TESTING THE RELATIONSHIP BETWEEN ACCESS TO WATER AND WASTEWATER SERVICES AND RATES OF INFECTIOUS DISEASES IN COLONIAS AND CENSUS TRACTS IN EL PASO COUNTY

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ABSTRACT

TESTING THE RELATIONSHIP BETWEEN ACCESS TO WATER AND WASTEWATER SERVICES AND RATES OF INFECTIOUS DISEASES IN COLONIAS AND CENSUS TRACTS IN EL PASO COUNTY

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This study tested hypotheses about the relationship between access levels to water and wastewater services and hepatitis A, shigellosis, and salmonellosis rates in the colonias and census tracts in El Paso County, Texas The infectious disease cases were mapped to identify their geographic locations in colonias and census tracts in El Paso County Significant relationships only were found between dwellings accessing different types of water and wastewater services and the average annual incidence rate per 100,000 of shigellosis in the census tracts ($p < 0\ 05$ or $0\ 01$). Accessing public or private water services was related to a decrease in the average annual incidence rate of shigellosis, while accessing water wells, other sources of water, and septic tanks or cesspools was related to an increase in the average annual incidence rate of shigellosis. Also, youth who were 1-11 had the highest average annual incidence rates per 100,000 of hepatitis A, salmonellosis, and shigellosis in the census tracts In the future, primary research should focus on identifying all potential risk factors (i e., personal hygiene, food preparation or storage, and water and wastewater access) contributing to the spread of hepatitis A, salmonellosis, and shigellosis in counties along the Texas-Mexico Border

CHAPTER 1

INTRODUCTION

The Rio Grande River stretches along border between Texas and Mexico for 1,254 miles from the north at the cities of El-Paso-Ciudad Juarez to the south at Brownsville-Matamoros (Sharp, 1998) The River wanders past nearly 1 6 million residents of El Paso-Juarez and past more than 300 maquiladoras or factories nearer the Gulf of Mexico Despite this source of water, more people along this Texas border than anywhere else in the United States live without access to adequate water and sewer services (Haurwitz, 1998, July 12). Most of the Texas' poorest areas, home to nearly 400,000 people, exist along the Mexican border

A 1996 assessment by the Texas Water Development Board (TWDB) and the Texas Natural Resource Conservation Commission (TNRCC) indicated that the Texas Border region needed $2 5 billion for improvements to water and wastewater systems (Texas Water Development Board & Texas Natural Resource Conservation Commission, 1997). Even the extraordinary growth and economic development along the Texas-Mexico Border at the end of a century has not eliminated the lack of running water in the homes of Border residents (Policy Research Project on Colonia Housing and Infrastructure, 1997b) "Life for them is a daily struggle with leaking septic systems, open-air cesspools, inadequate drainage, foul or nonexistent tap water and elevated rates of hepatitis A and other diseases associated with poor sanitation" (Haurwitz, 1998, July 12, p A1)

Scope of Problem – Border Water and Wastewater Services and Health Outcomes

The absence of water and wastewater services in poor communities or colonias along the Texas-Mexico Border has received considerable attention in the past several years (Haurwitz, 1998, July 12, Haurwitz, 1998, July 13, Policy Research Project on Colonia Housing and Infrastructure, 1997b, Texas Water Development Board & Texas Natural Resource Conservation Commission, 1997) A colonia is a subdivision of five or more structures in an unincorporated Border region within 100 miles of the Texas-Mexico Border (Policy Research Project on Colonia Housing and Infrastructure, 1997a) Hidalgo, Cameron, Webb, Starr, and El Paso counties house over 75% of colonias residents Developers of colonias sell lots to poor migrants or recent immigrants from Mexico with modal purchase costs of $1,000 to $2,000 (Ward, 1999). However, these lots that comprise colonias generally have unpaved streets and no services for water and wastewater

Improving the infrastructures of Texas colonias has moved at a glacial pace Various agencies have administered state and federal programs to improve water and wastewater infrastructures TWDB, Texas Department of Housing and Community Affairs, Rural Economic and Community Development Agency, U S Department of Commerce, U S Environmental Protection Agency (Policy Research Project on Colonia Housing and Infrastructure, 1997b) Since 1990, the State of Texas has invested $479 million to improve the water and wastewater systems in poor communities along the Border (Haurwitz, 1998, July 12) By 1998 this money had benefited an estimated 36,000 or 13% of the potential beneficiaries However, as the $479 million trickles into the Border counties, high rates of hepatitis A, salmonellosis, and shigellosis continue to occur in Texas communities along the Border where water and wastewater services are still inadequate

Rates of these infectious diseases, which can be caused by contaminated water, often have been higher along the Texas-Mexico Border than rates for Texas as a whole Texas counties along the Border reported infectious disease rates for 1998 at 29 53 per 100,000 for hepatitis A, 23 17 per 100,000 for shigellosis, and 17 50 per 100,000 for salmonellosis (Texas Department of Health, 1999) The hepatitis A rate was nearly 40 percent greater than the 1998 state's hepatitis A rate of 18 .0 per 100,000. In 1998 the statewide rates per 100,000 were 17 3 for salmonellosis and 20.3 for shigellosis In the end, "there is an economic toll to the diseases public and private health-care costs and wages lost by people too sick to work" (Haurwitz, 1998, July 13, p. A5)

Purpose of Study

Along the Texas-Mexico Border. particularly in colonias, use of contaminated water sources and inadequate sewage systems have been thought to be linked to incidences of infectious diseases and poor health (Haurwitz, 1998, July 13, Policy Research Project on Colonia Housing and Infrastructure, 1997a) Testing the existence of this link is the purpose of the present study A review of literature in Chapter 2 presents past research examining this link plus provides the justification for this study

The remainder of Chapter 1 sets the scene for this study Chapter 1 provides a review of factors linked to outbreaks of hepatitis A, salmonellosis, shigellosis, and cholera and examines on epidemiologic surveillance methods for examining this link. The significance of researching this link in El Paso County, Texas is explained in Chapter 1 Research issues are identified Then, the research questions and hypothesis in this study are introduced Finally, it concludes with the identification of the study's limitations

Factors Linked to Hepatitis A, Salmonellosis, Shigellosis, and Cholera

Past epidemiological studies have verified links between various factors and the spread of hepatitis A, salmonellosis, shigellosis, and cholera The purpose of epidemiology is to examine the patterns of disease occurrence in human populations along with factors that impact these patterns (Lilienfield & Lilienfeld, 1980) The primary focus of a descriptive epidemiological study is to examine the occurrence of disease by time, place, and person. Time refers to the date and hour of an occurrence Place refers to the location such as a geographical region or a physical structure, like a building The term person refers to the personal characteristics of individuals such as age, sex, physiological, genetic, or social and economic factors. An epidemiological study focuses on the link between a disease occurrence (e g., hepatitis A, salmonellosis, shigellosis, and cholera) and factors relating to this occurrence (e.g , contaminated water or poor personal hygiene)

Water sources have become contaminated in different ways For example, the absence of chlorination has been linked to the presence of infectious diseases in water systems Researchers have discovered that micro-organisms have seeped into unchlorinated water sources, such as water towers, wells, aquifers, rivers, canals, bays, and ponds (Angulo, Tippen, Sharp, Payne, Collier, Hill, Barret, Clark, Geldreich, Donnell, & Swerdlow, 1997, Al-Qarawi, El Bushra, Fontaine, Bubshait, & El Tantawy, 1995, Boyles, 1999, September 20, Boyles, 1999, January 25, "Drinking Water," 1999, November 15, Feldman, Baine, Nitzkin, Saslaw, & Pollard, 1974, Forgarty, Thornton, Hayes, Laffoy, O'Flanagan, Devlin, & Corcoran, 1995, Leach, Koo, Hilsenbeck, & Jenson, 1999, Rahaman, Khan, Aziz, Shafiqul Islam, & Golam Kibriya, 1975, Swerdlow, Malenga, Begkoyian, Nyangulu, Toole, Waldman, Puhr, & Tauxe, 1997)

The spread of hepatitis A, salmonellosis, shigellosis, and cholera also have resulted from infected sources other than contaminated water and wastewater systems Other sources of infectious agents have included hosts, such as infected individuals, and the environment, such as unsanitary living conditions Personal behaviors, such poor hygiene practices or improper storage and cooking of food, have been identified as sources of infectious diseases in several epidemiological studies (U S Department of Health and Human Services, 1999, July 23, Texas Department of Health, 1998, Texas Department of Health, 1999, Texas Department of Health, 2000, Longergran & Van Sickle, 1991, Massoudi, Bell, Paredes, Insko, Evans, & Shapiro, 1999, Hwang, 1999, May 19, Quick, Thompson, Zuniga, Dominguez, De Brizuela, De Palma, Almeida, Valencia, Ries, Bean, & Blake, 1995, Van Derslice & Briscoe, 1995) Research has identified contaminated environmental conditions as the sources of foodborne outbreaks of hepatitis A, salmonellosis, and shigellosis (Keene, 1999, Mohle-Boetani, Reporter, Werner, Abbott, Farrar, Waterman, & Virgia, 1999, "Outbreak of Salmonella Serotype Muenchez," 1999, August 25, "Outbreaks of Shigella Sonnei Infection," 1999, May 19) In addition, the living standard in a household environment, such as access to a hygienic toilet facility or a sanitary source of water, has been associated with incidences of infectious diseases (Cifuentes, Hernández, Venczel, & Hurtado, 1999; Longergran & Van Sickle, 1991)

Epidemiological Surveillance Methods

Epidemiological surveillance methods provide the means for detecting the source of infectious disease outbreaks, such as hepatitis A, cholera, salmonellosis and shigellosis, in water sources Health departments routinely collect statistics through surveillance activities to monitor morbidity and mortality trends Their sources of surveillance data have included mortality registries, morbidity reports, epidemic reports, laboratory investigations, surveys, hospital and medical statistics, absenteeism from work or school, and regional analyses with geographic information systems (Kelsey, Whittemore, Evans, & Thompson, 1996) Surveillance testing has included examinations of bacteria, viruses, and protozoa in the water

Geographic information systems or GIS provide a means for mapping the morbidity and mortality data on infectious diseases as well as chronic diseases (Barrera, Grillet, Rangel, Berti, & Ache, 1999, Childs, McLafferty, Sadek, Miller, Khan, DuPree, Advani, Mills, & Glass, 1998, Cifuentes et al., 1999, Glass, Schwartz, Morgan, Johnson, Noy, & Israel, 1995, Kulldorff, Feuer, Miller, & Freedman, 1997, Thomas, Schoenbach, Weiner, Parker, & Earp, 1996, Viel, Pobel, & Carré, 1995) A set of computer tools for collecting and displaying spatial data comprise GIS (Burrough & McDonnell, 1997) "Mapping can graphically track the spread of a disease or be used to search for causal agents in the environment and help understand the origins of a disease or condition" (Ricketts, Savitz, Gesler, & Osborne, 1999, March, p 8) GIS permits relational links among various attributes associated with the same location (Vine, Degnan, & Hanchette, 1997; Waller, 1996)

Significance of Thesis Study

Past research has established links between contaminated water sources and outbreaks of infectious diseases It has identified epidemiologic surveillance methods for detecting and mapping outbreaks of diseases And, it has provided the evidence to justify studying the impact of access to water and wastewater services on health outcomes along the Texas-Mexico Border

More people along the Texas-Mexico Border than anywhere else in the United States live without access to adequate water and sewer services (Haurwitz, 1998, July 12) In addition the Border houses most of Texas' poorest areas. The state's investment of $479 million toward the estimated $2 5 billion in necessary improvements to the water and wastewater infrastructures along the Border makes for glacial progress in improvements and high levels of infectious diseases among Border residents

Colonias are communities of mostly poor Mexican-Americans and fewer Mexican immigrants (Ward, 1999) Over 75% of colonias residents live in the Texas counties of Hidalgo, Cameron, Webb, Starr, and El Paso (Policy Research Project on Colonia Housing and Infrastructure, 1997a) The developers of colonias forgo the provision of paved streets, water systems, solid waste, and wastewater services (Ward, 1999). The absence of sanitation services might contribute to poor health and high rates of infectious diseases For example, a calculation of the hepatitis A rate for Border counties at 29 53 per 100,000 is nearly 40% greater than statewide rate of 18 0 per 100,000 in 1998 (Texas Department of Health, 1999)

The absence of quality water and wastewater services and the presence of high infectious disease rates are significant problems in all counties along the Texas-Mexico Border Of the 32 counties along the Border, El Paso contains the second highest number of colonias (157) and residents of colonias (72,754), Hidalgo County has the highest number of colonias (868) and residents living in colonias (124,010) (Ward, 1999) However, among the five counties with 75% or more of the colonias (i e , Cameron, El Paso, Hidalgo, Starr, and Webb) the best data for testing the link between water and wastewater infrastructures and infectious diseases in this thesis research is available for El Paso County

Research Issues

The design of this retrospective epidemiological study tested Van Derslice and Briscoe's (1995) suggestion that improvements in both water supply and sanitation are necessary to improve health According to Van Derslice and Briscoe (1995) " . improvements in water quality can be argued for with equal force as a 'necessary but not sufficient' condition" (p 143) The design of geographical analysis was modeled after the research of Thomas et al. (1996) by mapping by both numbers of infectious diseases and rates of infectious disease by colonias

The study addressed two research issues First, it explored the usefulness of GIS as an observational epidemiologic method for identifying geographic patterns in the occurrences of hepatitis A, salmonellosis, and shigellosis in census tracts in El Paso County. Second, it investigated whether any relationships exist between the incidence rates of hepatitis A, salmonellosis, and shigellosis and the characteristics of census tracts in El Paso County The research questions and hypotheses related to these issues

Research Questions

The study focused on these research questions

1 What levels of access did populations have to water and wastewater services in the colonias in El Paso County?

2 What levels of access did dwellings have to water and wastewater services in the census tracts in El Paso County?

3 What were the number of cases and average annual incidence rates per 100,000 of hepatitis A, salmonellosis, and shigellosis in the colonias in El Paso County?

4 What were the number of cases and average annual incidence rates per 100,000 of hepatitis A, salmonellosis, and shigellosis in the census tracts in El Paso County?

5 What were the number of cases and average annual incidence rates per 100,000 of hepatitis A, salmonellosis, and shigellosis by age group in the census tracts in El Paso County?

Research Hypotheses

Hypotheses tested the following relationships in the study:

H_{01} - H_{02}: The access levels of populations to water and wastewater services in the colonias of El Paso County were not related to the average annual incidence rates per 100,000 of hepatitis A, salmonellosis, and shigellosis

H_{01} $rxy = 0$ H_{A1} $rxy \neq 0$

H_{02}: $rzy = 0$ H_{A2}: $rzy \neq 0$

Hypotheses one and two were test with bivariate correlation

$H_{03} – H_{04}$ The access levels of dwellings to water and wastewater services in census tracts of El Paso County were not related to the average annual incidence rates per 100,000 of hepatitis A, salmonellosis, and shigellosis

H_{03}: $rxy = 0$ H_{A3}. $rxy \neq 0$

H_{04}. $rzy = 0$ H_{A4}. $rzy \neq 0$

Hypotheses three and four were tested with bivariate correlation

Study Limitations

A number of factors pose limitations to this study:

1. This study relied on the use of existing data resources at the TDH, the TWDB, the OAG, and the U S Census Bureau These government agencies compiled the data for their specific purposes As a result, secondary analysis in this study posed a limitation
2. Linking data resources from the previously mentioned government agencies presented several challenges Data variables sometimes have been defined slightly different Also, data resources were created at different points in time during the 1990s
3. The accuracy of data on the incidences of infectious diseases depended on reporting of doctors, laboratories and health care facilities in El Paso County Even state law cannot guarantee the reporting of infectious diseases to TDH
4. The study just focused on El Paso County The only source of GIS files on Texas colonias was the OAG It only permitted the use of its GIS files of colonias in El Paso County, not the remaining Border counties, at this time The OAG was the best and only source of colonias map data
5. A lack of transportation, limited access to health care services, poor living conditions, low incomes, and migration of colonias' residents were factors that may have been related to the reporting of infectious diseases
6. Aside from access to water and wastewater service, other factors of daily living, such as hygiene habits and food preparation conditions, may have been related to infectious disease rates for hepatitis A, salmonellosis, and shigellosis
7. Secondary analysis in this study limited statistical tests to those of relationship
8. This was an exploratory study of the relationships between water and wastewater services and infectious disease rates for the census tracts of El Paso County as well as the relation between age and incidence of an infectious disease
9. Infectious disease rates by age categories for the colonias could not be calculated due to the unavailability of population data from the TWDB for the colonias provided by age groups

CHAPTER 2

REVIEW OF LITERATURE

This review of literature provides support for an epidemiologic study of links between incidences of certain infectious diseases and contaminated water and inadequate wastewater disposal Section one presents a literature review that focuses on waterborne outbreaks of hepatitis A, salmonellosis, and shigellosis Section two provides a review of literature about factors other than contaminated water associated with the spread of these infectious diseases Section three presents a review of studies that focus on epidemiological surveillance techniques for investigating waterborne outbreaks of infectious diseases Section four identifies some of the strengths and limitations of using geographic information systems (GIS) in epidemiological surveillance as identified through past research Section five contains a review of studies that utilized GIS to analyze the spatial relationships between health outcomes and environmental factors

Causes of Water Contamination

The safety of water for consumption depends on its source Some sources are more vulnerable to contamination than others. Deep-water sources, such as wells and aquifers, are less vulnerable to contamination due to their depths below the surface Chlorinated and desalinized water sources, such as water treatment plants or pumps, also are less vulnerable to contamination The most vulnerable sources of contamination include surface water from ponds, rivers, lakes, and water channels as well as uncovered or unprotected water containers, like barrels or pots However, researchers reported that even the safest sources of water could become contaminated

A case-control study of a typhoid fever outbreak in districts of Tabuk City in northwestern Saudi Arabia pointed to a deep well as the disease source (Al-Qarawi et al., 1995) The odds ratio (OR) for getting typhoid fever was highest for persons using the Abu-Sabaa deep well (OR = 7 05, 95% Confidence Interval (CI) = 2.51-20.7) The city's water pumping facility overdrew water from the Abu-Sabaa well to meet an increase in demand for water However, the overdrawing pulled in contaminated surface water from an old sewage canal The pumping facility provided desalination treatment but no chlorination The researchers recommended precholorinating water from the well prior to the reverse osmosis desalination process in order to prevent microbiologic contamination

The city of Gideon, Missouri, experienced a salmonellosis outbreak in 1993 (Angulo et al , 1997) A case-control study was conducted to identify the source of contamination Though the water system was not chlorinated, the researchers believed contamination of the aquifer was unlikely None of the residents living in surrounding communities using the aquifer became ill However, the relative risk (RR) for those with diarrheal illness was highest for persons drinking city water originating in the aquifer (RR = 9.1, 95% CI = 2 9-28 4). Two city-owned storage towers for aquifer water became contaminated from the feathers and fecal matter of birds roosting on the towers' vents The researcher recommended better maintenance of the water towers and chlorination as methods for preventing future outbreaks

Studies in Bolivia and along the Texas-Mexico border supported the use of uncontaminated drinking water as a method for lowering hepatitis A rates ("Drinking Water," 1999, November 15; Leach et al., 1999) The results of a cross-sectional study indicated a high prevalence of Hepatitis A antibodies (94 1 % of 490 serum samples) occurred in the absence of sanitary drinking water ("Drinking Water," 1999, November 15) Another cross-sectional study found children living along the Texas-Mexico border in colonias had a significantly higher sero prevalence of hepatitis A. Leach et al (1999) reported that for a cohort of children enrolled in their study from 1996-1997, " . hepatitis A infection was identified in 37% (39/105), of children from colonias, 17% (11/65) of children from urban border communities, and 6% (1/115) of children from San Antonio ($p <$ 001, x^2) (p. 510)." The OR for residence in a colonia as a risk factor for previous hepatitis A infection was 6.22, 95% at the CI = 2 63-14.70

Communities also have used unchlorinated surface water, including rivers, bays and ponds, as sources of water for drinking, cooking and recreation Such sources of water have been more easily contaminated, as researchers have found

A dysentery outbreak that was caused by shigella dysentariae type 1 occurred in a community using unchlorinated surface water (Rahaman et al , 1975) The outbreak occurred during monsoon season on Coral Island in the Bay of Bengal, off the coast of Burma Though the exact means of transmission was not definitely established, bacteriological tests of water samples used for drinking and washing were heavily contaminated with fecal organisms During the 6 to 13 weeks after the shigellosis outbreak began, the case-fatality rates (CFR) were highest for infants less than 1 (CFR = 41.2 per 100) adults 50 or older at (CFR = 22.2 per 100) Indiscriminate defecation by the population heightened risk of surface water contamination since monsoon rainwater saturated sand and spread disease Public health workers provided Coral Islanders with chlorinating tablets for drinking water containers. Rahaman et al (1975) believed the use of chlorination tablets shortened the outbreak

Swerdlow et al. (1997) used a matched case-control method to study an outbreak of cholera among refugees from Mozambique in Malawi, Africa The methodology involved the random selection of two controls for every laboratory-confirmed case of cholera Cases initially presented with diarrhea Persons placing their hands in household water containers had the most significant risk for becoming ill (Matched Odds Ratio (MOR) = 6 0, 95% CI = 1.3-26 8, $p < 0\ 05$). The MOR for drinking from the river also was high (MOR = 3 0, 95% CI = 1 4-6 4, $p < 0\ 05$) The researchers identified noncompliance with camp policy for adding chlorine to their water containers as the source of contamination

Rather than consumption, exposure through recreation or work to contaminated canal waters in the Florida Keys increased human risk to numerous viruses including hepatitis A (Boyles, 1999, September 20) Researchers tested 19 canals for contamination. The testing revealed evidence of human fecal matter in the water A positive finding for hepatitis A occurred at 12 of the 19 canals

Water contamination also occurred in several communities using chlorinated water wells A rural Irish community had two water sources, one of which was an artesian well alleviating the overtaxing of another water source (Forgarty et al , 1995). Water from the artesian well was chlorinated However, it became contaminated with untreated human sewage, which leaked from an adjacent sewage conduit Reported cases suffered gastrointestinal illness Relative risk rates were significantly elevated for those using the artesian well (RR = 2 0, 95% CI = 1 7-2 4, p < 0 001) In addition, the artesian well users who did not boil their water during the reported outbreak had a significantly higher relative risk of gastrointestinal illness as compared to those who did boil their water (RR = 3.5, 95% CI = 2 7-4 6, p <0.001) The coliform count in the water was high but the contaminant never was isolated. The pipe system from the aquifer was hyperchlorinated to remove the unidentified contaminant

Another case study of a typhoid outbreak in a migrant farm camp in Dade County Florida identified a malfunctioning chlorinator for water as the source of contamination (Feldman et al , 1974) Two wells drew water through a single pumphouse tested positive for salmonella typhi or typhoid fever The number of persons with suspected typhoid fever infections were 309 among whom 246 were hospitalized Forty-three percent of the typhoid cases were exposed to contaminated water at the inception of the outbreak in February 1973 Possible sources of contamination were defecation in the pumphouse, contamination from a sewage canal, or the overflowing of the canal into the well water after a heavy rain.

Other Risk Factors for Hepatitis A, Salmonellosis, and Shigellosis

The spread of hepatitis A, salmonellosis, and shigellosis also occurs as a result of infected sources other than contaminated water or malfunctioning wastewater systems Infected individuals, or hosts, are disease sources Contaminated elements in an environment, such as unsanitary living conditions or tainted food, also are sources of infectious agents. Hand washing, hygienic handling of food (e.g , thoroughly washing surfaces and utensils and rinsing food), thoroughly cooking foods, such as meats and eggs, and safe sexual practices are methods to prevent the spread of infectious diseases (U S. Department of Health and Human Services, 1999, July 23; Massoudi et al., 1999, Hwang, 1999, May 19) Hepatitis A can also be prevented through immunization and with the use immunoglobulin after exposure (Deshaies, Dion, & Auger, 1999, February 15; "Hepatitis A· Foodborne Outbreaks," 1999, August 1)

Food handlers have been the sources of infectious hepatitis A outbreaks The spread of hepatitis A in a catered event in Kentucky resulted from an infected food handler who did not wear gloves during the preparation of food "Attending event at a site that lacked a kitchen (RR = 21.9, 95 % CI = 1.1 - 2 9) or a site that lacked a sink (RR = 2.3, 95% CI = 1.4 - 3.8) were associated with illness . (Massoudi et al., 1999, p 4) Investigators implicated a local restaurant as the source of a hepatitis A in an outbreak in Lavaca County, Texas, in 1998 (Texas Department of Health, 1999) In fact, good hygiene practices such as thorough hand washing before preparing food, after using the bathroom and after changing diapers prevents the spread of both hepatitis A and shigellosis The cause of salmonellosis is microbial contaminants in foods of animal origin. Nearly 50% of poultry and poultry products act as common-vehicles for the salmonella species (Texas Department of Health, 1999)

Environmental conditions have been associated with the contamination of other foods Foodborne outbreaks of hepatitis A occurred when school children and school employees ate strawberries as part of their lunches ("Hepatitis A· Foodborne Outbreaks," 1999, August 1) The probable source of contamination was unsanitary field conditions in Mexico rather the processing of the frozen strawberries in California Unchlorinated water in a hydrocooler in a packing shed in Baha California, Mexico, was identified as the probable source of contamination to fresh parsley eaten by restaurant patrons who contracted shigellosis in the United States ("Outbreaks of Shigella Sonnei Infection," 1999, May 19)

The California Department of Health Services traced a salmonella outbreak in the state to cantaloupes from Mexico (Mohle-Boetani et. al, 1999). Through a case-control study, the investigators found that 88% of case patients ate the cantaloupes while only 45% of the control patients ate these fruits. The MOR was 14 5 with a 95% CI equal to 1.7-1 39 The outbreak ended when domestic cantaloupes replaced imported cantaloupes. Unpasteurized milk in Mexican cheese, or queso fresco, was the source of salmonella in the investigation of foodborne outbreaks in California and Washington (Keene, 1999) "Without pasteurization or other processing to kills pathogens, consumption of raw milk is a high-risk behavior" (Keene, 1999, p. 4) Another outbreak of salmonella was related to the absence of pasteurization In the northwestern regions of the United States and Canada individuals became ill after consuming unpasteurized orange juice ("Outbreak of Salmonella Serotype Muenchen," 1999, August 25) Further investigations continued after identification of the salmonella source to determine where control measures in the processing failed and how the juice became contaminated.

The results of several studies identified water quality along with other factors impacting health status Lonergran and VanSickle (1991) obtained significant chi-square values for relationships between nine-risk factors and self-reported diarrhea There were highly significant relationships ($p < 0.001$) for self-reported diarrhea and race (i e , Chinese, Indian, Malay, or other natives), the frequency of boiling water, sanitary sources of water, the presence of a hygienic toilet facility, the cleanliness of kitchen, and the cleanliness of children (i e , they were bathed and wore clean clothing) In addition, there were significant relationships ($p < 0.01$) between self-reported diarrhea and the presence of treated water, drinking water source (i e , presence or absence of contaminants in drinking water source), and a garbage-free yard

In several investigations, hygiene and socio-economic factors were associated with cholera outbreaks In response to a cholera epidemic, a matched case-control study in El Salvador associated diarrhea and eating cold cooked or raw seafood and between diarrhea and drinking water outside the household with OR of 7.0 (95% CI = 1 4, 35 0) and 8 8 (95% CI = 1.7, 44 6) respectively (Quick et al , 1995) Socio-economic status (i.e , income level) was a risk factor for acute diarrheal diseases (ADD) associated with cholera in Mexican municipalities associated (Cifuentes et al , 1999) Lower mortality rate ratios (MRR) were exhibited for ADD in the higher socio-economic groups than for the lowest socio-economic group, category 1. Category 1, the poorest group, had a MMR of 1.00 per 1,000 while the wealthiest group, category 7, had a MRR per 1,000 of 0 21 ($p < 0.0001$)

Results from a longitudinal study of environmental interventions to prevent diarrheal disease also indicated multiple factors impacting morbidity outcomes. Van Derslice and Briscoe (1995) developed theoretical models of diarrheal disease in which the explanatory variables were partitioned into proximate biologic and behavioral determinants, such as nutritional status and hygienic habits The models suggested that improving water quality had greater impact for families with access to more sanitary methods of excreta disposal In addition, the improvement of drinking water quality in the absence of good sanitary conditions would have no impact on reducing diarrheal disease "Improvements in both water supply and sanitation are necessary if infant health in developing countries is to be improved" (Van Derslice & Briscoe, 1995, p. 135).

Epidemiological Surveillance

Enhancing surveillance methods can improve the detection of the sources of outbreaks Improvements in a surveillance system have included the following: detection of infectious outbreaks through the analysis of national laboratory reporting database, follow-up on increases in national or localized reporting of specific pathogens, and investigations of reported outbreaks through questionnaires (Furtado, Adak, Stuart, Wall, Evans, & Casemore, 1998) The enhancement of a surveillance system in Milwaukee, Wisconsin bolstered the means for detecting a cryptosporidium outbreak in a water system (Proctor, Blair, & Davis, 1997) Additional data surveillance included the water treatment plant effluent turbidity logs (i e , testing treated water leaving Milwaukee Water Works) and the water utility customer complaint log

Related to employing useful surveillance methods, Tillett, De Louvois, and Wall (1998) examined a surveillance methodology that was both sensitive and specific in detecting the causes of waterborne outbreaks in England and Wales Identifying water consumption as the source of infectious disease beyond reasonable doubt is difficult "Water samples from the time of exposure are seldom available, some organisms are difficult to detect and almost everyone has some exposure to water" (Tillett et al , 1998, p 37) They developed a classification method to recognize the degree of evidence used to implicate water as the source of an infectious disease outbreak

Epidemiological surveillance enhanced with GIS methods have been useful to researchers investigating the distributions of disease incidences (Barrera et al., 1999, Childs et al , 1998, Cifuentes et al., 1999, Glass et al., 1995, Kulldorff et al., 1997, Thomas et al., 1996; Viel et al., 1995) "Mapping can graphically track the spread of a disease or be used to search for causal agents in the environment and help understand the origins of a disease or condition (Ricketts et al., 1997, March)

Strengths and Limitations of Mapping in Epidemiological Research

The factors of place, time, and person influence the disease incidence patterns (Lilienfield & Lilienfield, 1980) Place is a spatial area, such as a building, or geographical region, such as a city Spatial analysis provides a method for examining the relationships between disease occurrence and geographic location. Maps aid this analysis by exhibiting the spatial distribution of geographical features (Burrough & McDonnell, 1998) "Maps are uniquely able to display incidence data for contagious diseases because physical proximity and human interaction are key elements in their spread" (Ricketts et al., 1997, March, p 8)

Geographical information systems or GIS are computer systems that provide both mapping and spatial analysis capabilities using large quantities of data (Vine et al , 1997) The data may be raster-based (i e , data appear in a grid with pixels representing geographic characteristics) or vector-based (i e , data appear as points, lines or polygons) (Waller, 1996) For example, an individual case of a disease incidence is one box within a grid An individual case of data is a point in vector-based GIS The spatial variation may be expressed in several ways Points or grid boxes representing cases of a disease, for example, may be closely or loosely clustered and may be systematically or randomly distributed (Briggs & Elliott, 1995) Mapping the disease clusters or distributions exhibits spatial patterns

This review of literature identifies the strengths of mapping health data with GIS There are seven strengths identified for GIS First, GIS strength provides a visual depiction of the geographical dispersion of a health condition Ricketts et al. (1997, March) noted that, "Maps are uniquely able to display incidence data for contagious diseases because physical proximity and human interaction are key elements in their spread" (p 8) Second, GIS provides an address matching function known as geocoding. Geocoding permits the mapping of health outcomes (Vine et al , 1997) For example, "The exposure information, combined with knowledge of health/disease status (e g., immune competence as indicated by immunoglobulin levels) by residential location could be included in a traditional epidemiological study to investigate relationships between exposure to contaminated water and disease risk" (Vine et al , 1997, p 599). Third, GIS permits the integration of spatial data with non-spatial data of environmental or health conditions (Briggs & Elliott, 1995) This integration allows the mapping of environmental risks and health outcomes. Fourth, GIS supports statistical analyses of the strength of relationship between geographic factors and health outcomes (e.g., proximity to geographic feature, like a contaminated water source to an infectious disease incidence) (Vine et al , 1997) Fifth, when spatial data are available, GIS permits a closer examination of health outcomes within smaller geographical levels, such as zip code area, census block or neighborhood A sixth strength of GIS is that "maps are powerful communicators" (Waller, 1996, p. 87) GIS provides visual perspectives on the links between the environment and health outcomes. Last, GIS provides a useful surveillance method for monitoring health outcomes and hazardous emissions into the environment Waller (1996) noted that, "Such monitoring does not result in direct studies of health effects of environmental exposures but it does suggest areas for more detailed study" (p. 87)

While it permits the mapping of health data, past literature has identified the limitations of GIS First, spatial detail is generally unavailable in official health data (Twigg, 1990) Geographical data may not be necessary from a health management perspective Second, geographical detail necessary for examining health conditions at a community level (such as zip code areas or census tracts) may not be available (Twigg, 1990) Third, the absence or inconsistency of spatial data may be purposeful as to protect anonymity to individual health cases (Twigg, 1990) Many agencies and researchers consider an address as a personal identifier, which is not released with health data to maintain confidentiality (Vine et al , 1997) Fourth, the absence of an appropriate data on a population serves as a limitation Fifth, a variable with random variation in a geographic region, such as a rare disease in a small area, may appear to reflect consistent variation when it is mapped (Briggs & Elliot, 1995) Sixth, the presence of certain underlying social and demographic characteristics (e g , educational attainment, ethnicity, and health status) may be more powerful indicators of disease incidence than geographic location (Briggs & Elliot, 1995).

Even with the limitations, the strengths of GIS would aid epidemiological surveillance at the community level by providing a computer software system for collecting, storing, retrieving, transforming, and displaying spatial data, such a the geographic locations of infectious disease incidences or of a contaminated source of water (Burrough & McDonnell, 1998). Epidemiological surveillance incorporating GIS might provide the means for monitoring and identifying communities at risk for waterborne infectious diseases (Vine et al., 1997). "Methods of studying environmental and health data depend to a large extent upon the availability and quality of data, especially measures of exposure" (Briggs & Elliott, 1995, p. 90)

Spatial Analyses in the Surveillance Method in Epidemiological Studies

Through past studies, researchers examined the distributions of health outcomes within geographic regions They examined questions and hypotheses regarding the possible links between health conditions and environmental risk factors (Glass et al.,1995). Spatial associations, spatial clustering and spatial proximity were reviewed.

Studies of spatial associations examined how various diseases varied with risk factors in environments (Glass et al., 1995, Barrera et al., 1999, Cifuentes et al , 1999) Glass et al. (1995) asked, "What environmental risk factors were associated with Lyme disease in Baltimore County, Maryland, from 1989 to 1990?" The transmission of Lyme disease occurs when vectors such as ticks bite mammalian hosts such as a human These vectors tend to inhabit woodland and forest areas

Glass et al (1995) used raster-based GIS to map their variables The grid map of the county contained 164,248 cells of 400 feet (ft) by 500 ft for each variable, each cell represented a variable value A Lyme disease risk-density map exhibited the continuous variation across the grids According to Burrough and McDonnell (1998), "The variations are conventionally shown by isolines or contours—that is lines connecting points of equal value—or by sets of monotonically increasing grey or colour scales" (p 4) The residences of individuals with Lyme Disease were geocoded along with the residences of randomly selected controls Glass et al (1995) found 11 variables associated with Lyme disease ($p < 05$) four types of soil, two watershed regions, and two types of geological conditions Odds ratios for environmental factors and Lyme disease were strongest for residence in forested areas (OR = 3 7, 95% CI = 1 2 - 11 8), by specific soils (OR = 2 1, 95%, CI = 1.0 - 4 4) and in two regions (OR = 3 5, 95% CI = 1 6 -7 4, OR = 2 8, 95% CI = 1 0 - 7.7)

Infected vectors such as mosquitoes transmit malaria to human hosts Barrera et al 's (1999) study in northeastern Venezuela posed the question, "What is the association between environmental variables and the incidence and persistence of malaria?" Environmental variables studied included altitude, terrain slope, number of inhabitants, number of immature mosquito habitats within 500 meters of human residences, and distance to the nearest immature mosquito habitat The researchers used vector-based GIS to mapped temporal patterns of the geocoded malaria incidences (i.e , identification of the month and year of an incidence). They attempted to stratify 35 villages and locations in northeastern Venezuela by the persistence of malaria, which was the maximum number of consecutive months with malaria incidences A malaria reinfection in this region occurred from May to December 1985 The researchers studied malaria incidence data for 1985 to 1997.

Barrera et al (1999) found residential areas with high malaria persistence and prevalence were associated with a larger population, close proximity to immature mosquito habitats, and low elevations on gentle slopes. A step-wise multiple regression on $\log_{10}$ revealed significant outcomes for the following: (a) number of consecutive months with malaria cases per village ($F = 22.3$, $p < 0\ 001$, by analysis of variance) with regression coefficients for the number of inhabitants ($\log_{10}$, 0.37 ± 0.14 [± SE], $t = 2.68$, $p < 0\ 01$) and the number of close immature mosquito habitats ($\log_{10}$, 0 10 ± 0 04 [± SE], t = 2 78, p < 0 01), and (b) total number of malaria cases plus one (F = 25 9, p < 0 001, by analysis of variance) with regression coefficients for number of inhabitants ($\log_{10}$, 0 81 ± 0 17 [± SE], t = 4 85, p < 0 01) and distance to the mosquito habitats ($\log_{10}$, -1 00± 0 24 [± SE], t = 4 09, p < 0 01) Barrera et al (1999) suggested " performing spatial analysis to determine the overlap between human settlements and anopheline [mosquito] breeding places as a tool to identify areas at risk of malaria, or to decide where to allocate limited resources for control operations [for reducing mosquito breeding]" (p 789)

In 1991, cholera reemerged in Mexico, after declining in the late 1980s (Cifuentes et al., 1999) Acute diarrhea is a symptom of cholera infection Cifuentes et al (1999) researched factors associated with the 1991-reemergence of cholera in Mexico, as reflected by mortality rates for acute diarrhoeal diseases (ADD). They asked several question including 1) "Where were the most affected populations located in Mexico?" and 2) "What socio-cultural factors (e g , personal socio-economic status, economic status of a municipality) were most relevant?" For their research methods, Cifuentes et al (1999) used vector-based GIS, mortality rates and linear regression They computed ADD and cholera mortality rates for 1985-1995 plus mapped their temporal patterns across Mexico

The large regions of Campeche, Tabasco, Veracruz, Chiapas, Yucatán, Guerrero, State of Mexico, Guanajuato, Jalisco, Puebla, Tamaulipas, Coahuila and isolated villages within the mountainous regions of Michoacán and Colima had the highest cholera mortality rate ratios of more than 0.003 per 1,000 inhabitants (Cifuentes et al., 1999, p 254) Applying regression, the mortality rate ratios for ADD were highest for the poorest socio-economic group in category 1 (MRR = 1 00, p <0.0001) and lowest for the wealthiest socio-economic group of category 7 (MRR = 0 21, p < 0 0001) The researchers concluded, "Notwithstanding these efforts, unequal access to primary health, resulting from geographical isolation and extreme poverty are contributing to maintain high mortality rates in remote communities and shanty towns around the cities" (Cifuentes et al , 1999, p 254)

The observations of disease clustering in geographic regions provided another method of spatial analysis. Viel et al (1995) investigated the incidence of leukemia in young people residing near the La Hague nuclear waste processing plant in Normandy, France They wanted to know, "How did incidences of childhood leukemia cluster around the La Hague nuclear waste plant?" A choropleth map exhibited the proximity of 10 cantons (electoral ward of around 6,000 inhabitants) to the nuclear waste plant, each canton was within 35 kilometers of the plant Burrough and McDonnell (1998) defined a choropleth map as, "a map consisting of a series of single-valued, uniform areas separated by abrupt boundaries," with an areas value represented by a pattern The GIS mapping base (i e , raster or vector) was not identified The data set of leukaemia cases consisted of people under 25 for the period of January 1, 1978 to December 31, 1993 The geographic region consisted of 10 cantons (electoral wards) within a 35 kilometer radius of the nuclear waste plant The researchers used three methods of statistics to test for the clustering of leukaemia incidences around the nuclear waste processing plant.

(a) standardized incidence ratios (SIR) with 95% CI, which were based on Poisson distribution, to identify obvious locational pattern in rates;

(b) Poisson maximum (PM) test, which was based on isotonic regression with simple ordering and tests for a decreasing trend for proximity, and

(c) extraction mapping, which was based on kernel regression smoothing, to allow the extraction of underlying disease rate in the population and pattern of incidence clustering

Their statistical testing served a twofold purpose to test the sensitivity of the statistics in detecting clusters and to confirm the existence of a distinct clustering of leukemia in youth

As the result of these statistical tests, Viel et al. (1995) drew several conclusions First, the three statistical tests provided the sensitivity to assess the relationship between the La Hauge nuclear waste processing plant and leukemia incidences Second, the outcomes of the statistical tests demonstrated the apparent existence of a distinct cluster of youth with leukemia living in close proximity to the La Hague nuclear waste processing plant. The SIR for youth under 25 residing in the closest area, which was under 10 kilometers from to the plant, was 2 8 (95% CI = 0.8-7 2). The PM test reflected a nearly significant (p = 0 06) level for the difference between the observed and expected cumulative numbers of leukemia cases in the closest canton, Beaumont, to La Hague. The extraction mapping produced a maximum cumulative Sirs ranging from 2 7 to 3.3 for Beaumont which also were nearly significant (p = 0 05 – 0 07) Viel et al (1995) suggest, "The identification of clusters of a disease is only the first stage in assessing the public health outcomes, and only one of several approaches that will be necessary in trying to establish cause and effect" (p. 2470)

In another study, researchers examined the clustering of gonorrhea cases among county residents in 28 census block groups of a principal town in a rural North Carolina county (Thomas et al , 1996) They asked questions to test the stereotype that rural life provided a more wholesome alternative to city life and that rural life fostered lower incidences of sexually transmitted diseases (STD), like gonorrhea They also examined whether rural cases of gonorrhea distributed in a contiguous core with concentric, adjacent, and peripheral areas, what demographic factors correlated with gonorrhea rates, and what characteristics of the rural block groups impacted STD rates

This study of geographical distribution of gonorrhea was part of the Sexually Transmitted Epidemic Prevention (STEP) Project in North Carolina Demographic, morbidity and characteristic data on the rural block groups were obtained through the STEP Project The gonorrhea morbidity data were from the period of August 11, 1992 to August 10, 1993 For this period, the researchers used 732 cases of gonorrhea, for which there were residential addresses. The distribution of gonorrhea cases in the 28 block groups of the principal town of the STEP county in North Carolina was exhibited in a choropleth map The type of GIS base (i e , raster or vector) was not identified.

Analyses were performed to obtain morbidity rates and correlations. The distribution of rural gonorrhea rates was in a contiguous core with concentric, adjacent, and peripheral areas for seven of the 28 contiguous block groups The rate was 4,294 cases per 100,000 population The gonorrhea rate correlated with block group median income ($\underline{R}$ = 0 74, $\underline{p} < 0.01$), but did not correlate with population density ($\underline{R}$ = 027, $\underline{p}$ = 0 16). Ethnographic interviews revealed three prominent themes regarding gonorrhea transmission and STDs: (a) inadequate access to private physicians, (b) absence of anonymity in obtaining treatment of STDs , and (c) sexual activities for drugs or money

Thomas et al (1996) concluded with several recommendations. They recommended educating people concerning the myth of the absence of STDs in rural life. They also recommended that "additional steps are likely to include enhancing employment opportunities and improving access to care, including care of high quality that is culturally sensitive and takes extra measures toward confidentiality to address the lack of anonymity in a rural community" (Thomas et al., 1996, p. 276)

Past research provided evidence of the usefulness of GIS in examining the spatial distributions of health conditions in various geographic regions Maps developed with GIS exhibited patterns of diseases associated with or clustered within geographic regions with certain risk factors These spatial patterns enhanced researchers' understandings of the occurrences of disease incidences and of risk factors associated with geographic regions

CHAPTER 3

METHODS

Chapter 3 describes the research methods for this descriptive epidemiological study The primary purpose of this study was to assess the relationship between the access to water and wastewater services and the incidence of selected infectious diseases in communities of El Paso County As observed in Chapter 2, past epidemiological studies identified relationships between contaminated water and the incidence of hepatitis A, salmonellosis, and shigellosis

Four sections comprise this chapter. Section one defines of key factors in this study Section two identifies the categories of data, sources of data, methods of data sampling, and construction of databases Section three describes the research methods for conducting the secondary analyses Section four identifies the types of statistical methods used in this study

Definitions of Terms

Lilienfield and Lilienfield (1980) identified person, place, and time as terms of importance to a descriptive epidemiological study In the current study, persons were defined as confirmed infectious disease cases, residents of colonias, and populations of census tracts within El Paso County. Confirmed cases of hepatitis A, shigellosis, or salmonellosis were determined by standard case definitions set forth by the Texas Department of Health (TDH). Residents were persons living in colonias of El Paso County, as defined by the Texas Water Development Board (TWDB), the total number of residents in a colonia equaled the colonia's total population The populations of census tracts were individuals living in the census tracts of El Paso County, as defined by the U.S Census Bureau (USCB)

Time was a calendar year (January – December) in which one of these cases was reported to TDH The calendar years were 1997, 1998, and 1999 In this research, a case of hepatitis A, salmonellosis, or shigellosis infectious diseases was confirmed according to TDH booklet, "Identification, Confirmation, and Reporting of Notifiable Conditions" (Texas Department of Health, 1996, September). Serology testing confirmed the presence of single serum IgM and anti-HAV for cases of hepatitis viral, type A (hepatitis A) Salmonellosis confirmation occurred with a culture from stool or blood sample for isolation and identification for salmonella species Shigellosis confirmation occurred with a culture from stool sample for isolation and identification of the shigella species TDH received reports of confirmed infectious disease cases in accordance with the Communicable Disease Prevention and Control Act. Texas Health and Safety Code, Chapter 81

This study included several definitions of place. census tracts, colonias, and dwellings The USCB described census tracts as "small, relatively permanent subdivisions of statistical subdivisions of a county" and as homogeneous areas in terms of population attributes, economic status, and living circumstances (U S Census Bureau, 1999, September 7) The definition of a colonia was a subdivision of five or more structures standing in an unincorporated border region within 100 mile of the Texas-Mexico Border (Policy Research Project on Colonia Housing and Infrastructure, 1997a) The colonias housed poor migrants or recent immigrants to the United States (Ward, 1999)

The USCB and the TWDB, both sources of data, defined homes differently In census tracts, homes were housing units In the colonias, homes were dwellings For the purpose of this study, dwelling was used to describe homes in both census tracts and the colonias

The definitions of statuses for water service or wastewater service in the colonias and the census tracts of El Paso County were defined according to their data sources The TWDB defined water service access as the population of a colonia with or without public water suppliers Wastewater service access was defined by TWDB as the population of a colonia with or without wastewater service providers The USCB defined water service access as dwellings in a census tract with use of a public system or private company, an individual drilled well, an individual dug well, or some other source Sewage service access was defined by the USCB as dwellings in the census tracts with use of a public sewer, a septic tank or cesspool, or other means

Categories, Sources, and Samples of Data

Data constituted five categories in this study. The first category was cases of infectious diseases, consisting of hepatitis A, salmonellosis, or shigellosis among residents of El Paso County. Category two consisted of demographic data. Population data comprised the third category, which provides the number of individuals in the census tracts and colonias in El Paso County. The fourth category was water and wastewater service statuses by dwelling in the colonias and census tracts. Geographic information was the fifth category, which contains geographic information on the features of El Paso County and its communities. All data were drawn through purposeful sampling (i.e., the sampling of all available data).

Several state agencies specified conditions for use of their data in this study. It was agreed to analyze TDH's infectious disease data at the aggregate level and not the individual level, in order to maintain anonymity of individual cases. It was agreed to use Texas Office of the Attorney General's (OAG) vector data of El Paso colonias for research and educational purposes only, to document the date of OAG vector data and not to publish the data on the internet or other electronic forms.

Data for this study came from five sources (see Table 3.1). Infectious disease data came from the TDH. The demographic data came from TDH and the USCB. Water and wastewater infrastructure data came from the TWDB and USCB. Population data came from the USCB, TDH, and TWDB. Geographic Data Technology (GDT), OAG and TDH provided the geographic data, GDT and OAG's data were in vector format.

The Texas Department of Health permitted the use of de-identified cases of hepatitis A, salmonellosis, and shigellosis, which were infectious diseases commonly associated with contaminated water sources or inadequate sewage sources. Epi Info Version 6.04B (1997)was the data base system from which cases were drawn. After 1996, the address field was available for disease cases in Epi Info. As a result, cases of hepatitis A, salmonellosis and shigellosis infectious diseases were sampled for 1997 – 1999. Initially, the sampled infectious disease cases included the counties of Cameron, El Paso, Hidalgo, Starr, and Webb. However, as explained in the later section on research methods, the final data set only included El Paso County. The case totals in El Paso County were 414 in 1997, 361 in 1998 and 124 for 1999 (see Table

3 2) The disease data were converted from Epi Info to a Microsoft® (MS) spreadsheet Excel 4 and to dBase® IV

The sources of data on demographics and population size were TDH, USCB, and TWDB Each infectious disease case included information on age, sex, race, and ethnicity The 1990 U S census data provided age ranges for the census tracts of El Paso County The USCB was the source of the population size for the census tracts of El Paso County for 1990 ("U S Census, 1990 STFA3A Texas," 1992). The 1996 data on the El Paso colonias from the TWDB provided the numbers of residents receiving water and wastewater services from which the population sizes of the colonias was derived The demographic and population data were converted into MS® Excel spreadsheet and dBase® IV database files

Table 3 1

Data Sources by Data Categories of Colonias and Census Tracts in El Paso County

Data Source	Infectious Disease Data	Population Data	Demographic Data	Water/Wastewater Services Data	Geographic Data
GDT[a]					X
OAG[b]					X
TDH[c]	X	X	X		X
TWDB[d]		X		X	
USCB[e]		X	X	X	X

[a]Geographic Data Technology
[b]Texas Office of the Attorney General
[c]Texas Department of Health
[d]Texas Water Development Board
[e]U.S Census Bureau

Water and wastewater infrastructure data came from both TWDB and USCB Service data from TWDB identified availability water and wastewater services to residents of colonias in El Paso County, as of 1996 (Texas Water Development Board, 1996) The infrastructure data from the USCB's 1990 census provided data on the availability of waster and wastewater services to El Paso County's census tracts. The infrastructure data from both sources were converted into MS Excel spreadsheet and dBase IV database files

Sources of geographic data were TDH, GDT, and OAG The addresses (i e , street address, city, and zip code) of infectious disease cases were from TDH Vector data of the county borders, census tracts, and streets of El Paso County were from GDT Dynamap® 2000 Vector data of the colonias of El Paso County's colonias were from OAG as of June 2000 ("Colonias Shapefiles," 2000, June 2)

Table 3.2

Cases of Hepatitis A, Salmonellosis, and Shigellosis by Year in El Paso County

Infectious Disease	1997	1998	1999	Total
Hepatitis A	165	128	37	330
Salmonellosis	141	111	55	307
Shigellosis	108	122	32	262
Total	414	361	124	899

Research Methods

The research methods for this study included techniques associated with a geographic information system (GIS) and epidemiological methods The GIS software of ArcView® 3.1 provided the means for creating maps with the geographic data (ArcView® GIS Version 3.1, 1992-1998) The maps contained the geographic information or themes for El Paso County that included its borders, streets, colonias, census tracts, and street addresses of the hepatitis A, shigellosis, and salmonellosis cases The GDT shapefiles (i.e., points, lines, and polygons representing themes) had the standard projection of "Projections of the World" and the projection type of "Geographic" in ArcView® Initial projection of colonia shapefile from the OAG was in Albers The colonia shapefile was reprojected to match the projections of the GDT shapefiles

The result was matching projections that resulted in compatible map layers These map layers resulted in the standard projection in the category of "Projections of the World" and the type of "Geographic."

The water and wastewater infrastructure database of the 151 colonias in El Paso County from the TWDB was joined to the OAG database table of its map of the shapefile of 191 colonias, using ArcView® In order to join these two databases, the colonia identification number field from the TWDB infrastructure data was added to the OAG colonia map database table In order to add this field, a cross verification was made between the TWDB colonias names with identification numbers and the OAG colonias names This joining resulted in 132 colonias with infrastructure status attributes in the final map data layer, the matching process was not successful for 30 percent of the OAG identified colonias (see Figure 3 1 in Appendix A) Matching failure resulted from the absence of an OAG colonia in the TWDB database of colonias (e.g., a colonia existed in 1999 but not in 1996) or the absence of a TWDB colonia in the OAG database of colonias (e g., a colonia existed in 1996 but did not appear in OAG list for 1999)

Using ArcView®, the database table for the shapefile of the 1990 census tracts of El Paso County was joined with the database of USCB data (see Figure 3 2 in Appendix B) This joining occurred on the data field of the census tract number. The result was the inclusion of the fields related to age range, population size, water and wastewater services, infectious disease incidences, and infectious disease rates from the 1990 census survey, the TDH infectious disease data base for 1997-1999 and the 1996 TWDB data base in the data table in the shapefile of the 95 census tracts

Address matching for the infectious disease cases proceeded with the geocoding against the GDT street map files for El Paso County with ArcView® The geocoding process permitted the matching of the address for an infectious disease case to an exact street location in El Paso County. The geocode system for address marching was set for the address style of "U.S. Streets with Zones" and set for the geocoding preferences of spelling sensitivity to 80% match, minimum maximum score of 60% match and minimum to be candidate of 30% match Each year of infectious disease cases was gecoded separately The geocoding process proceeded first through a batch address match of all cases, then a batch rematch for partially matched addresses and finally a batch rematch for the unmatched addresses The batch matches resulted in 240 good address matches for 1997, 215 good address matches for 1998 and 61 good address matches for 1999 (see Table 3.3)

Finally, two databases were created One database, both in dBase IV format for ArcView and Excel for SPSS, provided a census tract profile with demographics, statuses for water and wastewater services, and infectious disease information The second database, created in Excel for SPSS, provided a census tract profile for age by infectious disease case

Table 3 3

Geocoding of Addresses for Hepatitis A, Salmonellosis, and Shigellosis by Year

Year	Total Batch Matches	Good Matches Number	Good Matches Percentage	No Matches Number	No Matches Percentage
1997	414	240	58 0%	174	42 0%
1998	361	215	59 6%	146	40 4%
1999	124	61	49 2%	63	50 8%
Total	899	516	57 4%	383	42 6%

Statistical Methods

This descriptive epidemiological study involved the secondary analysis of data in the examination of the relationship between water and wastewater service access and incidences and rates of infectious diseases The research model for the geographical analysis was a study by Thomas et al (1996) They examined the epidemiological patterns (i e., frequencies and rates) of gonorrhea within North Carolina communities. The examination in the current study was of the frequencies and rates of infectious disease at the community level (i e., colonias and census tract). The relationships between water and wastewater service access and infectious disease rates were tested. Performance of statistical tests occurred with the Statistical Package for the Social Sciences 1995 (SPSS® Windows Release 9.0, 1998, December 18)

The use of descriptive statistics profiled the infectious disease cases, the census tracts and the colonias The descriptive profiles included frequencies, percentages and measures of central tendency The profiles noted the demographic characteristics of cases of hepatitis A, salmonellosis, and shigellosis. The profiles of census tracts described population age and size, dwelling access to water and wastewater services, number of colonias, as well as incidences and rates of infectious diseases Colonias' profiles included population size, census tract location, population access to water and wastewater services, along with incidences and rates of infectious diseases

The average annual incidence rates of hepatitis A, salmonellosis, and shigellosis per 100,000 were calculated for the total populations for 1997-1999 for the Texas, El Paso County, the colonias, the census tracts and age grouping in the census tracts The total Texas population for 1997-1999 was calculated by summing the total populations for those years provided in TDH's 1997-1999 annual epidemiology reports for Texas The total population for El Paso County for 1997-1999 was calculated by summing the total populations in the county for those years provided in TDH's 1997-1999 annual epidemiology reports for Texas (Texas Department of Health, 1998; Texas Department of Health, 1999, Texas Department of Health, 2000). The estimated total population for 1997-1999 for the colonias was calculated by summing the number of persons with access infrastructure services in 1996 from the TWDB and multiplying it by three The colonias' population data were unavailable by age categories. USCB data for 1990 provided population size for total population and age groups in the census tracts The estimated total population for 1997-1999 was calculated by taking a census tract's population for 1990 and multiplying it by three The estimated total populations for nine age groups (i e , 1-5, 6-11, 12-16, 17-21, 22-34, 35-49, 50-64, 65-79, and 80 plus) for 1997-1999 were calculated by taking a census tract's population for 1990 for the age groups and multiplying by three

Research Questions and Hypotheses

The five research questions were tested with several statistical methods Descriptive statistics were used with the first four questions The fifth question and the hypotheses were tested with bivariate correlation (i.e., Pearson *r*) The fifth question tested the relationship between the age and infectious disease rates The bivariate correlation tested the relationship between statuses of water access or wastewater access and infectious disease rates in the colonias and census tracts of El Paso County

The statistical methods were used to test the following research questions

1 What levels of access did populations have to water and wastewater services in the colonias in El Paso County?

2 What levels of access did dwellings have to water and wastewater services in the census tracts in El Paso County?

3 What were the number of cases and average annual incidence rates per 100,000 of hepatitis A, salmonellosis, and shigellosis in the colonias in El Paso County?

4. What were the number of cases and average annual incidence rates per 100,000 of hepatitis A, salmonellosis, and shigellosis in the census tracts in El Paso County?

5 What were the number cases and average annual incidence rates per 100,000 of hepatitis A, salmonellosis, and shigellosis by age group in the census tracts in El Paso County?

The statistical methods were used to test the following research hypotheses

H_{01} - H_{02} The access levels of populations to water and wastewater services in the colonias of El Paso County were not related to the average annual incidence rates per 100,000 of hepatitis A, salmonellosis, and shigellosis

$H_{01}: rxy = 0$ H_{A1} $rxy \neq 0$

$H_{02}: rzy = 0$ $H_{A2}: rzy \neq 0$

H_{03} – H_{04} The access levels of dwellings to water and wastewater services in census tracts of El Paso County were not related to the average annual incidence rates per 100,000 of hepatitis A, salmonellosis, and shigellosis

$H_{03}. rxy = 0$ $H_{A3}: rxy \neq 0$

H_{04} $rzy = 0$ H_{A4} $rzy \neq 0$

CHAPTER 4

RESULTS

Chapter 4 describes the results emerging from the statistical tests of the study questions and hypothesis Five sections introduce the study results Section one presents the descriptive statistics on the sample of cases of hepatitis A, salmonellosis, and shigellosis Section two provides descriptive analyses on the population sizes and number of dwellings in the colonias and census tracts in El Paso County Section three presents the descriptive analyses answering the study questions about accessibility to water and wastewater services in the colonias and census tracts. Through descriptive analyses, section four provides answers to three research questions regarding the number of cases and average annual incidence rates per 100,000 of hepatitis A, salmonellosis, and shigellosis in the colonias and census tracts as well as cases and rates of these infectious diseases by age group in the census tracts Section five presents the results of Pearson's correlations assessing relationships between the average annual incidence rates of the infectious diseases and accessibility to water and wastewater services in colonias and census tracts

Descriptions of The Sample of Infectious Disease Cases

The drawing of the purposive sample of 899 hepatitis A, salmonellosis, and shigellosis came from 1997-1999 infectious disease databases at the Texas Department of Health The address geocoding of the infectious disease cases resulted in a final sample of 516 mapped cases. The cases for each infectious disease were aggregated for 1997-1999

Among the 516 cases, hepatitis A comprised the largest percentage of the total cases at 38.2% (n = 197) Shigellosis was next with 31 8 % (n = 164) of the total cases Salmonellosis comprised 30.0% (n = 155) of the total cases (see Table 4.1)

The proportions of the infectious disease cases by sex were examined (see Table 4 2) The hepatitis A cases consisted of 52 8% males (n = 104) and 47.2% females (n = 94) The proportions of salmonellosis cases by sex were 56 1% females (n = 87) and 43 9% males (n = 68) Shigellosis cases consisted of 51 8% females (n = 85) and 48 2% males (n = 79)

Table 4 1

Number of Cases of Hepatitis A, Salmonellosis, and Shigellosis

Infectious Disease							
Hepatitis A		Salmonellosis		Shigellosis		Total	
197	38 2%	155	30 0%	164	31 8%	516	100 0%

Note. Number of cases of infectious diseases were aggregated for 1997-1999

Table 4 2

Number of Cases of Hepatitis A, Salmonellosis, and Shigellosis by Sex

Infectious Disease	Sex: Female		Male	
Hepatitis A	93	47 2%	104	52 8%
Salmonellosis	87	56 1%	68	43 9%
Shigellosis	85	51 8%	79	48.2%

Note Number of cases of infectious diseases were aggregated for 1997-1999

The ages of the infectious disease cases were aggregated into nine age categories (see Table 4.3) By age group, most of hepatitis A cases were in the age group of 6-11 at 39.1% (n = 77) The majority of the hepatitis A cases were within the age range of 16 and under (66.5%, n = 131) Across the age groups, the 1-5 age group had the most salmonellosis cases at 32.3% (n = 50). The age range of 16 and under had the majority of salmonellosis cases (54 9%, n = 85) By age group, most of the shigellosis cases were in the age group of 1-5 at 50 0% (n = 82) The age range of 11 and under had the majority of shigellosis cases (77 5%, n = 116)

Table 4 3

Number of Cases of Hepatitis A, Salmonellosis, and Shigellosis by Age Group

Infectious Disease	Age Groups for 1- 34: 1-5		6-11		12-16		17-21		22-34	
Hepatitis A	31	15 7%	77	39 1%	23	11 7%	14	7 1%	31	15 7%
Salmonellosis	50	32.3%	31	20 0%	4	2.6%	5	3.2%	24	15.5%
Shigellosis	82	50.0%	34	27 5%	6	3 7%	6	3.7%	14	8 5%
Total	163		142		33		25		69	

Infectious Disease	Age Groups for 35 - 80+: 35-49		50-64		65-79		80+		Total of Age Groups	
Hepatitis A	14	7 1%	2	1 0%	5	2.5%	0	0 0%	197	100 0%
Salmonellosis	16	10 3%	7	4.5%	15	9 7%	3	1 9%	155	100 0%
Shigellosis	9	5.5%	7	4.3%	6	3.7%	0	0.0%	164	100 0%
Total	39		16		26		3		516	100 0%

Note. Number of cases of infectious diseases were aggregated for 1997-1999

Table 4 4

Number of Cases of Hepatitis A, Salmonellosis, and Shigellosis by Ethnicity

Infectious Disease	Ethnicity: Hispanic		Non-Hispanic		Unknown	
Hepatitis A	169	85 8%	24	12 2%	4	2 0%
Salmonellosis	126	81 3%	23	14.8%	6	3.9%
Shigellosis	142	86 6%	18	11 0%	4	2 4%

Note Number of cases of infectious diseases were aggregated for 1997-1999.

The ethnic classifications for the cases of the infectious diseases were Hispanic, non-Hispanic and unknown (see Table 4 4). The majority of cases for each of the infectious diseases were Hispanic Hispanics comprised 85.5% (n = 169) of the hepatitis A cases The salmonellosis cases were 81.3% (n =126) Hispanic Nearly 87% (n = 142) of the shigellosis cases were Hispanic.

Descriptions of Populations and Dwellings in Colonias and Census Tracts

Figure 3.1 shows the colonias and census tracts in El Paso County (see Appendix A) The 132 colonias fall within 12 or 13% of the 95 census tracts. The most of the colonias are located in the southwestern portion of the county

The study data for the 132 colonias provided the number of dwellings each colonia but not the total population for each colonia However, calculating population size was possible by either summing the number persons with and without access to water or wastewater services The summing of access level to either of the services yielded the same total population. Also in the colonias, the minimum population was 11 while the maximum was a population of 3,650 (see Table 4 5) The measures of central tendency were a mean population of 510 3 and a median population of 268.5

The number of dwellings in a colonias varied from a minimum of 2 to a maximum of 681 (see Table 4 5) The mean number of dwellings in the colonias was 99.2 The median number of colonias' dwellings was 50

Table 4 5

Total Population and Dwellings in the Colonias in El Paso County

Descriptive Statistics	Total Population	Dwellings
Minimum	11	2
Maximum	3,650	681
Mean	510 3	99.2
Median	268.5	50 0
Std. Deviation	653.1	121 1
Skewness	2.7	2 3

Note The Texas Water Development Board was the source of this 1996 data about the 132 colonias in El Paso County

Table 4.6

Total Population and Dwellings in the Census Tracts in El Paso County

Descriptive Statistics	Total Population	Dwellings
Minimum	911	204
Maximum	15,337	4,819
Mean	6,227 7	1,973 4
Median	6,317.0	1,872 0
Std. Deviation	2,755.4	907 3
Skewness	0 7	0 5

Note. The U.S Census Bureau was the source of this 1990 data about the 95 census tracts in El Paso County

The census tracts had a mınımum populatıon of 911 and a maxımum populatıon of 15,337 (see Table 4 6) The measures of central tendency were a mean of 6,227 7 and a medıan of 6,317 0 Dwellıngs ın the census tracts ranged from a mınımum of 204 dwellıngs to a maxımum of 4,819 dwellıngs

Access Levels to Water and Wastewater Services in Colonias and Census Tracts

The descrıptıve analyses provided answers to several study questıons regardıng access to water and wastewater services in the colonıas and census tracts of El Paso County The Texas Water Development Board defined access ın the colonıas as the number of persons resıdıng ın a colonıa wıth or wıthout access to publıc water supplıers and to wastewater servıce provıders The U S Census Bureau defined water servıce access accordıng to the number of dwellings ın a census tract wıth access to a publıc or prıvate water system, a drılled or dug well and other sources of water Sewage access in a census tract was defined as dwellıngs with access to a public sewage system, a septıc tank or cesspool or other means of wastewater dısposal

Table 4 7

Access Levels of Populatıons to Water and Wastewater Services ın the Colonıas ın El Paso County

Descrıptıve Statıstıcs	Access Levels of Populatıons (Number of Persons)							
	Water Servıce		No Water Servıce		Wastewater Servıce		No Wastewater Servıce	
Mınımum	0	0.0%	0	0 0%	0	0.0%	11	66 0%
Maxımum	3,650	100.0%	2,710	100 0%	1,120	34 0%	3.650	100 0%
Mean	373 58	63.2%	136 75	36 8%	8 48	0 3%	501 85	99.7%
Medıan	143.5	100.0%	0.00	0.0%	0.00	0 0%	268 50	100.0%
Std. Devıatıon	640.57	48 2%	345.10	48.2%	97 48	3 0%	622.85	3 0%
Skewness	2.97	-0.6%	4.50	0.6%	11.49	11.5%	2.55	-11.5%

Note. The Texas Water Development Board was the source of thıs 1996 data about the 132 colonıas ın El Paso County

One question was, "What levels of access did populations have water and wastewater services in the colonias in El Paso County?" Access to public water services ranged from a minimum of no one having water service access to a maximum of 100 0% of the population having access (see Table 4 7) The measures of central tendency exhibited a mean level of water service access at 63.2% for a colonia's population and a median level of access at 100 0% with a standard deviation (SD) equal to 48 2% The minimum and maximum levels of a colonia's population with no water access were 0 0% and the 100.0% respectively. The measures of central tendency were a mean of 36 8% for a colonia's population without water service access and a median of 0 0% without access to water with a SD equal to 48 2% The descriptive statistics showed a central tendency toward most of the population in a colonia having access to public water services (see Table 4.7).

Access to centralized wastewater collection and treatment facilities ranged from a minimum of no one having access to a maximum of 34 0% access (see Table 4 7) The measures of central tendency exhibited a mean of level of access to wastewater services at less 0 3% and a median level of access at 0 0% with the SD equal to 3 0%. Next, the absence of wastewater service access had a minimum of 66 0% of a colonia's population and a maximum of 100.0% of a colonia's population The measures of central tendency were a mean of 99.7% and a median of 100 0% for a population without access to wastewater services Most of the population in a colonia had no access to wastewater services as indicated by the measures of central tendency (see Table 4.7).

A second study question asked, "What levels of access did persons have to water and wastewater services in the census tracts of El Paso County?" In the 95 census tracts, the levels of access to public/private services ranged from a minimum of 45.5% of the dwellings to a maximum of 100.0% of the dwellings (see Table 4 8) The measures of central tendency indicated that a mean of 96.7% of the dwellings and a median of 100.0% of the dwellings had access to public/private water services with a SD equaling 10 0%. Wells also were sources of water to dwellings in the census tracts (see Table 4 8) The minimum and maximum percentages of dwellings accessing drilled water wells were 0.0% and 0 4% respectively The mean and median percentages of dwellings accessing drilled water wells were 0.02% and 0 0% respectively; the SD equaled 0.07% Access to dug water wells ranged from a minimum of 0 0% of dwellings to a maximum of 0 1% of dwellings in a census tract The measures of central tendency were a mean of 0 001% and a median of 0 0% for dwelling access dug water wells with the SD equaling 0 02% Some dwellings access other water sources which ranged from a minimum of 0 0% to a maximum of 7 7% The mean and median for dwellings accessing other sources of water were 0 4% and 0 0% respectively, the SD equaled 1 4% The descriptive statistics indicated a central tendency toward most dwellings in a census tract having access to public/private water services (see Table 4 8)

The wastewater services reported as available to dwellings in the census tracts were public wastewater services, septic tanks, cesspools, and other wastewater disposal sources The levels of access to public wastewater services ranged from a minimum of 93 0% to a maximum of 100 0% of dwellings in a census tract (see Table 4.9). The measures of central tendency were a mean of 99 1% and a median of 99 7% for dwelling access public wastewater services, the SD equaled 1 5% Access levels to septic tanks or cesspools ranged from a minimum of 0 0% to a maximum of 94 0% of dwellings in a census tract The mean and median levels of dwellings accessing septic tanks or cesspools were 8 8% and 0 5% respectively, the SD equaled 23 1% Dwellings accessing other wastewater disposal sources in the census tracts ranged from a minimum of 0 0% to a maximum of 7 0% The measures of central tendency for accessing other wastewater disposal sources were a mean of 0 9% and a median 0 2% with a SD equaling 1 5% Most of the dwellings in the census tracts had access to public wastewater services as indicated by the measures of central tendency (see Table 4 9)

Cases and Rates of Infectious Diseases in Colonias and Census Tracts

The third and fourth study questions asked about the cases and rates of hepatitis A, salmonellosis, and shigellosis in the colonias and the census tracts in El Paso County Average annual incidence rates per 100,000 for the period of 1997-1999 were calculated for each of these infectious diseases for the 132 colonias and the 95 census tracts In addition, statewide and county level, average annual incidence rates per 100,000 also were calculated The average annual incidence rates for the colonias and the census tracts were compared to average annual incidence rates for Texas and El Paso County

Table 4 8

Access Levels of Dwellings to Water Services in the Census Tracts in El Paso County

Descriptive Statistics	Public/Private Water Service		Drilled Water Well		Dug Water Well		Other Water Source	
	Access Levels of Dwelling to Water Services							
Minimum	204	45 5%	0	0 0%	0	0 0%	0	0 0%
Maximum	4,819	100 0%	787	0 4%	253	0 1%	181	7 7%
Mean	1,915 0	96 7%	41 8	0 02%	9 6	0 001%	7 0	0 4%
Median	1,872 0	100 0%	0 0	0 0%	0 0	0 0%	0 0	0 0%
Std Deviation	912.2	10 0%	136 2	0 07%	35 2	0 02%	27 5	1 4%
Skewness	0 5	-3.5%	3 8	3 4%	4 8	4 7%	4 8	3 9%

Note The U S Census Bureau was the source of this 1990 data about the 95 census tracts in El Paso County

Table 4 9

Access Levels of Dwellings to Wastewater Services in the Census Tracts in El Paso County

Descriptive Statistics	Public Wastewater Service		Septic Tank/ Cesspool		Other Wastewater Disposal Source	
	Access Levels of Dwelling to Wastewater Services					
Minimum	41	93.0%	0	0 0%	0	0.0%
Maximum	4,787	100 0%	2,413	94.0%	135	7.0%
Mean	1,809 6	99 1%	149 7	8 8%	14.2	0.9%
Median	1,786 0	99 7%	11 0	0 5%	4 0	0.2%
Std. Deviation	982 3	1 5%	424.0	23 1%	24.1	1.5%
Skewness	0.3	2.3%	3.5	2.9%	2.7	2.2%

Note The U.S Census Bureau was the source of this 1990 data about the 95 census tracts in El Paso County

Table 4 10

Number of Cases and Average Annual Incidence Rates per 100,000 for Hepatitis A, Salmonellosis, and Shigellosis in Texas, 1997-1999

	Hepatitis A	Salmonellosis	Shigellosis
Number of Cases	10,565	8,392	9,773
Average Annual Incidence Rate	17 9	14 2	16 6

Note. The 1997-1999 Epidemiology in Texas annual reports from the Texas Department of Health were the sources of the number of cases of the infectious diseases and the annual statewide population figures that were used to calculate the rates

Table 4 11

Number of Cases and Average Annual Incidence Rates per 100,000 for Hepatitis A, Salmonellosis, and Shigellosis in El Paso County, 1997-1999

	Hepatitis A	Salmonellosis	Shigellosis
Number of Cases	330	307	262
Average Annual Incidence Rate	14 9	13 9	11 9

Note. The 1997-1999 Epidemiology in Texas annual reports from the Texas Department of Health were the sources of the number of cases of the infectious diseases and the annual population figures for El Paso County that were used to calculate the rates

The number of cases and average annual ıncıdence rates per 100,000 for Texas are shown ın Tables 4 10 and 4 11 The statewıde average annual ıncıdence rates per 100,000 were 17 9 for hepatıtıs A, 14 2 for salmonellosıs, and 16 6 for shıgellosıs The average annual ıncıdence rates per 100,000 ın El Paso County were 14.9 for hepatıtıs A, 13 9 for salmonellosıs, and11 9 for shıgellosıs Average annual ıncıdence rates for the ınfectıous dıseases were hıgher for at the state than for El Paso County

Table 4 12 shows the number of cases and average annual ıncıdence rates for the colonıas ın El Paso County Twenty-five of the 516 cases of ınfectıous dısease were located ın 17 or 13% of the 132 colonıas The average annual rates per 100,000 for the colonias were 3.5 for hepatıtis A, 4.9 for salmonellosıs, and 4 0 for shıgellosis For all three ınfectıous dıseases the average annual ıncidence rates per 100,000 for the colonıas were lower in comparıson to both the statewıde and El Paso County average annual ıncıdence rates (see Tables 4 10 and 4 11)

Descriptıve statistics exhibited the dıstributıons of the infectıous dıseases wıthın the 132 colonıas (see Table 4 13) Hepatıtıs A ranged from a mınimum of 0 to a maxımum of 2 cases, for whıch the average annual ıncıdence rate was 88 3 per 100,000 The cases of salmonellosıs wıthın the colonias ranged from a minimum of 0 to a maxımum of 3, for which the annual ıncidence rate was 219 8 per 100,000 Shıgellosıs cases within the colonias ranged from a minimum of 0 to a maxımum of 2, for whıch the average annual ıncıdence rate was 73 3 per 100,000

Wıthın the colonias ınstances exısted ın whıch the maxımum values for average annual ıncıdence rates per 100,000 for each of the ınfectıous dıseases were hıgher than the rates for the Texas, El Paso County and all of the colonıas For example, the maximums for the average annual rates per 100,000 were 88 3 for hepatıtıs A, 219.8 for salmonellosıs, and 73.3 for shıgellosıs (see Table 4.13) In addıtıon, the number of cases and the average annual ıncıdence rates were calculated for the aggregate of the three ınfectıous diseases within the 132 colonias (see Table 4 13 and Figure 4.1 ın Appendıx C) The mınımum number of cases was 0 and the maximum number of cases was 3 for the ınfectious dıseases, for which the average annual ıncıdence rate was 219 8 per 100,000

Table 4 12

Number of Cases and Average Annual Incidence Rates per 100,000 for Hepatitis A, Salmonellosis, and Shigellosis in the Colonias in El Paso County, 1997-1999

	Hepatitis A	Salmonellosis	Shigellosis
Number of Cases	7	10	8
Average Annual Incidence Rate	3.5	4.9	4 0

Note Number of cases of the infectious diseases were drawn from the Texas Department of Health's database of disease events for 1997-1999 and the population figures to calculate the rates were from the Texas Water Development Board database of the 132 colonias in El Paso County

Table 4 13

Number of Cases and Average Annual Incidence Rates per 100,000 for Hepatitis A, Salmonellosis, and Shigellosis within the Colonias in El Paso County, 1997-1999

	Hepatitis A		Salmonellosis		Shigellosis		Three Infectious Diseases	
Descriptive Statistics	Number of Cases	Rate	Number of Cases	Rate	Number of Cases	Rate	Number of Cases	Rate
Minimum	0	0.0	0	0 0	0	0.0	0	0.0
Maximum	2	88 3	3	219 8	2	73 3	3	219 8

Note Number of cases of the infectious diseases were drawn from the Texas Department of Health's database of disease events for 1997-1999 and the population figures to calculate the rates were from the Texas Water Development Board database of the 132 colonias in El Paso County

The 1997-1999 cases and average annual incidence rates per 100,000 for hepatitis A, salmonellosis, and shigellosis in the 95 census tracts in El Paso County were reported in Table 4 14 In the census tracts, the hepatitis A cases equaled 175 and the average annual incidence rate was 11 1 per 100,000 Salmonellosis cases equaled 155 and the average annual incidence rate was 8 7 per 100,000 Cases of shigellosis equaled 162 and the average annual incidence rate was 9 2 per 100,000 The average annual incidence rates per 100,000 for the three diseases were lower than the average annual incidence rates for Texas and El Paso County (see Tables 4.10-4 11) However, the rates of the infectious diseases for the census tracts were higher than the average annual incidence rates for the colonias (see Table 4 12)

Descriptive statistics exhibited how the infectious diseases were distributed within the 95 census tracts (see Table 4 15) The minimum was 0 and the maximum was 10 for the cases of hepatitis A. The average annual incidence rate per 100,000 for hepatitis A ranged from a minimum of 0 to a maximum of 72 3 The range of salmonellosis cases was 0 to a maximum of 8 (see Table 4.15) The annual average incidence rates per 100,000 ranged from a minimum of 0 to a maximum of 37 3 for salmonellosis The cases of shigellosis within the census tracts ranged from 0 to a maximum of 10 (see Table 4 15) The average annual incidence rates per 100,000 for shigellosis ranged from a minimum of 0 to a maximum of 42 8

The number of cases and average annual incidence rates per 100,000 for the aggregate of the three infectious diseases also were reported in Table 4 15 Within the census tracts the total cases ranged from 0 to a maximum of 24 The average annual incidence rates per 100,000 ranged from 0 to a maximum of 108 5 for the three infectious diseases combined Figure 4 2 showed the natural breaks for the average annual incidence rates for the aggregate of the infectious diseases within the 95 census tracts (see Appendix D)

The fifth research questioned focused on the number of cases and average annual incidence rates per 100,000 by age group in the census tracts The average annual incidence rates per 100,000 by age groups were calculated for the census tracts (see Table 4 16). Youth in the age groups of 1-5 and 6-11 had the highest, average annual incidence rates per 100,000 for hepatitis A, salmonellosis, and shigellosis The rates for ages 1-5 were as follows hepatitis A, 19 08; salmonellosis, 30.78, and shigellosis, 50 48 The rates for ages 6-11 were as follows hepatitis A, 40.27, salmonellosis, 16.21; and shigellosis, 17.78.

Table 4 14

Number of Cases and Average Annual Incidence Rates per 100,000 for Hepatitis A, Salmonellosis, and Shigellosis in the Census Tracts in El Paso County, 1997-1999

	Hepatitis A	Salmonellosis	Shigellosis
Number of Cases	197	155	164
Average Annual Incidence Rate	11.1	8 7	9.2

Note Number of cases of the infectious diseases were drawn from the Texas Department of Health's database of disease events for 1997-1999 and the population figures to calculate the rates were from the U S. Census Bureau's 1990 database of the 95 census tracts in El Paso County

Table 4 15

Number of Cases and Average Incidence Rates per 100,000 for Hepatitis A, Salmonellosis, and Shigellosis within the Census Tracts in El Paso County, 1997-1999

	Hepatitis A		Salmonellosis		Shigellosis		Three Infectious Diseases	
Descriptive Statistics	Number of Cases	Rate	Number of Cases	Rate	Number of Cases	Rate	Number of Cases	Rate
Minimum	0	0 0	0	0.0	0	0 0	0	0 0
Maximum	10	72.3	8	37 3	10	42 8	24	108.5

Note Number of cases of the infectious diseases were drawn from the Texas Department of Health's database of disease events for 1997-1999 and the population figures to calculate the rates were from the U S Census Bureau's 1990 database of the 95 census tracts in El Paso County.

Table 4 16

Number of Cases and Average Annual Incidence Rates per 100,000 by Age Group for Hepatitis A, Salmonellosis, and Shigellosis in the Census Tracts in El Paso County, 1997-1999

Infectious Disease	Age Groups for 1- 34									
	1-5		6-11		12-16		17-21		22-34	
	Cases	Rate	Cases	Rate	Cases	Rate	Cases	Rate	Cases	Rate
Hepatitis A	31	19 08	77	40 27	23	14 36	14	8 54	31	7 92
Salmonellosis	50	30 78	31	16 21	4	2 50	5	3 05	24	6 13
Shigellosis	82	50 48	34	17 78	6	3 75	6	3 66	14	3 58
Total	163	100 35	142	74.27	33	20.61	25	15 25	69	17 62

Infectious Disease	Age Groups for 35 - 80+							
	35-49		50-64		65-79		80+	
	Cases	Rate	Cases	Rate	Cases	Rate	Cases	Rate
Hepatitis A	14	4 27	2	0.97	5	4 24	0	0.00
Salmonellosis	16	4 88	7	3 41	15	12.73	3	11.44
Shigellosis	9	2 75	7	3 41	6	5.09	0	0 00
Total	39	11 90	16	7 80	26	22.06	3	11.44

Note. Number of cases of the infectious diseases were drawn from the Texas Department of Health's database of disease events for 1997-1999 and the population figures to calculate the rates were from the U S Census Bureau's 1990 database of the 95 census tracts in El Paso County

Tests of Relationships with Rates of Infectious Diseases

Pearson *r* was used to test the relationships between several between several independent variables and the dependent variables of aggregate infectious disease rates for the colonias and census tracts in El Paso County Assessing the direction and the magnitude of these relationships tested several null hypotheses

The first null hypothesis stated, "The access levels of persons to water and wastewater services in the colonias of El Paso County were not related to the average annual incidence rates per 100,000 of hepatitis A, salmonellosis, and shigellosis " The computation of the Pearson *r* was a two-tailed test with the significance level set $p \leq 0\ 05$ The independent variables were the percentages of colonia's residents who did or did not have access to public water or sewage services The dependent variables were the average annual incidence rates of hepatitis A, salmonellosis, and shigellosis in a colonia The statistical results did not reject the null hypothesis (see Table 4 17) No relationships occurred between residents' access levels to water or sewage services and infection disease rates in a colonia

The second null hypothesis stated, "The access levels of dwellings to water and wastewater services in census tracts of El Paso County were not related to the average annual incidence rates per 100,000 of hepatitis A, salmonellosis, and shigellosis " Computation of the Pearson *r* was a two-tailed test with the significance level set $p \leq 0.05$ The independent variables were the percentages of dwellings in a census tract with access to various types of water services public water and sewage services. The dependent variables were the average annual incidence rates of hepatitis A, salmonellosis, and shigellosis in a census tract The results of the correlation did not reject the null hypothesis for the relationship between access levels to water and wastewater services and the rates of hepatitis A and salmonellosis in the census tracts (see Tables 4 18 and 4 19)

However, significant relationships occurred between access levels to water and wastewater services and the average annual incidence rates of shigellosis in the census tracts (see Tables 4.18 and 4 19) A negative and significant relationship occurred between percentages of dwellings with access to public or private water services and the average annual incidence rates per 100,000 for shigellosis in the census tracts ($p < 0\ 01$, $r = -0\ 324$) Positive and significant relationships occurred between the following independent

Table 4 17

Correlation between Populations' Access Levels to Water and Wastewater Services and the Average Annual Incidence Rates per 100,000 for Hepatitis A, Salmonellosis, and Shigellosis in the Colonias in El Paso County

	Populations' Access Levels and r Values			
Infectious Disease	Water Service	No Water Service	Wastewater Service	No Wastewater Service
Hepatitis A	0.131	-0 131	0 065	-0 065
Salmonellosis	0 096	-0 096	-0 019	0 019
Shigellosis	0.151	-0 151	-0 017	0 017

Table 4.18

Correlation between Dwellings' Access Levels to Water Services and the Average Annual Incidence Rates per 100,000 for Hepatitis A, Salmonellosis, and Shigellosis in the Census Tracts in El Paso County

	Dwellings' Access Levels and r Values			
Infectious Disease	Public/Private Water Service	Drilled Water Well	Dug Water Well	Other Water Source
Hepatitis A	0.054	-0 057	-0 066	-0 003
Salmonellosis	-0 041	0 033	0.051	0.052
Shigellosis	-0.324**	0.325**	0.247*	0 311**

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed)

variables and the dependent variable, average annual incidence rates per 100,000 of shigellosis in the census tracts at $p < 0.01$ dwellings with access to water from drilled wells, $r = 0.325$, dwellings with to other sources of water, $r = 0.311$, and dwellings with access to septic tanks or cesspools for waste disposal, $r = 0.275$ Another positive and significant relationship occurred at $p < 0.05$ between the average annual incidence rates for shigellosis dwellings with access to water from dug wells in the census tracts ($r = 0.247$)

Post-hoc analyses of the relationships between types of water services and wastewater services in census tracts' dwellings reflected some significant correlations (see Table 4 20) Dwellings with access to public or private water services were positively and significantly related to access to public wastewater services ($p < 0.01$, $r = 0.617$) while negatively and significantly related to access to septic tanks or cesspools ($p < 0.01$, $r = -0.931$) and to other sources of wastewater disposal ($p < 0.01$, $r = -0.617$) Dwellings with access to drilled water wells were negatively and significantly related to access to public wastewater services ($p < 0.01$, $r = -0.582$) while positively and significantly related to access to septic tanks ($p < 0.01$, $r = 0.914$) and to other sources of wastewater disposal ($p < 0.01$, $r = 0.582$). Dwellings with access to dug water wells were negatively and significantly related to public wastewater services ($p < 0.01$, $r = -0.588$) while positively and significantly related to access to septic tanks or cesspools ($p < 0.01$, $r = 0.836$) and to other sources of wastewater disposal ($p < 0.01$, $r = 0.588$)

Finally, dwellings with access to other sources of water were negatively and significantly related to with public wastewater services ($p < 0.01$, $r = -0.598$) while positively and significantly related to access septic tanks or cesspools ($p < 0.01$, $r = 0.798$) and to other sources of wastewater disposal ($p < 0.01$, $r = 0.598$) In summary, access to public or private water services was positively related to access to public wastewater disposal. However, access to all other types of water sources was positively related to access to septic tanks, cesspools or other sources of wastewater disposal.

Table 4.19

Correlation between Dwellings' Access Levels to Wastewater Services and the Average Annual Incidence Rates per 100,000 for Hepatitis A, Salmonellosis, and Shigellosis in the Census Tracts of El Paso County

	Dwellings' Access Levels and *r* Values		
Infectious Disease	Public Wastewater Service	Septic Tank/ Cesspool	Other Wastewater Disposal Source
Hepatitis A	-0 015	-0 065	0.015
Salmonellosis	-0 186	0 106	0 186
Shigellosis	-0 152	0 275*	0.152

* Correlation is significant at the 0 01 level (2-tailed)

Table 4.20

Correlation between Dwellings' Access Levels to Water and Wastewater Services in the Census Tracts of El Paso County

	Dwellings' Access Levels for Wastewaterater Services and r^a Values		
Water Services	Public Wastewater Service	Septic Tank/ Cesspool	Other Wastewater Disposal Source
Public/Private Water Service	0.617	-0.931	-0 617
Drilled Water Well	-0.582	0 914	0.582
Dug Water Well	-0 588	0 836	0 588
Other Water Source	-0.598	0.798	0 598

[a]All correlations were significant at the 0 01 level (2-tailed)

CHAPTER 5

DISCUSSION

As an exploratory venture into descriptive epidemiology, this thesis study culminates with a discussion of the salient observations emanating from research results. The discussion in Chapter 5 consists of five sections. Section one presents the notable findings from the descriptive statistics for the sample of hepatitis A, salmonellosis and shigellosis cases and for access levels to water and wastewater services in the colonias and census tracts in El Paso County Section two provides the notable findings emerging from the calculations of the average annual incidence rates per 100,000 of hepatitis A, salmonellosis, and shigellosis Section three provides the conclusions that were drawn from the study results Section four presents suggestions for future research

Notable Findings from the Descriptive Statistics

Descriptive statistics provided profiles of the sample of hepatitis A, salmonellosis, and shigellosis cases and the status of water and wastewater services in the colonias and census tracts in El Paso County Children comprised the largest numbers of hepatitis A, salmonellosis, and shigellosis cases among the study sample of 516 cases (see Table 4.3 and 4.16) Children between the ages of 6-11 constituted the largest portion (59 1%) of the cases

The answers to study questions one and two provided an understanding about the access levels to water and wastewater services in the colonias and census tracts in El Paso County Populations' access levels were greater for water services than for wastewater services in the 132 colonias (see Table 4.7). A majority of populations in the colonias had access to water services, the mean for water access level was 63.2% However, a majority of the colonias' populations had no access to wastewater services; the mean for no access to wastewater services was 99 7% A limitation of the data of populations' access to water and wastewater services in the colonias was the absence of data on other available sources of water like well and on other available sources of wastewater disposal like cesspools or septic tanks For example, the access levels to wastewater services may have been greater if information about cesspools and septic tanks had been available from the data from the Texas Water Development Board (TWDB)

Dwellings had greater access to public or private water services than to public wastewater services in the census tracts (see Tables 4 8 and 4 9) The mean access level for dwellings to public or private water services was 96 7% The mean access level for dwellings with access to public wastewater services was 99.1%

Notable Findings from the Average Annual Incidence Rates

Research questions three and four asked about the average annual incidence rates per 100,000 of hepatitis A, shigellosis, and salmonellosis in the colonias and census tracts in El Paso County Their average annual incidence rates per 100,000 of the three infectious diseases were compared with the average annual incidence rates for Texas and for El Paso County (see Tables 4 10-4 15) However, the geocoding of the cases of the three infectious diseases biased the final sample of cases, which was 516 or 57% of the original sample of 899 cases of those infectious diseases In other words, only those cases with an accurate address were included in the sample for the colonias and the census tracts.

Only 25 or 55 of the 516 cases were found to be located in the colonias In addition, these 25 cases were located in the 17 or 13% of the 132 colonias. The average annual incidence rates per 100,000 of hepatitis A, salmonellosis, and shigellosis were lower in the colonias than the rates for these three diseases in Texas, El Paso County and the census tracts

The 516 infectious disease cases fell within 87 of the 95 census tracts The census tracts' average annual incidence rates per 100,000 of hepatitis A, salmonellosis, and shigellosis were lower than the rates for Texas and El Paso County. Yet, the census tract's average annual incidence rates were higher than the rates in the colonias

Research question five asked about the average annual incidence rates per 100,000 of the three infectious diseases by age group Youth under age 12 had the highest, average annual rates for hepatitis A, salmonellosis, and shigellosis (see Table 4 16) The average annual incidence rate of shigellosis was higher than the rates were of hepatitis A and salmonellosis for 1-5 year olds However, the average annual incidence rate of hepatitis A was higher than the rates of salmonellosis and shigellosis for 6-11 year olds

Notable Findings from the Bivariate Correlations

The purpose of research hypotheses was to test relationships The first hypothesis tested the relationship between populations' levels of access to water and wastewater services and the average annual incidence rates per 100,000 of hepatitis A, salmonellosis, and shigellosis in the colonias The results of the bivariate correlations indicated no relationships in the colonias between access levels to water and wastewater services and the average annual incidence rates for the three infectious diseases (see Table 4.17). The testing of this relationship may have been biased by low numbers of cases that were geocoded as residing in the colonias

The second hypothesis tested the relationship between dwellings' access levels to different types of water and wastewater services and the average annual incidence rates per 100,000 of hepatitis A, salmonellosis, and shigellosis in the census tracts The resulting only indicated significant relationships for access levels to certain services and the average annual rate of shigellosis. The services significantly related to the shigellosis rates were public or private water services, drilled water wells, dug water wells, other sources of water, and septic tanks or cesspools (see Tables 4.18 and 4.19). Accessing water wells, other sources of water, as well as septic tanks or cesspools was related to an increase in the rate of shigellosis However, accessing public or private water services was related to a decrease in the rate of shigellosis

A limitation in testing relationships between access levels to water and wastewater services and the average annual rates of hepatitis A, salmonellosis, and shigellosis was the absence of the access levels for each infectious disease case in this study. Levels of access to water and wastewater services was defined for the geographical regions of colonias or census tracts and not for the cases. Assessing the level of common variation may been hampered by the absence of data on access to water and wastewater services for each disease case

Finally, post-hoc analysis of bivariate correlations between water and wastewater service access in the census tracts provided interesting observations (see Table 4 20) Dwellings accessing public or private water services were more likely to be accessing public sewage services However, dwellings with water wells or other water sources were less likely to be accessing public sewage services and more likely to accessing septic tanks, cesspools, and other sources of sewage disposal

Conclusions

What were some obvious conclusions drawn as the consequence of this thesis study? First, the use of existing data to conduct secondary analyses provided valuable fuel for an exploratory study Tying the variety of data sources together allowed the connecting of infectious disease incidences of hepatitis A, salmonellosis, and shigellosis to colonias or census tracts This was possible due to the availability of shapefiles for geographic software from the GDT Dynamap®, which provided geographic boundary files of El Paso County and its census tracts, along with the files of the boundary files of the colonias in El Paso County provided by the Texas Office of the Attorney General (OAG)

The availability of addresses for infectious disease cases from the Texas Department of Health (TDH) permitted geocoding the cases to geographic locations in El Paso County Three years of case data (i e., 1997 to 1999) ensured a large sample size However, approximately 43 0% of cases were not geocoded due to missing or inaccurate addresses.

In the end, the availability of data bases from the TDH, OAG, TWDB, and USCB created the possibility for examining the relationships between infectious disease rates in two types of communities and levels of access to water and wastewater services. This possibility permitted a study design to examine descriptive profiles about access levels to water services and wastewater disposal and the populations impacted by hepatitis A, salmonellosis, and shigellosis In addition, the secondary analysis permitted testing the relationships among these variables

Finally, perhaps personal habits rather than accessibility to water and sewage services were the link to the spread of these infectious diseases in El Paso County. Levels of access to public or private water systems were high in both the colonias and the census tracts. Also, a positive and significant relationship occurred between public or private water access and the average annual incidence rate of shigellosis. This relationship ran counter to past research in Chapter 2 indicating that the access to pubic or private water services reduced the risk of acquiring waterborne infectious diseases such as shigellosis

The results also indicated that children were at greater risk for contracting hepatitis A, salmonellosis. and shigellosis Young children generally have learned good hygiene habits as they mature Perhaps the children in the study sample were more vulnerable due to a lack of knowledge about hygiene measures to prevent contracting or spreading disease Or, characteristics of the environments in which they spent their days may have placed them at greater infectious disease risk Finally, older persons in the study sample may have practiced good hygiene habits and may have been immune to hepatitis A due to past exposure

Suggestions for Future Research

The results of this study underlined the importance of gathering primary data on risk factors associated with incidences of hepatitis A, salmonellosis, and shigellosis It would be helpful to survey every reported case or survey a sample of report cases about access to types of water and wastewater services. Other pertinent survey questions would include inquiring about other risk factors identified associated with contracting and spreading hepatitis A, salmonellosis, and shigellosis For example, questions would focus on behavioral habits associated with personal hygiene, cooking, and food storage along with identifying if the cases reside in a colonia

This type of health risk survey would be helpful for several reasons First, it would provide information on risk factors associated with the three infectious diseases. Second, it would permit a source of primary data that could lend itself to statistical test assessment of key risk factors using logistic or Poisson regression The results of these forms of analyses would provide a clearer representation of what factors contribute to the spread of hepatitis A, salmonellosis, and shigellosis along the counties along the Texas-Mexico Border.

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APPENDIX A – Figure 3.1

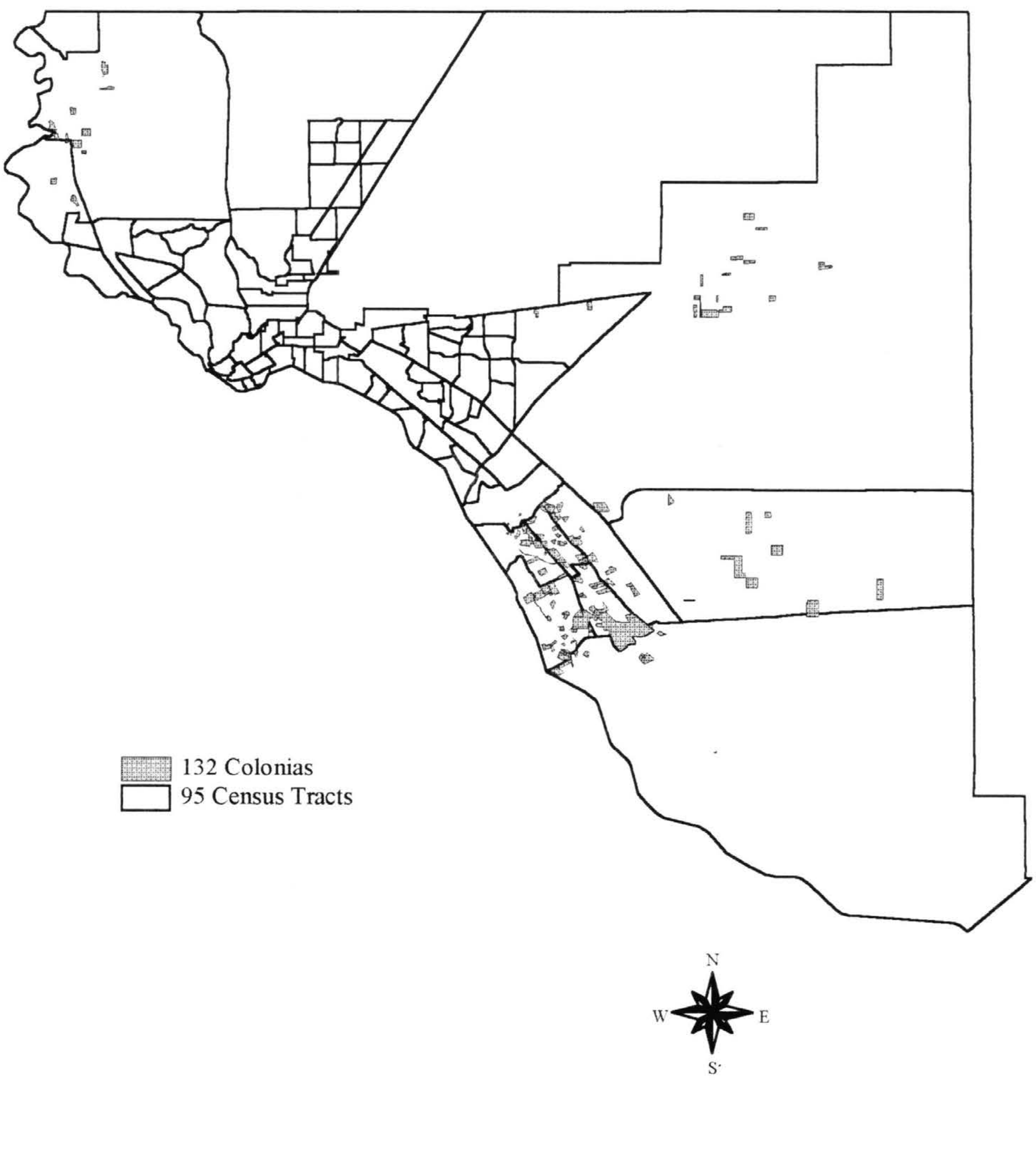

Figure 3.1 Colonias and Census Tracts in El Paso County

APPENDIX B – Figure 3.2

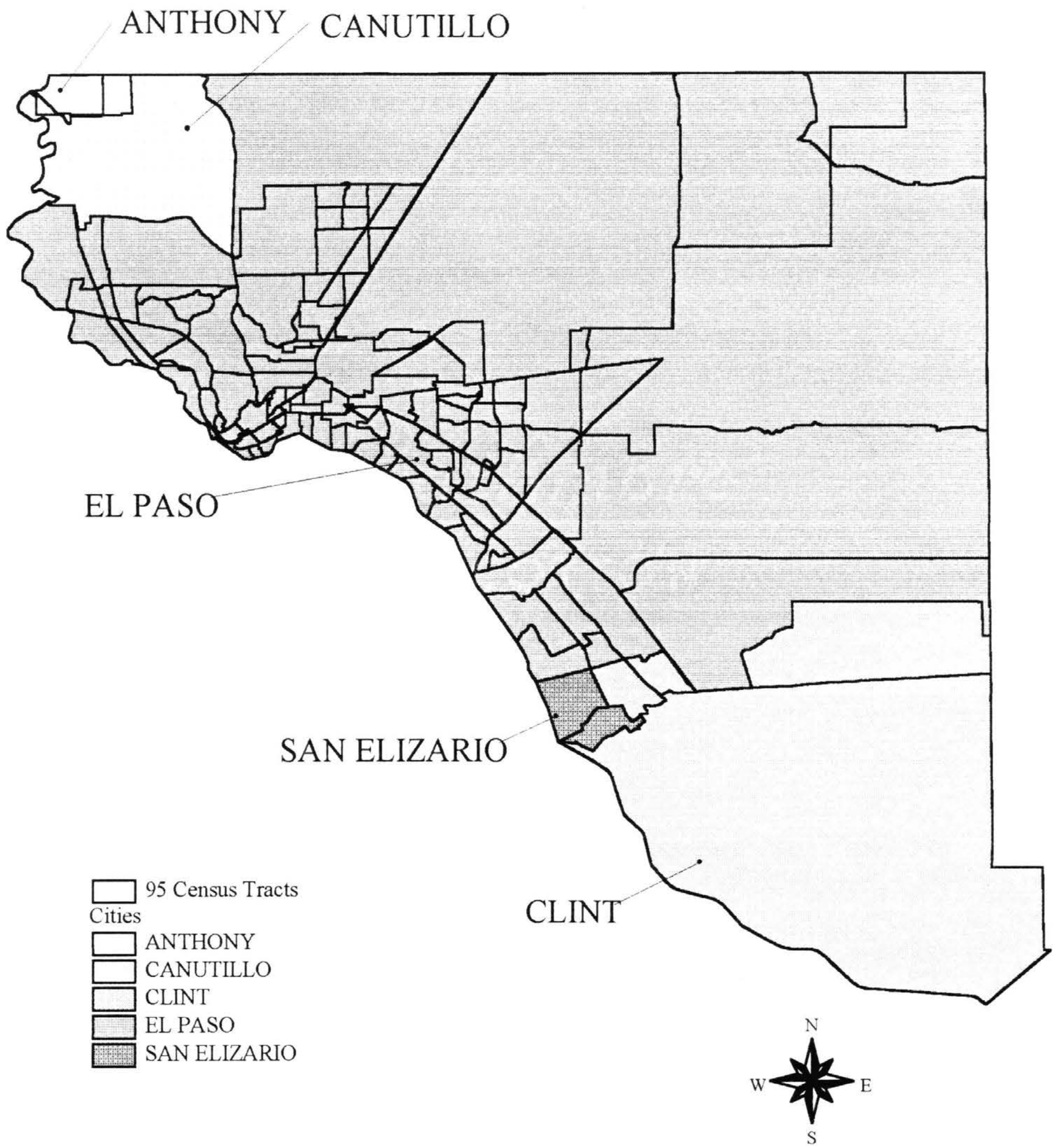

Figure 3.2 Census Tracts and Cities in El Paso County

APPENDIX C – Figure 4.1

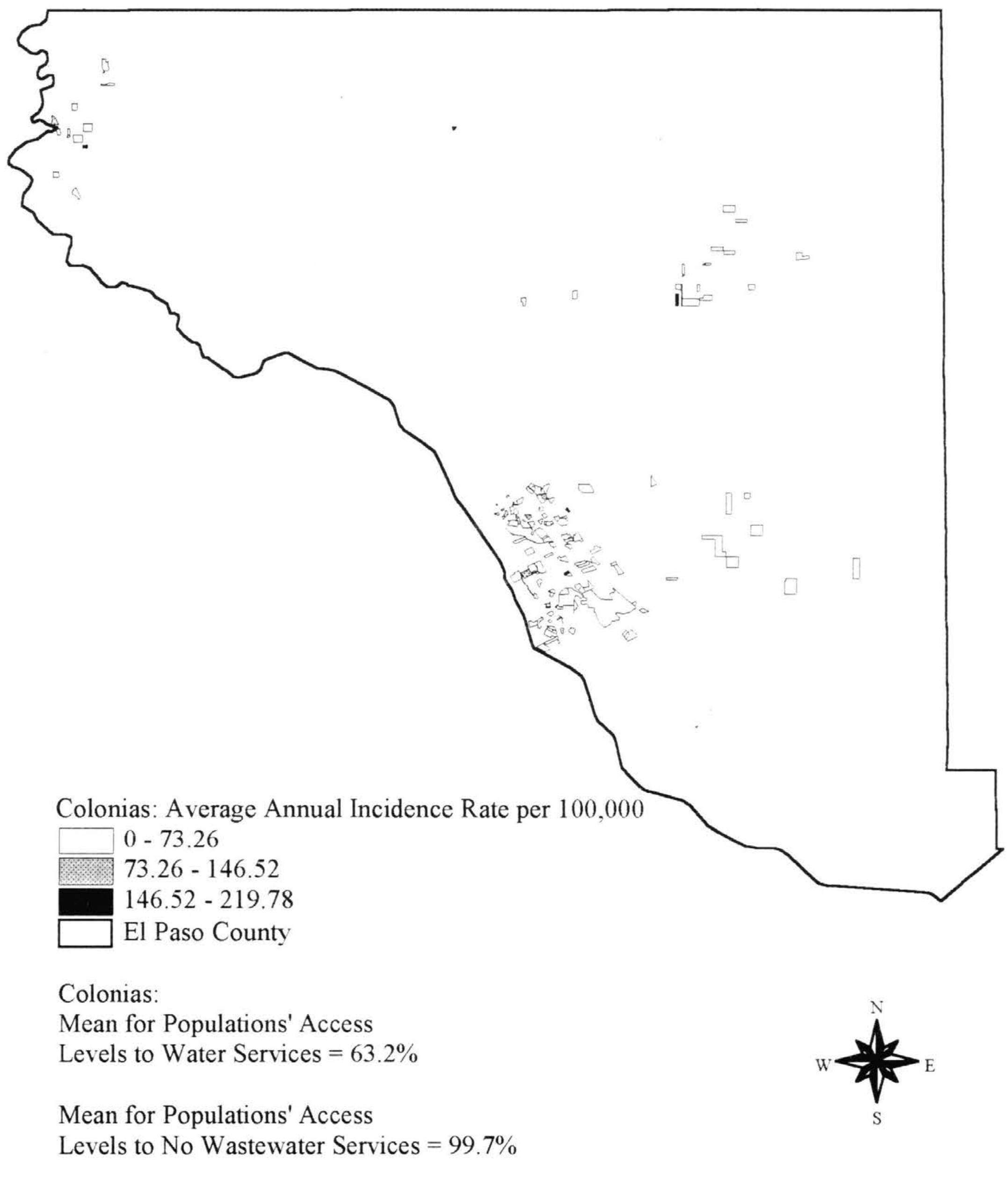

Figure 4.1 Average Annual Incidence Rates per 100,000 for the Aggregate of Hepatitis A, Salmonellosis, and Shigellosis in the 132 Colonias in El Paso County, 1997-1999

APPENDIX D – Figure 4.2

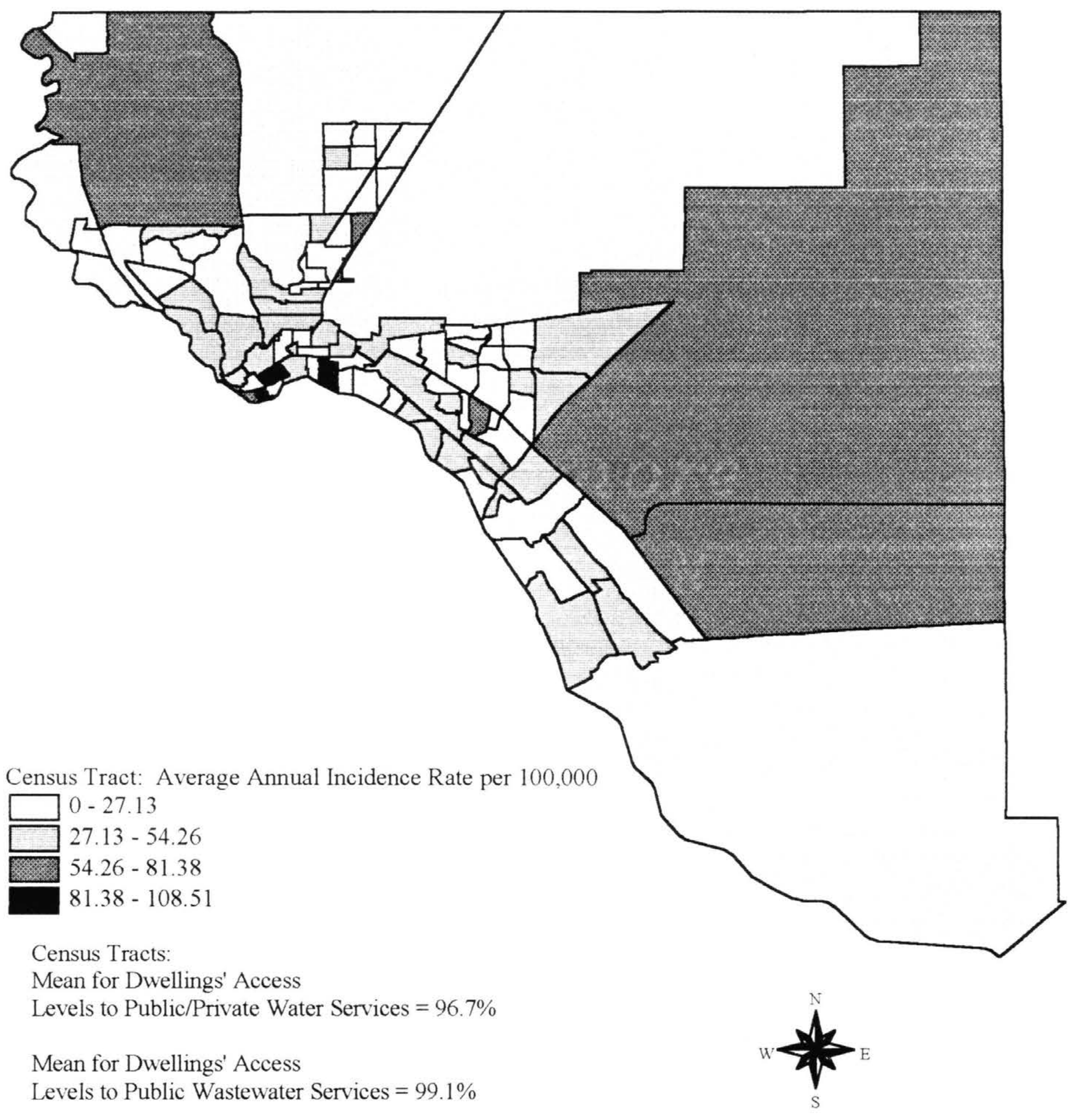

Figure 4.2 Average Annual Incidence Rates per 100,000 for the Aggregate of Hepatitis A, Salmonellosis, and Shigellosis in the 95 Census Tracts in El Paso County, 1997-1999