Original Article

Diarrhea and parasitosis in Salta, Argentina

Cristian F. Aramayo[1], José F. Gil[1], Mercedes C. Cruz[1], Hugo R. Poma[1], Michael S. Last[2], and Verónica B. Rajal[1,2,3]

[1]*Instituto de Investigaciones para la Industria Química (INIQUI-CONICET, UNSa)*
[2]*Fogarty International Center (FIC-NIH), UC Davis, USA,*
[3]*Facultad de Ingeniería, Universidad Nacional de Salta, Buenos Aires*

Abstract

Background: Salta city is the capital of the province with the same name located in the northwest of Argentina. Its great growth over the last decade was not organized and the population expanded to occupy places where water and sanitation were not yet available. Although the Arenales River, crossing the city, receives the impact of point and non-point source pollution, the water is used for many purposes, including domestic in the poorest areas, industrial, and recreational with children as the main users. According to the World Health Organization, an estimated 24% of the global disease burden and 23% of all deaths can be attributed to environmental factors. In particular, an estimated 94% of the diarrheal burden of disease is attributable to environment, and is associated with risk factors such as unsafe drinking water and poor sanitation and hygiene. Chronic diarrhea can be caused by an infection or other etiologies; however, most of the times the etiological agent is not identified.
Methodology: All the cases of diarrhea and parasitosis reported during 2005 in four public health centers of the city of Salta were classified by gender and age, analyzed, and represented geographically to show areas of higher morbidity rates, which were probably related to environmental factors.
Results: Water, poor sanitation, and pollution are candidate risk factors. Diarrhea cases showed seasonality, with the highest incidence during late spring and summer, while parasitosis was persistent throughout the year.
Conclusion: Our spatial analysis permitted us to detect the regions of higher incidence of diarrhea and parasitosis during 2005 in the area of study.

Keywords: Diarrhea; parasitosis; Geographical Information Systems; Argentina

J Infect Developing Countries 2009; 3(2):105-111.

Received 18 May 2008 - Accepted 22 September 2008

Introduction

Salta, a province located in the northwest of Argentina, has a total surface of 155,488 km^2 and a population of 1,067,350 inhabitants, 46% of whom live in its capital, Salta city. The main economic activities in the province are agriculture, cattle ranching, petroleum, electricity, mining industry, and tourism. The city of Salta has grown a great deal in the last decade. This growth was not organized and the population expanded to occupy places where basic services (water and sanitation) were not yet available; 59% of homes are poor in Salta city and 32% are under the line of poverty [1]. According to Aguas de Salta (a private company in charge of water and sanitation services since 1998), 97% and 71% of the total population receive drinking water and sanitation, respectively [1].

The Arias and Arenales rivers originate in the Eastern Andes and join before the city of Salta, becoming the Arenales River. The river runs through a semi-rural area where the main uses are water supply for a drinking water plant, agricultural irrigation, and for livestock maintenance. Then, west to south-east, the river crosses Salta city, and at the south discharges into the Cabra Corral reservoir, which provides hydroelectric energy and water for recreational activities, fishing, and irrigation to downstream locations. When crossing the city, the river receives the impact of point and non-point source pollution, such as illegal discharges of raw domestic wastewater, storm-water, illegal and improper solid waste disposal, and discharges of industrial effluents. Despite these pollutants, the water is used for many purposes, including domestic in the poorest areas (hygiene, cooking, watering plants and vegetables that are growth for self-consumption, animals, etc.), industrial, and recreational where children are the primary consumers. The impact of these pollutants on the population is significant. Previous studies performed on the river (in water and sediments) showed increasing concentrations of some ions (Na^+, K^+, Ca^{++}, Cl^-, and HCO_3^-); trace elements (As, Cd, Cu, Cr, Mn, Hg, Ni, Pb, Zn, and B), some of them in concentrations that affected the aquatic life; and the presence of parasites such as *Balantidium coli*, *Entamoeba histolytica*, *Entamoeba coli*, and *Giardia lamblia* [2]. Although Salta's environmental laboratory is currently monitoring some physicochemical parameters, inorganic compounds and indicator bacteria, the contamination situation has not changed to date.

According to the World Health Organization, an estimated 24% of the global disease burden and 23% of all deaths can be attributed to environmental factors. These numbers differ strongly between non-developed (350 to 500 deaths/100,000 population) and industrialized countries (100 to 150 deaths/100,000 population). Diseases with the largest absolute burden attributable to modifiable environmental factors included, in decreasing morbidity rate: diarrhea, lower respiratory infections, "other" unintentional injuries, and malaria. In particular, an estimated 94% of the diarrheal burden of disease is attributable to environment, and is associated with risk factors such as unsafe drinking water and poor sanitation and hygiene. Children 0 to 14 years of age contribute 19% and 1.5% of the diarrhea and intestinal nematode infections, respectively, within the environmental burden of disease [3].

Parasitosis can be briefly defined as the infestation or infection with parasites [4], while diarrhea is defined clinically as loose, watery, and frequent stool [5]. It is considered chronic or persistent when loose or frequent stools last for more than two weeks. Chronic diarrhea can be caused by an infection or other etiologies. According to the US Center for Disease Control [6], diarrhea not caused by an infection may result from antibiotics, high blood pressure medications, cancer drugs, Crohn's disease, colitis, diabetes, thyroid and other endocrine diseases, food additives (sorbitol, fructose, and others), food allergies, previous surgery or radiation of the abdomen or gastrointestinal tract, tumors, reduced blood flow to the intestine, heredity, and travel. The principal pathogens responsible for causing persistent diarrhea have long been recognized to be the parasites *Giardia lamblia* and *Entamoeba histolytica*. However, numerous other enteric pathogens, including bacteria (*Escherichia coli*, *Shigella*, *Salmonella*, *Campylobacter*, *Aeromonas*, *Clostridium difficile, listeria monocytogenes*), mycobacteria (*Mycobacterium tuberculosis* and *Mycobacterium avium-intracellulare*), viruses (rotavirus, adenovirus, enterovirus, Norwalk-like viruses, pestivirus, astroviruses, HIV), fungi (the role is not clear but *Candida* is frequently associated with persistent diarrhea), and other parasites (*Microsporidia*, *Strongyloides stercoralis*, *Cryptosporidium parvum*, *Cyclospora cayetanensis*) can also contribute to more persistent, as well as to acute, diarrheal illnesses [7-9]. However, most often, the etiological agent of diarrhea is not identified.

The main route involved in these infectious illnesses is the oral-fecal, and contaminated water and foods are the principal vehicles for the pathogens. Poor hygiene is also considered a major cause. Thus, chronic diarrhea can be prevented by drinking clean or purified water, using proper food handling techniques, and by maintaining proper hand-washing habits.

There is a wide variety of software to analyze, evaluate, and help in making decisions for different complex situations in public health. Geographic Information Systems (GIS) are currently used to organize, visualize and analyze the information available in geographical areas to assess for the validity of some hypotheses or to modify them. GIS are useful for the surveillance and control of public and environmental health [10], especially considering that an important burden of illness is attributed to environmental factors [3]. In these cases, GIS allows for the visualization of the geographical regions of higher risk for a certain illness, the identification and analysis of the spatial factors related [11,12], and the assessment of the evolution of illnesses along time [13].

The aim of this work was to demonstrate the application of GIS analysis to the diarrhea and parasitosis cases reported during a year in a region of Salta city in order to determine the possible impact of the Arenales River on the Standard Morbidity Rate. Higher morbidity in areas close to the river would support our hypothesis that contamination of available water supplies with pathogens significantly contributes to a major public health problem, childhood and infant diarrhea and parasitosis. To accomplish this goal, the cases of diarrhea and parasitosis reported during 2005 in four health centers of Salta city were classified, analyzed, and represented geographically with the purpose of identifying areas of higher morbidity rates or higher risk, which most probably were related to environmental factors. We hypothesize that this approach can demonstrate to public health officials in developing countries that analysis of the relationship between the water supply and clinical disease, in conjunction with subsequent GIS-guided analysis of specific contaminants in the drinking water supply, will allow for prioritization of precious capital for water purification where they will do the most good.

Materials and Methods

Source and organization of data

The area of study (33,175 inhabitants according to Census 2001) included seven neighborhoods of Salta city: Arenales, Don Ceferino, Municipal, Vélez Sarsfield, San Antonio, Hernando de Lerma, and Soledad, the first four of which are located on one bank of the Arenales River. The epidemiological information was collected at the only four Health Centers (Nº 3 Barrio Hernando de Lerma, Nº 4 Villa San Antonio, Nº 43 Barrio Evita and Nº 48 Barrio Don Ceferino) of the area for the period from January to December of 2005 from the Statistical Reports of Ambulatory Medical Assistance (Official Form C4). The date, gender, age (in years for older than one, and in months and days for younger), address (converted in Gauss-Krüger coordinates), and diagnosis (as diarrhea or parasitosis) were registered.

The diarrhea (DC) and parasitosis cases (PC) diagnosed and treated at the four health centers (HCs) under study were classified by age and gender, and grouped in quarters (c) according to the frequency of occurrence to analyze for the seasonal effect. There are no other public or private HCs in the area, so people tend to go only to those included in this study, especially for minor illnesses. However, they will often seek assistance in more distant public hospitals or private clinics for more complex situations.

Spatial analysis

The population data were obtained from the Instituto Nacional de Estadísticas y Censos (National Institute of Statistics and Census, INDEC) and provided by the Dirección General de Estadísticas de la Provincia de Salta (General Agency of Statistics of the Province of Salta, DGE). They correspond to the 2001 Census, organized by radium (a subdivision adopted by INDEC for the collection of census information) and fractions, since the corresponding information was not available for the year 2005.

For each quarter (c) and block (m) the Standard Morbidity Rate ($TME_{m,c}$) was determined by taking into account the cases reported and the total population per block and quarter. The population per block was calculated by dividing the population per radium by the number of blocks in it, assuming a uniform distribution.

The global prevalence rate of the area per quarter (tp_c) was later determined as the ratio of the total number of positive reported cases in that period (P_c, from the health care centers) and the total population of the area (N, obtained as the addition of the population of all blocks of the area). The expected number of positive cases per block and quarter ($Pe_{m,c}$) was calculated as the global prevalence rate of the area per quarter, times the population per block ($Pe_{m,c} = tp_c \times N_m$). Finally, the standard morbidity rate per block and quarter ($TME_{m,c}$) was calculated as the ratio between the positive reported cases ($P_{m,c}$) and the expected positive ($Pe_{m,c}$), both per block and quarter.

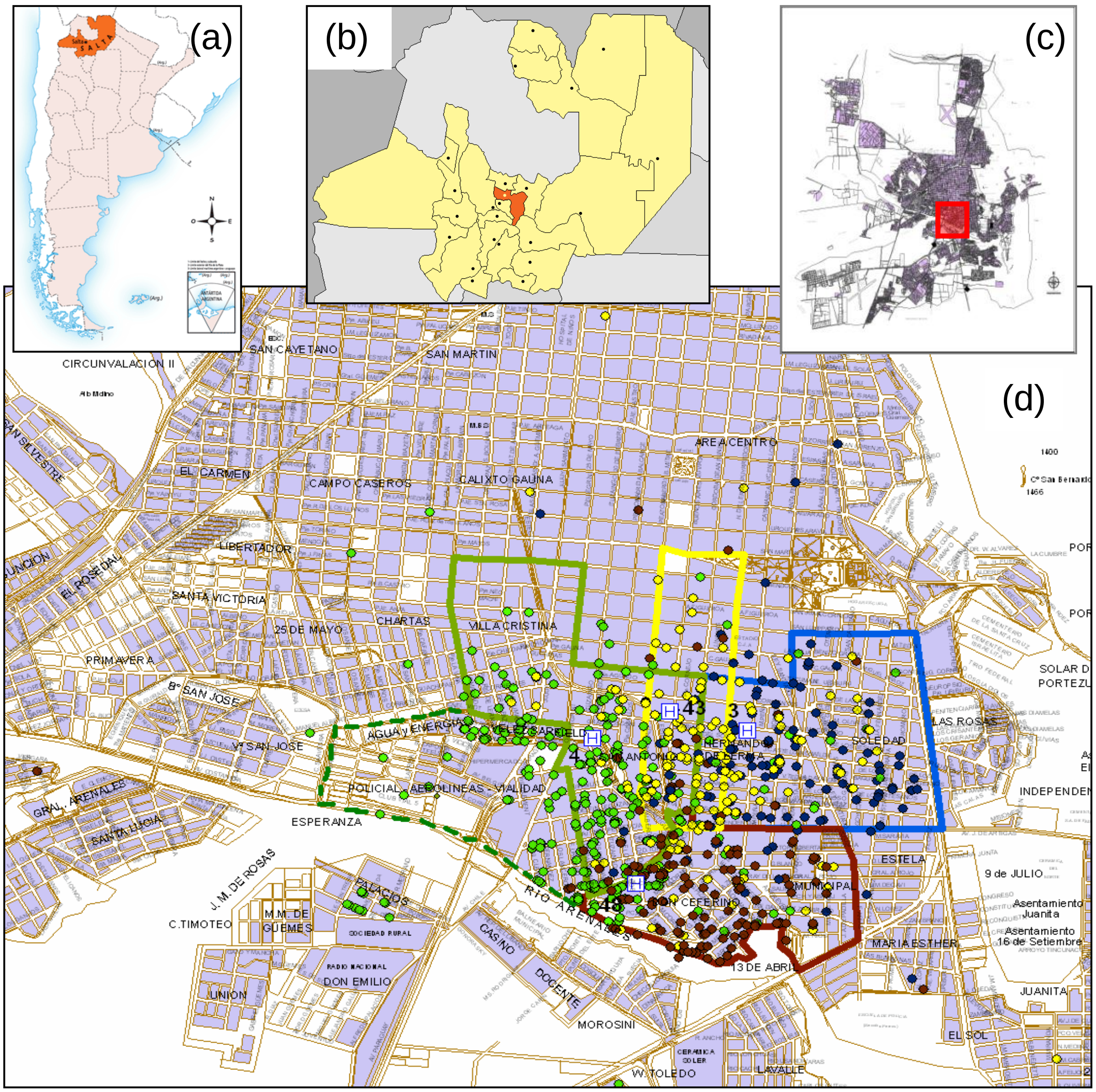
The $TME_{m,c}$, as well as the rest of the information collected were geo-located in the centroid of each block. The spatial distribution of $TME_{m,c}$ was smoothed using a kernel density function with the software Spatial Analyst from ArcGIS (ESRI, http://www.esri.com). The kernel density assigns a number ($TME_{m,c}$ in this case) to the centroid of the block and scales it over a circular area emanating from the centroid for a distance defined by a radius. The selection of the radius, which may be thought of as the sphere of influence, can significantly affect results and their interpretation. As the radius increases, local information may be diluted, and smoother or more gradual differences in the distribution of cases are predicted. The selection of the radius length for the kernel density in this study was chosen to include all the neighbour blocks of a particular block, which is equivalent to assuming that the value of P in a block is only influenced by the values obtained at the neighbour blocks. The Chi-square test was applied to evaluate the null hypothesis that the frequency of cases observed per quarter does not differ significantly among the different quarters ($p \geq 0.05$). A relatively large percentage (17%) of the total cases was not included for the spatial analysis due to lack of address (illegible handwriting of the practitioner, non-existent address, or address not declared by the patient). The information was represented in a georeferenced map using the software ESRI® ArcMap™ 9.1.

Table 1. Total of diarrhea and parasitosis cases reported at the four health centers under study during 2005 classified by gender and age.

Diagnosis	Gender	Intervals of age (years)							Total
		[0 - 1)	[1 - 5]	(5 - 14]	(14 - 20]	(20 - 60)	[60 - 85]	NR	
Diarrhea	Female	49	150	34	22	96	32	6	**389**
	Male	63	199	48	11	64	25	6	**416**
	Total	**112**	**349**	**82**	**33**	**160**	**57**	**12**	**805**
Parasitosis	Female	5	92	69	8	26	1	1	**202**
	Male	8	100	79	5	4	3	0	**199**
	Total	**13**	**192**	**148**	**13**	**30**	**4**	**1**	**401**

Note: Open intervals indicated by parenthesis do not include the value, while closed intervals indicated by square brackets do include the value.

Figure 1. Geographical representation of the area under study



(a) Province of Salta in Argentina, **(b)** Capital Department in the Province of Salta, **(c)** area of study in Salta City, main city of the Capital Department, **(d)** diarrhea and parasitosis cases (dots) and Health Centers (H) in the area of study (each color corresponds to a different center).

Results

Each of the four HCs under study has a specific assignment (see boundary lines in different colors in Figure 1, d) for medical assistance coverage established by the health authority. The DC and PC cases diagnosed and treated at each HC are marked as dots (with the related color) according to the address of the patient. As represented in Figure 1, d, most of the people sought assistance at their corresponding HC, although there were some other cases reported that were included in the study. The dashed green line corresponds to an extension of the original assigned area for the HC N° 4 (solid green line). As there are no other public or private possibilities for medical assistance in the area, people living in these neighbourhoods usually go to the HCs shown, especially for minor illnesses, since they are close to home and faster, while they prefer going to private doctors, hospitals or clinics downtown for situations of higher complexity. If a large number of people sought health care in neighbourhoods other than that of their residential addresses, the conclusions presented here would be affected, but given how few people travel far to attend the local HC, we think this is unlikely.

The DC and PC diagnosed and treated at the four health centers under study, classified by age and gender, are summarized in Table 1. About half of the total cases (57% for DC and 51% for PC, respectively) occurred in children under five years of age and 87% of the PC corresponds to children up to

Figure 2. Quarterly frequency of diarrhea and parasitosis cases reported at the four health centers under study during 2005.

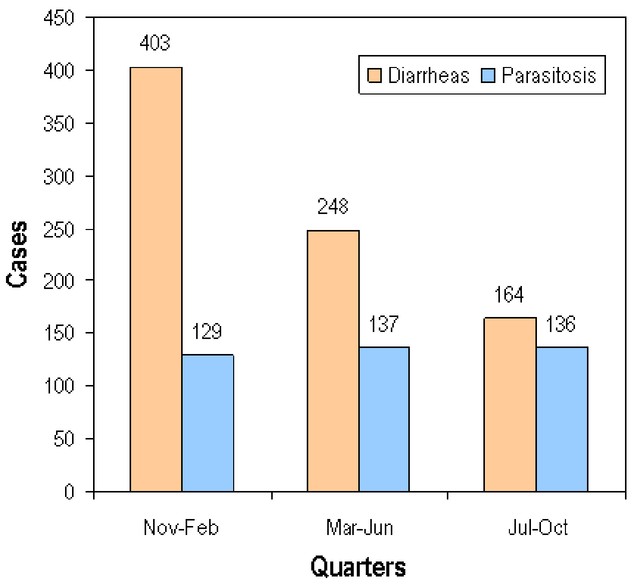
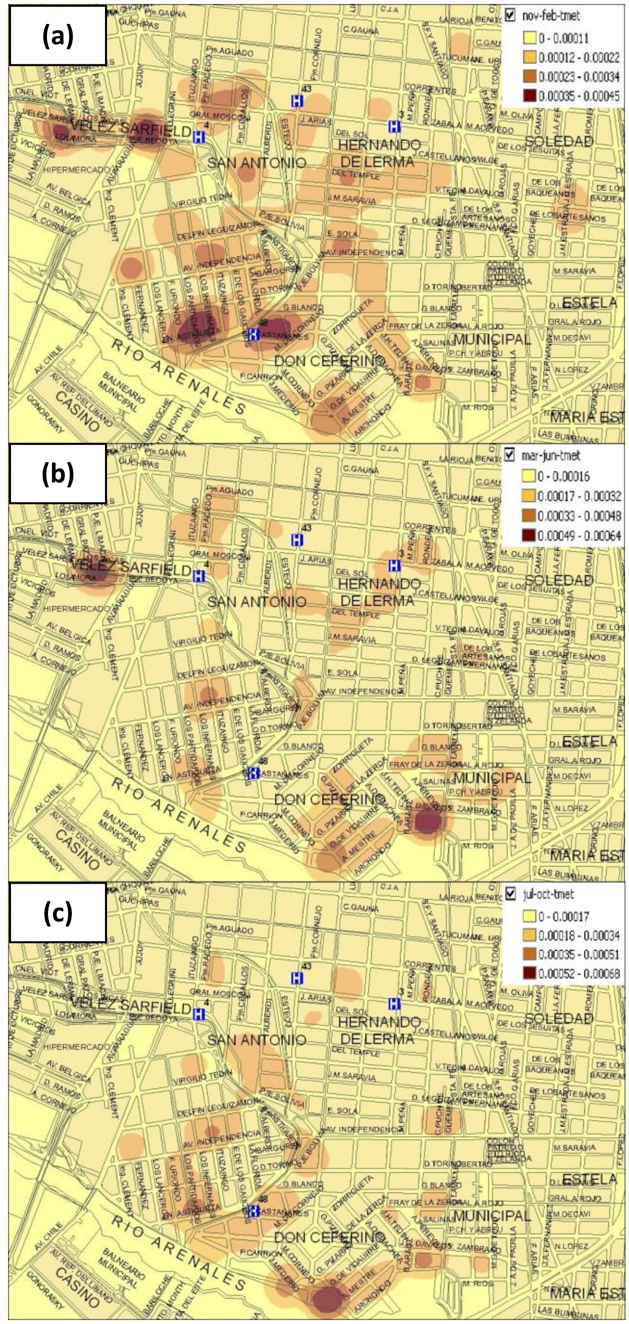


Figure 3. Spatial distribution of TME for the months of 2005.

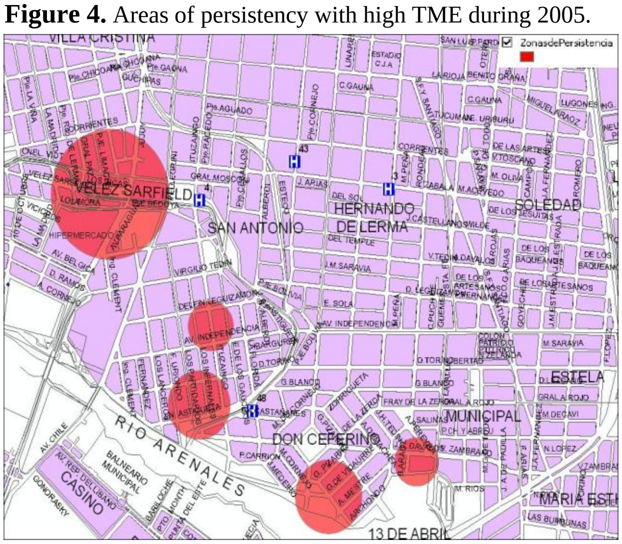


(a) November to February (late spring and summer), (b) March to June (fall) and (c) July to October (winter and early spring). The "H" symbols correspond to the Health Centers under study.

the age of 14. The number of DC for girls is notably lower than that for boys up to 14 years old, while the opposite trend is seen for older subjects. The DC and PC were grouped in quarters (*c*) according to the frequency of occurrence (Figure 2), allowing the visualization of the seasonal effect. Diarrheas are high incidence during late spring and summer (November to February at the south hemisphere) and decrease along the year ($\chi^2 = 107.3$, $p < 0.001$), while parasitosis showed a constant frequency ($\chi^2 = 0.284$, $p = 0.868$). The cases presented here do not include data from the months from January to April for Health Center Nº 48 because they were lost, so the total number of cases is underestimated for the corresponding periods.

The geographical presentation of all the DC and PC (Figure 1, d) were of such high density that the observation of any particular effect was not possible. However, the representation of the spatial distribution of TME_{mc} permitted easy detection of the areas with a higher concentration of cases in relation to the population per block for each quarter (Figure 3). The highest incidence rate was found to occur from November to February (Figure 3, a). From the overlay of spatial distributions per time period it was possible to detect the temporal-spatial patterns of distribution of TME to generate hypotheses about the geographical persistence of those illnesses (Figure 4). This analysis showed that the areas closest to the Arenales River are critical.

Figure 4. Areas of persistency with high TME during 2005.



Discussion

The effort needed to collect, classify and process all the data in Salta was enormous for various reasons. The information was not compiled and organized properly at the Health Centers (in one of them the forms were lost, although it is mandatory to keep them for ten years) and the forms were handwritten, which made the task even more difficult. The geographic systems and the methodology employed to gather/classify information for epidemiologic and demographic purposes are not consistent between institutions; thus the data can not conveniently be used jointly, exchanged, or processed together for a better interpretation of data and for a quick response to public health problems. For most of the cases of diarrhea and parasites, the etiological agent was never identified and even if it was, that information was not later correlated with the initial diagnosis.

The number of cases presented in this study was obtained from Public Health Care Systems; therefore, they constitute an underestimate of the actual amount. The area under study was middle socio-economical class, and a (small) part of the study population may have had access to private medical assistance.

The spatial analysis permitted us to detect the regions of higher incidence of diarrhea and parasitosis during 2005 in the area of study. Our analysis showed that the areas closest to the Arenales River are critical (Figure 4). It would be necessary to perform further studies to determine all of the specific risk factors and to execute corrective and/or preventive actions. However, some obvious factors that contribute are poverty, lack of hygiene, malnourished children, no sanitation in many houses that discharge illegally into the Arenales River (already highly contaminated at that point), and some access limitations to safe drinking water. In summary, GIS are helpful tools for public and environmental health and provided useful information about regions with a high prevalence of gastrointestinal illness in this study. It will be important, and could guide prioritization of subsequent public health interventions, to supplement this study with pathogen water-monitoring information from the Arenales River and from the drinking water network. Salta (and all of Argentina) has been affected by periodic deep economic and social crises, which tend to occur after many years of economic recession. These economic recessions impact all aspects of life, but especially socially critical aspects such as access to work, food, education and health, and disproportionally impact upon the poorest groups of the population. The public health budget, especially in times of crisis, is mainly used for emergencies, while prevention is neglected. While ideally the level of source water contamination may be used to determine the extent of treatment processes needed to ensure public safety, this is generally not the case in this region [14]. In this study we propose an approach to rectify this problem.

Acknowledgments
The authors would like to thank Andres Perez for his invaluable help. This work was funded by the Fogarty International Center at the University of California in Davis (USA). It was performed based on the epidemiological information obtained through a collaboration with Dr. Alberto Gentile at the Epidemiology Coordination Agency of Salta Province. The authors also want to thank the Nivel Primario de Atencion and the Health Centers studied for their support. The worthy help from the Dirección Provincial de Estadísticas y Censos through its director Lic. Mauro Rosas, and directly from Gladis Romero from the Cartography section, is especially appreciated.

References

1. Latinaguas (2003) Latin American and Caribbean Water Week 2003. Available: http://wbln0018.worldbank.org/lac/lacinfoclient.nsf/69bd5cba306da19e8525695d00701f3c/cb337cb6f3abd80785256cf000064d1a/$FILE/SALTA.pdf Accessed in March, 2008.
2. Musso H (2000) Impacto del municipio de Salta sobre la contaminación del río Arenales. Tesis de Maestría. Universidad Nacional de Tucumán. Tucumán, Argentina.
3. Prüss-Üstün A, Corvalán C (2006) Preventing disease through healthy environments. Towards an estimate of the environmental burden of disease: World Health Organization.
4. Medical Dictionary, Parasitosis. Available at: http://medical-dictionary.thefreedictionary.com/parasitosis. Accessed in September, 2008.
5. MedlinePlus, Diarrhea. Available: http://www.nlm.nih.gov/medlineplus/ency/article/003126.htm Accessed in March, 2008.
6. CDC, Center of Disease Control, Parasitic Disease Information, Fact Sheet, Chronic Diarrhea. Available: http://www.cdc.gov/NCIDOD/DPD/parasites/diarrhea/factsht_chronic_diarrhea.htm Accessed in March, 2008.
7. Wanke CA, McAuliffe JF, Guerrant RL (1996) In Pathogenesis of persistent diarrhea. Chapter 10. Guerrant RL., Souza MAD, and Nations MK, editors. At the edge of development. Health crises in transitional society. Durham, North Carolina: Carolina Academic Press.
8. Percival SL, Chalmers RM, Embrey M, Hunter PR, Sellwood J and Wyn-Jones P (2004) Microbiology of waterborne diseases. Amsterdam: Elsevier Academic Press.
9. Cloete TE, Rose J, Nel LH and Ford T (2004) Microbial Waterborne Pathogens. London: IWA Publishing.
10. Peluso F, Cazenave L and Usunoff E (2004) Análisis areal y prospectivo de riesgo sanitario incorporando modelos de transporte de solutos en aguas subterráneas. GeoFocus 4: 166-178.
11. Scholten HJ and Lepper MJCD (1991) in The benefits of the application of geographical information systems in public and environmental health. WHO Statistical Quarterly.
12. Kabel R (1990) in Predicting the next map with spatial adaptive filtering. Fourth International Symposium in Medical Geography. Norwich, UK: University of East Anglia.
13. Ward MP and Perez AM (2004) Herd demographics correlated with the spatial distribution of a foot-and-mouth disease epidemic in Buenos Aires province, Argentina. Preventive Veterinary Medicine 65: 227–237.
14. Rajal VB, Cruz C, Last JA (2008) Water Quality Issues and Infant Diarrhea in a South American Province. Global Public Health, in press.

Corresponding author: Verónica B. Rajal, INIQUI-UNSa, Buenos Aires 177, Salta, 4400, Argentina
Email: vbrajal@gmail.com

Conflict of interest: No conflict of interest is declared.