform over space.

In both models, data has been read for 164 data points. The study region lies within an area some 117 km from west to east, and some 152 km from south to north. In model 1, the optimal bandwidth is about 90 objects in the local sample, while in model 2, the optimal bandwidth reaches 141 data points. Therefore, 54% and 85% of the number of observations were respectively selected for model 1 and model 2. These bandwidths will show a very small degree of smoothing. The number of function calls, referring to the number of times fitted to obtain the optimal model are eight for each model.

Table 2 shows a summary of the two global Poisson GWR regression models. The Akaike Information Criterion (AIC) is 336.65 for model 1 and 334.70. In Model 1, areas with lower IMR would appear to be those with higher levels of prenatal care coverage. If there is a one percent increase on prenatal coverage, the difference in the log of expected infant deaths would be expected to decrease by 0.993 (exp(-0.007)). In the model 2, the significance of prenatal coverage seems to disappear when controlled by proportions of low-educated, rural and poor women. The remaining significant predictor is the proportion of low-educated women. Areas with higher IMR would appear to be those areas with higher levels of low-educated women. Holding the other factors constant, a one percent increase of low-educated women is estimated to increase IMR by 1.010 (exp(0.010).

Table No. 2: Global Poisson GWR Model for explaining changes in IMR96-00 on selected variables

	Model 1		Model 2	
	Parameter Estimate	T value	Parameter Estimate	T Value
% Low-educated Women			0.010	*
Std.error			(0.004)	
% Poor women			0.001	
Std.error			(0.002)	
Rural (1:rural cluster, 0: otherwise)			-0.004	
Std.error			(0.002)	
% Women who received prenatal care while pregnant	-0.007	*	-0.001	
Std.error	(0.003)		(0.004)	
Constant	1.820	*	1.136	*
Std.error	(0.166)		(0.348)	
AIC	336.65		334.70	
-2 Log likehood	332.65		324.70	

*Significant at .05 level

The next table shows the output results for the local model. First of all, note that there is a substantial decrease in the AIC for both models. This suggests that the local model provides a better fit to data than the global model despite the increase in the effective number of parameters. In Model 1, the AIC is 181.31, with 7.28 effective parameters, while in model 2 the AIC is 185.55 with 10.44 effective parameters. Non-stationarity is evident in model 1 for the constant term and in model 2 for the proportion of rural women. Therefore, we can expect more local variability in these two variables as they relate to IMR.

Table No. 3: Local Models and Test for Stationarity

	Model 1			Model 2		
	2x standard error	Interquartile range		2x standard error	Interquartile range	
% Low-educated Women				0.008	0.005	
Rural (1:rural cluster, 0: otherwise)				0.004	0.011	*
% Poor women				0.004	0.003	
% Women who received prenatal care while pregnant	0.006	0.004		0.008	0.004	
Constant	0.332	0.416	*	0.696	0.467	
AIC	181.31			185.55		
-2 Log likehood	166.75			164.67		
Effective number of parameters	7.28			10.44		

* Non-stationarity

In the Table No. 3 we can check the 5 number summaries for the parameter estimates. In Model 1 and Model 2, prenatal care holds a constant negative effect on IMR in all the area under s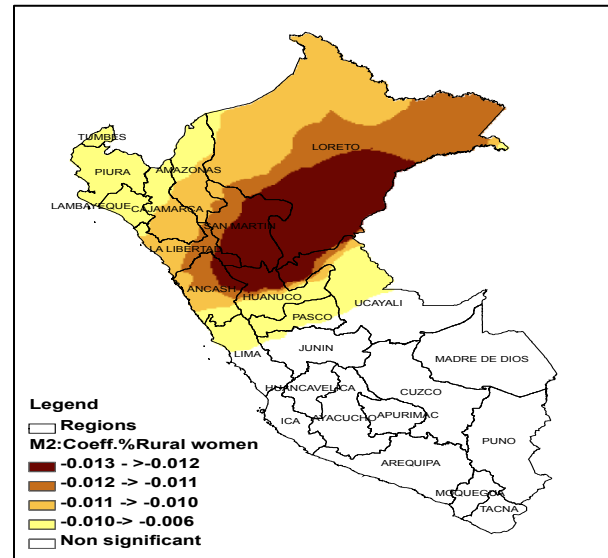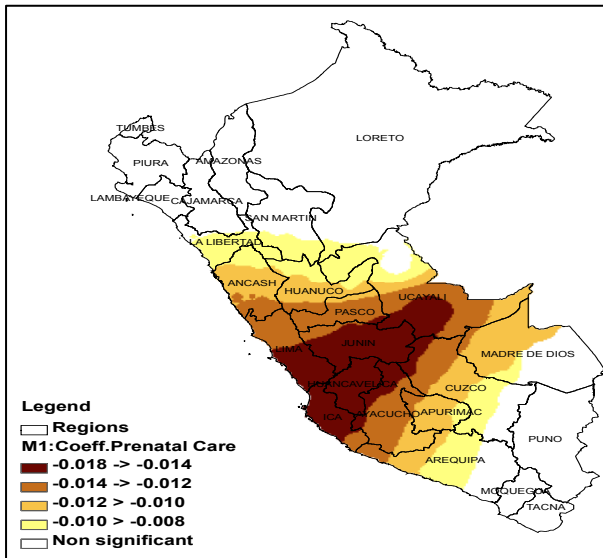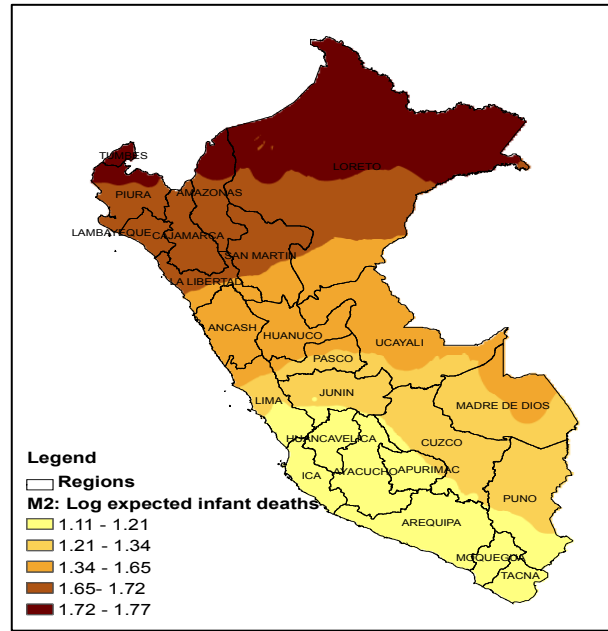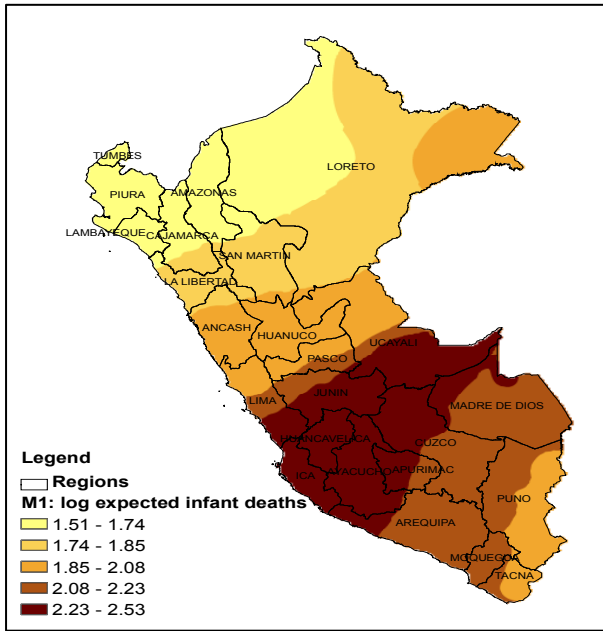tudy. In model 2, at least 75% of the values of the proportion of rural women are negative. Also, only in 25% of the values for proportions of poor women hold a negative effect on IMR. The effect of education on IMR is positive for all the study area.

Table No. 3: Parameter 5 number summaries

Variables	Minimum	Lwr Quartile	Median	Upr Quartile	Maximun
Model 1					
% Prenatal Care	-0.018	-0.012	-0.010	-0.007	-0.001
Constant	1.516	1.783	1.967	2.199	2.540
Model 2					
% Low educ.	0.007	0.008	0.011	0.012	0.015
% Rural	-0.012	-0.010	-0.009	0.007	0.002
% Poor	-0.004	-0.001	0.001	0.002	0.003
% Prenatal Care	-0.009	-0.008	-0.006	-0.003	-0.002
Constant	1.114	1.209	1.377	1.676	1.774

The test of variability suggest that the constant term in both models, prenatal care in model 1 and just the proportions of rural women are the variables that can accurately shown a significant variation in the local estimates. Nevertheless, the global model also brings attention to education. In the following illustration we map local coefficients of each model for those who are significant at 0.05 level. In model 2, poverty and prenatal coverage rendered non significant results for the whole area under study. Curiously, the constant term flips from south to north from model 1 to model 2. Model 1, in which IMR is explained by prenatal care coverage, shows that prenatal coverage is a strong predictor in the center to the central south and southern Peru, reaching regions of the South Andes, which may suggest a large impact of public policy. Nevertheless, when adding the controls of socio-demographic variables in model 2, the constant flips to the north. Neither low-education nor rural population reaches the South Andes. Rather, the east side of the Jungle area is much more sensitive to these variables, explaining variations in the Central-North Andes and reaching part of the central coast particularly in the case of education.

Illustration 4: Model 1 and Model 2 Local Coefficients of IMR 96-00 on selected variables

Legend
Regions
M1: log expected infant deaths
- 1.51 - 1.74
- 1.74 - 1.85
- 1.85 - 2.08
- 2.08 - 2.23
- 2.23 - 2.53

Legend
Regions
M2: Log expected infant deaths
- 1.11 - 1.21
- 1.21 - 1.34
- 1.34 - 1.65
- 1.65- 1.72
- 1.72 - 1.77

Legend
Regions
M1:Coeff.Prenatal Care
- -0.018 -> -0.014
- -0.014 -> -0.012
- -0.012 > -0.010
- -0.010 > -0.008
- **Non significant**

Legend
Regions
M2:Coeff.%Rural women
- -0.013 - >-0.012
- -0.012 -> -0.011
- -0.011 -> -0.010
- -0.010-> -0.006
- **Non significant**

Legend
Regions
M2: Coeff.%Low educ.women
- 0.011 - >0.012
- 0.012 - >0.013
- 0.013 - >0.014
- 0.014- >0.016
- **Non significant**

Conclusions

Overall, our results suggest that sub-regional differentials are highly important when accounting for the association between use of prenatal care and infant mortality. In general trends, the importance of this access is meaningful for the period 1996-200, when coverage has increased as well. Nevertheless, socio-demographic variables can blurred the impact of prenatal use, suggesting that the impact of policy may be also reflecting the changing nature of the social composition of that period. Education, as classical studies on IMR for the developing countries has emphasized, remains as the principal predictor to determine the success of maternal health access. With the increasing urbanization trends, the proportion of rural population has not necessarily to uniform strong impact on the effectiveness of these policies.

The poverty impact has to be revised. The lack of significance in these tests can not yield to a definite conclusion. It is necessary to test for other indicators or a index that can accurately described the poverty effect.

The significance of this relationships tested at the regional level suggest that there are more factors explaining the reduction of IMR in regions with high reduction. I fail to explain why infant mortality rates are much more heavily reduced in the South Andean regions regardless their adverse factors. It can only be stated that education barriers conditions the success of the access to maternal health programs for 1996 and 2000 and the proportion of rural population holds a strong effect in the jungle side.

In this sense, further research is needed to assess the impact of other policies such as assistance at the moment of delivery, and the coverage of other health programs. This could be done if aggregate data also improves in quality and is collected in permanent time series. Still, the exercise suggests that this methodology has a great potential to assess policy and to produce more aggregate estimates to orient policy-making.

References Cited

Andes, N. (1989). "Socioeconomic, Medical Care and Public Health Contexts Affecting Infant Mortality: A study of Community-Level Differentials in Peru." <u>Journal of Health and Social Behavior</u> 30 (4): 386-397.

Behm, H. (1979). "Socioeconomic Determinants of Mortality in Latin America." In <u>Proceedings of the Meeting on Socioeconomic Determinants and Consequences of Mortality</u>, El Colegio de Mexico, Mexico City:UN/WHO.

Caldwell, J. (1979) "Education as a Factor in Mortality Decline: An Examination of Nigerian Data." <u>Population Studies</u> 33:395-413.

Dammert, A. Acceso a servicios de salud y mortalidad infantil en el Perú. Lima.2001

Demeer, K., R. Bergman, et al. (1993). "Sociocultural Determinants of Child-Mortality in Southern Peru - Including Some Methodological Considerations." <u>Social Science & Medicine</u> 36(3): 317-331.

Ferrando, D. La mortalidad infantil en el Perú: niveles y tendencias, 1955-1990: proyecciones, 1990-2000. Lima. 1993

Fotherington, S.; Brunsdon C. & Charlton, M. 2002. Geographically weighted regression : the analysis of spatially varying relationships. Chichester : Wiley, 2002.

Francke, P. 1998. Focalizacion del Gasto Publico en Salud en el Peru: situación y Alternativas Lima: Partnerships for Health Reform.

Gotmaker, S. and P.H. Wise (1997) "The First Injustice: Socioeconomic Disparities, Health Services, Technology and Infant Mortality" <u>Annual Review Sociology</u> 23: 147-170.

Hobbs F., E. Arriaga & Johnson P. (1982).Techniques for estimating infant mortality / by. Washington, D.C. : U.S. Dept. of Commerce, Bureau of the Census.

International Family Planning Perspectives 1986 "Public Health Programs Greatly Reduce Infant Mortality in Costa Rica" 12 (3):103-104.

Mosley H and L Chen. An analytical framework for the study of child survival in developing countries. International Population Conference 1981 2:97-112

Murillo, J.P. 2002. Efecto de las Intervenciones en salud en el perfil de determinantes intermedios y proximos de la mortalidad infantil. Working Paper. Lima, Octubre 2002. INEI-DHS

Paxson, C. and N. Schady (2005). "Child health and economic crisis in Peru." <u>World Bank Economic Review</u> 19(2): 203-223.

Preston, S. (1980). "Causes and Consequences of Mortality Declines in Less Developed Countries during the Twentieth Century." In <u>Population and Economic Change in developing Countries</u>, edited by Richard A. Easterlin. Chicago: University of Chicago Press.

Turner, R. (1991). "Better Access to Health Services in Nicaragua Lowered Infant Mortality." <u>International Family Planning Perspectives</u> 17 (2):77-78.

Vicuña, O.M. Efecto de la intervenciones del estado en la utilización de servicios de Salud maternos en el Perú 1991'2000 cambios y factores. INEI, DHS, 2002.

Vicuña, OM. J.P Murillo and V.S Ampuero. Evaluación de los efectos de los Acuerdos de Gestión 1999 en redes de servicios de salud, uso y percepción de servicios de salud en la población beneficiaria. MINSA-PAAG-SBPT'AC 2000