Dengue in Buenos Aires: An analysis of the factors contributing to increased incidence of dengue fever in urban environments

by

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Dengue in Buenos Aires: An Analysis of Factors Contributing to Increased Incidence of Dengue Fever in Urban Environments

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Dengue is a neglected infectious disease transmitted by the *Aedes aegypti* mosquito, which primarily inhabits urban tropical areas. Dengue is endemic in more than 100 countries; over the last 50 years, there has been a 4.6 fold increase in dengue incidence, spreading to a larger geographical region. In Argentina, there is low dengue incidence, and cases are concentrated in the northern tropical regions. However, in 2009, the capital city of Buenos Aires, located in a temperate region, experienced a historic outbreak of autochthonous and imported dengue. This study approaches the socio-demographic factors possibly associated with this outbreak and the spatial relationship between these factors and dengue fever in Buenos Aires.

Fieldwork was done in Buenos Aires where I conducted interviews with dengue experts, and collected dengue and socio-demographic data. Dengue cases in 2009 were analyzed by hospital area of the city in relation to 2010 census data on population density, place of birth, proportion of the population with unsatisfied basic needs, and sanitary installations in homes. Odds ratios and case level analyses were done between dengue and these risk factors. GIS was used to determine spatial distribution of risk factors and dengue in Buenos Aires.

In interviews, dengue experts in Buenos Aires argued immigration and access to sanitation contributed to the spike in dengue incidence and high concentration of cases in the southern periphery of the city during the 2009 outbreak. High immigrant populations were

thought to be associated with spatial disparities of dengue and increased incidence in these areas. Yet, contrary to interview findings, odds ratios fail to show correlation between areas with increased immigration and high dengue by hospital area. Findings suggest trends of positive correlation between areas with high dengue and high poverty. Dengue appears to be higher in areas with low population density as well.

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PREFACE

I would like to extend my sincerest thanks to a number of organizations and people without whom this Bachelor in Philosophy thesis would have been impossible. Thank you to the SIT Argentina: Public Health in Urban Environments study abroad program staff for your exceptional help and guidance. Thank you for facilitating my interviews with everyone I requested and assisting with my data collection and analysis. I especially want to thank María Eugenia Royer and Ana Rita Diaz Muñoz, whose guidance was critical in the development of this study and the success of my fieldwork. Thank you for your help editing my emails and interview questions, ensuring that questions were asked respectfully and in a culturally sensitive context.

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1.0 INTRODUCTION

Dengue fever is a tropical infectious disease endemic in over 100 countries throughout South America, Southeast Asia, the Western Pacific, and Africa.[1] Over the last 50 years, dengue has affected larger geographical region and disease incidence has increased, causing serious challenges internationally in its prevention and treatment.[2] Areas that have previously not been affected or trained to handle dengue are forced to deal with larger outbreaks.

Global political, social, and climate changes are believed to contribute to growing international dengue prevalence. Climate and temperature changes, increased migratory and travel patterns, economic restructuring and socio-demographic inequalities in urban areas must all be considered in the context of this disease. It is critical to understand the risk factors affecting rising incidence rates globally in order to develop effective prevention and treatment strategies for large urban areas generally unprepared to handle this serious disease.

In the past ten years, Buenos Aires, Argentina, has experienced historically high dengue incidence.[1] Buenos Aires is located in a temperate area and does not exhibit the typical tropical environment in which dengue is endemic. This study examines the relationship between socio-demographic risk factors and dengue fever, using a historic outbreak in 2009 as the point of

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[1] Incidence is used to compare disease patterns on the population level. In this study, incidence refers to the number of cases/100,000 people.

analysis. I analyze the spatial distribution of dengue cases within areas of Buenos Aires, and the associated risk factors that may contribute to this geographic disparity in spread of dengue.

This study is critical in providing an epidemiological perspective to a situation that has largely been studied from an individual patient or biological level. I intend to contribute to the larger discussion of the evolving role of dengue in Buenos Aires by analyzing this disease at a population level, which can be used in constructing comprehensive prevention and treatment models can be used for modeling larger prevention and treatment models for Buenos Aires and other cities experiencing a growing dengue problem.

I approach this analysis by first focusing on the disease itself, and then applying this background to disease incidence in Argentina and Buenos Aires and to a historical context. I intend to identify underlying contributors that may have played a part in the distribution and quantity of cases during the 2009 outbreak. I argue that the presence of high poverty indicators and low population density are associated with higher dengue incidence in certain areas of Buenos Aires during this outbreak. Immigration from Bolivia and Paraguay is commonly cited as the primary reason for the spike in dengue cases in Buenos Aires. Yet, this study fails to find statistically positive correlation between areas with high dengue and areas with high immigration rates.

This first chapter of background focuses on the rising global incidence of dengue since the 1970s, methods of transmission and treatment. The second chapter puts dengue into a political and social context in Argentina and within Buenos Aires specifically.

2.0 BACKGROUND: DENGUE FEVER

Dengue is a tropical infectious disease that is rising in severity and prevalence in the Global South, especially in Latin America, Southeast Asia, and the Pacific. In September 2013, 40% of the world's population was at risk for contracting dengue.[1] Approximately 50 to 100 million infections occur each year.[1]

The *Aedes aegypti* is the primary vector that transmits the dengue virus.[1] The *Ae. Aegypti* prefer an urban habitat to lay their eggs in artificial water storage containers that are common in cities, including flowerpots and water storage containers.[1] These containers are often present in lower-economic areas lacking sanitary installments and running water. Here, water is often kept in storage containers for drinking, cooking and discretion purposes.

Dengue is spread through a cycle that begins with the *Ae. Aegypti* laying eggs in artificial water storage containers.[1] *Ae. Aegypti* are first infected with the virus when feeding on someone infected with dengue, normally five days after the person contracts the virus.[3] The mosquito carries the virus for the rest of its average 14 day lifespan, transmitting dengue to other healthy humans when feeding.[3] Four to seven days after becoming infected, patients may begin exhibiting symptoms, though many are asymptomatic.[3]

There are four strains of dengue, and infection with one does not provide immunity against the others.[1] Infection with dengue produces flu-like symptoms; dengue hemorrhagic fever can develop when a patient is infected with the same strain of dengue more than once.[1]

Currently there is no treatment for dengue, but early detection and appropriate case management can reduce fatality rates to below 1%.[4] Control of dengue depends on the reduction of *Ae. Aegypti* and *Ae.* a*lbopictus* (secondary vector) populations, e.g. through community interventions including the elimination and treatment of mosquito infested containers.[5, 6]

The *Ae. Aegypti* is highly sensitive to changes in climate and temperature. Rising temperatures, and increased precipitation and humidity characteristic of tropical areas lead to faster vector reproduction, and thus increased spread of dengue. [7]

2.1 DENGUE IN LATIN AMERICA

Dengue is a growing problem in Latin America and the Caribbean. An epidemic in Mississippi, USA, in 1945 spurred the Pan-American Health Organization (PAHO) to call for the elimination of the *Ae. Aegypti* strain in the Americas entirely by 1947.[8] Between 1952 and 1965, 19 countries in Latin America were free of the mosquito.[8] However, in the past 30 years, there has been a 4.6 fold increase in dengue incidence in areas where the disease was previously eliminated.[8]

This reappearance in Latin America is predominantly in the Southern Cone of South American, which includes Brazil, Paraguay, Bolivia, Chile, Uruguay and Argentina. In 2007, more than one million cases were reported in the Americas.[9] Since 2000, Brazil has accounted for 63% of cases in South America.[10] Beginning in the 1980s, Bolivia, Paraguay and northern Argentina have reported cases as well.[10] The tropical environment in this region allows for easier transmission of dengue.[3]

In 2009, there were significantly higher numbers of cases of dengue throughout the Latin American region. Outbreaks were observed in Bolivia, Paraguay, Mexico, as well as Argentina.

[11] Brazil reported steadily increasing numbers of cases from 2008-2010 as well. [11] The regional increase in dengue transmission during this time also led to increase in dengue throughout Argentina, including more temperate regions. This 2009 outbreak is significant because it was the first time that a large number of cases of this tropical disease were recorded in temperate regions of Argentina, including Buenos Aires, Argentina. [12]

2.2 DENGUE IN ARGENTINA

The number of cases in Argentina prior to 2009 was relatively low, especially compared to endemic countries such as Brazil.[12] With the tropical climate, dengue has long been an issue in the northern provinces of Argentina, especially those bordering with Brazil.[12] In line with eradication trends in the mid-20th century, dengue was eradicated from the country as part of the nation-wide campaign in 1963. Yet, in 1986, the vector was reported again, increasing the spread of the disease.[12] Over the next 10 years, provinces throughout the country were declared re-infested with the disease.[12] 2009 marked a year of especially high numbers of cases throughout the country, in line with the larger regional outbreak. Over the first half of this year, when the outbreak was the most severe, Argentina reported over 26,000 confirmed cases of dengue, and deaths from dengue for the first time. (Figure 1) The majority of cases were in the northern provinces of Chaco, Catamarca and Salta, located closer to the equatorial belt. [11]

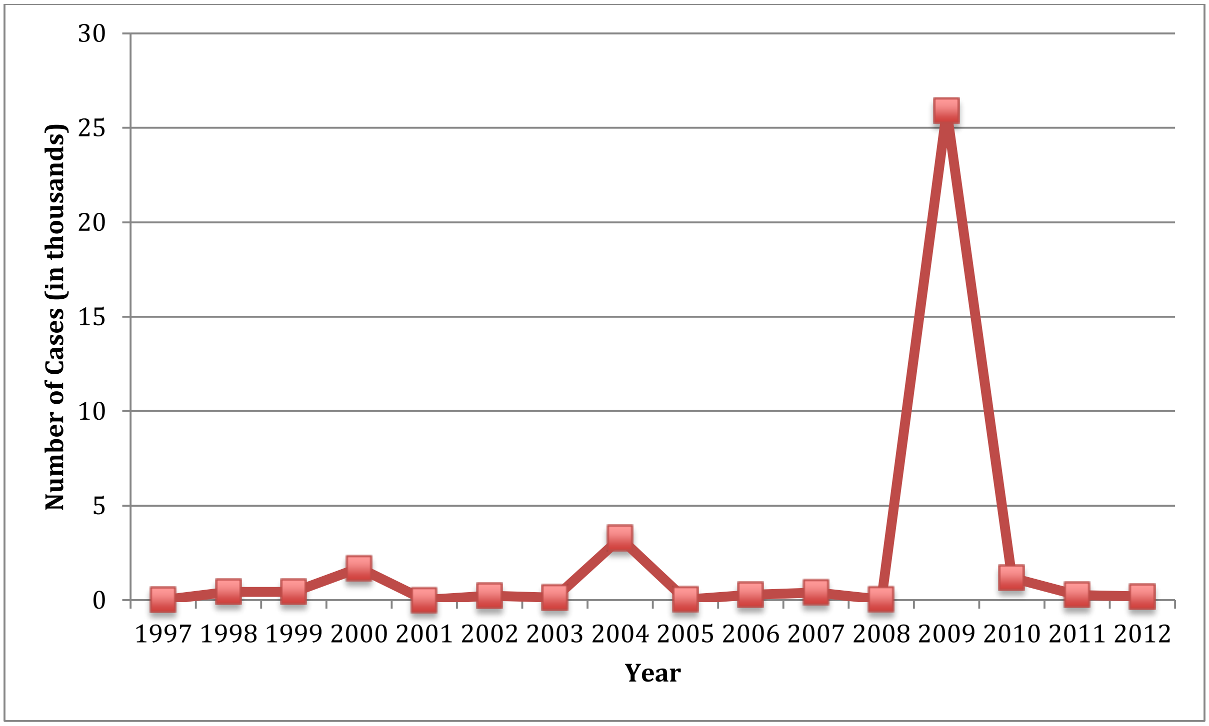

Figure 1: Confirmed Cases of Dengue in Argentina, by year. [13]

2.2.1 The Emergence of Dengue in Buenos Aires

Up until the early 2000s, the southern central region of Argentina was dengue-free.[12] Cases were only occasionally diagnosed, due to travel to endemic regions by patients who develop symptoms upon their return to Buenos Aires.

The 2009 outbreak throughout the Americas also affected the more temperate areas in Argentina.[11] The federal capital city, Buenos Aires, located in this temperate region, was previously dengue-free, but in 2009, reported cases of both imported and autochthonous (locally transmitted and infected) dengue.[10] Buenos Aires recorded 240 laboratory-confirmed cases in 2009, and over 600 cases were suspected to be dengue. [12] (Figure 2) This was the highest number of cases ever recorded in the city.[12]

Buenos Aires is one of the most densely populated cities in the continent with three million habitants; an outbreak of dengue has serious implications for a city of this size.[6] The federal capital city is only 78 square miles, small compared to other large metropolitan areas in South America, including Sao Paulo, which is 576 square miles or Rio de Janeiro (the largest city in South America), which is 16,871 square miles. [14] Thus, with a large population in a small geographic area, the spread of any infectious disease must be taken seriously.

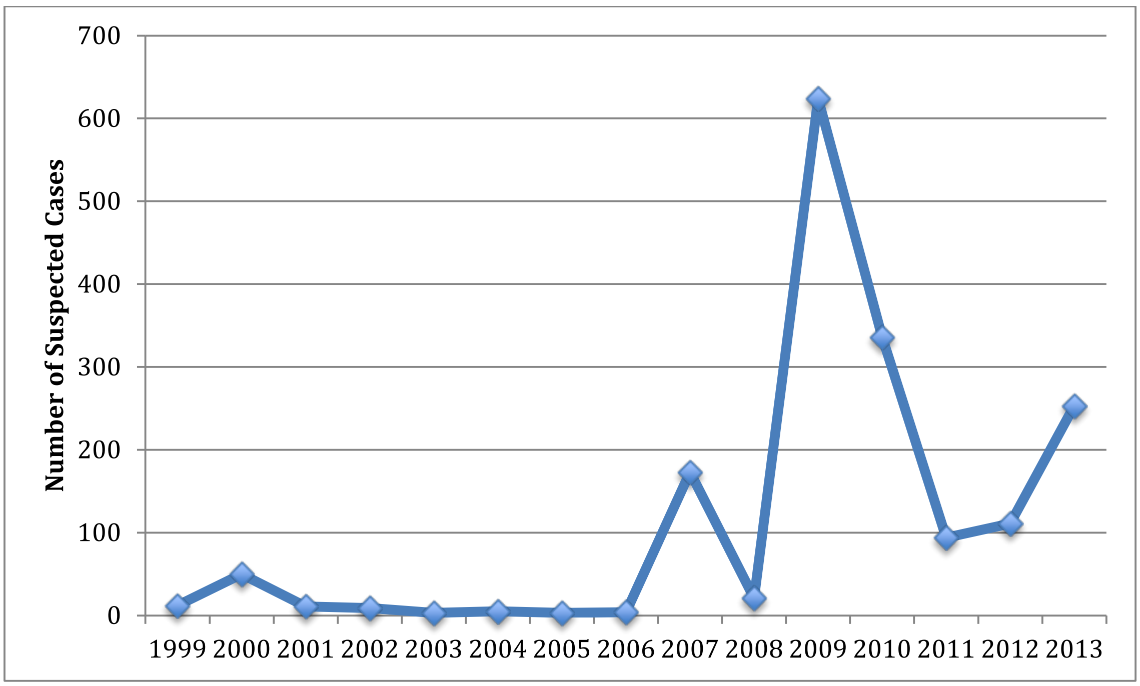

Figure 2: Suspected Cases of Dengue in Buenos Aires, Argentina. [13]

The dengue outbreak in 2009 was unique because it was the first time Buenos Aires reported autochthonous cases of dengue. Prior cases had been imported from other areas. This outbreak is also historic because it occurred in a relatively temperate area; Buenos Aires has a climate similar to New York City, USA, and is located on the same latitude lines as Cape Town, South Africa. In 2009, the city faced a serious dengue problem, and had to not only limit disease importation into Buenos Aires, but also stop the spread of the disease within its own boundaries.

A variety of factors are thought to contribute to the 2009 outbreak in Buenos Aires. Worldwide, climate change is considered the major contributor to increased dengue incidence.[15] With increased temperatures and precipitation, the *Ae. Aegypti* has a more comfortable climate in which to reproduce, with more clean water sources to lay eggs. However, prior studies demonstrate that temperature change in Buenos Aires and Argentina is a contributor but not the only factor causing increased dengue incidence.[15] Carbajo et al. proposed that a combination of geographic, demographic, and climate factors influenced the spread of the vector further south in Argentina into Buenos Aires, and contributed to Buenos Aires reporting cases during the outbreak in 2009. [15]

These investigators emphasized the multi-faceted approach to analyze the spread of dengue.[15] While temperature may have its impacts, geographic and demographic factors are influential in spread.[15] However, this study does not outline specific geographic and demographic factors that may contribute to increased incidence.[15] As a result, my study serves as a follow-up to analyze particular poverty and geographic indicators within Buenos Aires, within a certain timespan, to reiterate the claim that societal risk factors have an effect on dengue spread as well.

Immigrant movement into Buenos Aires from the bordering countries of Paraguay and Bolivia is a main factor that dengue experts focused on when discussing dengue prevention and rising incidence rates.[10] With regular travel between Bolivia, Paraguay and Brazil and Argentina, immigrants and travelers are thought to be importing the disease into the northern provinces and to migrant populations in large urban areas such as Buenos Aires. [10]

However, I argue that other characteristics of the capital city besides immigration increased the area's susceptibility to dengue during this broader outbreak throughout the region. Immigration may be a factor in the transmission of dengue, but it is not the only factor that is associated with dengue spread throughout Buenos Aires. Rather, I argue poverty indicators account for the spread of dengue in the city better than immigration, and can be used to understand the uneven distribution of dengue cases throughout the city.

At this point in time, there is particular reason to focus on dengue spread in previously unaffected areas. New evidence has demonstrated that other mosquito species, including a subtropical and temperate species are more comfortable in the climate in Buenos Aires, and have substantial competence for the dengue vector. [16] These studies suggest that a higher incidence rate of dengue in these climates, especially more southward in Argentina in areas including Buenos Aires, is possible in the future. [16]

3.0 BACKGROUND: THE REPUBLIC OF ARGENTINA

The Republic of Argentina is a geographically and environmentally diverse country, making the study of dengue particularly interesting. It is located in the 'Southern cone' of South America, with the northern provinces located directly below the equatorial belt, while the southernmost provinces are home to numerous glaciers and penguin populations. [17]

Argentina is a middle-income country based on a federal system, with 22 provinces and a federal capital of Buenos Aires.[18] Argentina has a population of 41.09 million, the second largest population in South America after Brazil.[19] The population is predominantly of European descent, with only a small proportion of indigenous or mestizo descent.[20] Argentina is considered an exception in the Latin American region in terms of its homogenous, highly educated population largely made up of European immigrants. [17]

The majority of the Argentine population (89.4%) lives in urban areas, resulting in socio-economic disparities between rural and urban areas and elite and poor within the country.[19] The rural areas in the northern tropical areas of Argentina located near the country border are generally poorer with large minority populations, and report much higher dengue incidence. For the most part, these areas have poorer access to medical resources and a generally poorer quality of health. [19]

However, the federal capital of Buenos Aires, located within the larger province of Buenos Aires, has a much different demography. Quality of life is generally higher and people with different ethnic and socio-economic backgrounds live in the city, creating deep cultural divides between Buenos Aires residents and those of the rural inland.[17] There are deep-set inequality issues in the country, especially between the "porteños" who live in Buenos Aires, and those who live inland. Analysts argue Argentina has "little potential for social progress" given this disparity. [17]

Socio-economic inequality issues are particularly relevant in infectious disease spread. I argue that it is through the establishment of inequality throughout Argentina that poorer areas become much more susceptible to contract and spread dengue without proper prevention and treatment practices in place.

3.1 ECONOMIC DEVELOPMENT IN ARGENTINA 1990-PRESENT

The inequality reported in Buenos Aires has increased exponentially in the past 20 years, which may have made some populations more susceptible to dengue transmission compared to others. Due to neoliberal influences and economic restructuring in the 1990s, the economic and political climate in Argentina changed significantly.[21] The introduction of new economic policies focused on restructuring Argentina's economy led to high inflation, increasing rates of income inequality, and huge trade deficits in the late 1990s and early 2000s.[21] Between 2001 and 2002, Argentina's economy collapsed when they defaulted on over $144 billion in loans.[21] This economic collapse increased the poverty rate from 35.9% to over 53% of the population. The percentage of poor households also doubled 26.2 in May 2001 to 41.4 in May of 2002. [21]

The economic and political turmoil during this time had huge implications for public health, and arguably created an environment that allowed for increased dengue transmission in certain areas of the city during the regional outbreak of 2009. With poverty and unemployment increasing significantly, a greater proportion of the population was living in poor conditions with poor access to health care due to lower access and higher cost. The economic crash furthered the divide between rich and poor, leaving greater proportions of the population with unsatisfied basic needs and less access to sanitary installments (i.e. flushing toilets), potentially increasing risk of contracting dengue.

The economic crash resulted in a variety of populist policies and restructuring aimed at reducing poverty and restoring the country to pre-crisis conditions. A reformed universal health system was established with stratified levels of payment and service, with the aim of providing equal access health services.[22] Though complicated, this system was influential in reducing the major health disparities apparent after the economic crash.

This restructuring, among other governmental programs, has resulted in major health improvement over the past 10 years and arguably limited what could have been much worse dengue epidemics later on, with a more centralized health system. These reforms were critical in Argentina's recovery from the 2001-2002 crash though poverty rates were slow in declining over the next 10 years. In 2009, poverty rates throughout the country were still higher than they were in 1990. [23]

3.2 AN URBAN HISTORY OF BUENOS AIRES

Within the larger socio-economic and geographic context of Argentina, we can better understand the factors affecting dengue incidence and its spread. In this section, I approach the urban development of Buenos Aires through socioeconomic divides and the issues existing within the federal city limits. The City of Buenos Aires is its own “federally constitutional unit” in the larger province of Buenos Aires that includes the surrounding municipalities, towns and suburbs. The federal capital city has a population of approximately three million people, with the greater region containing approximately 9.5 million people. [24] The greater metropolitan area of Buenos Aires is important to study as well; however this study, due to data availability, focuses only on the federal capital of Buenos Aires.

3.2.1 Immigration to Buenos Aires

Buenos Aires has become a conglomerate of international and domestic immigrants and their descendants. This movement escalated particularly in the 1940s when millions of Europeans moved to Buenos Aires to escape World War II Europe.[25] In the early 20th century, roughly 80% of these immigrants were from Italy or Spain.[25] The influx of immigration provided a large source of labor that, combined with major industrialization, allowed Buenos Aires to become a major economic force and urban center in South America. In the twentieth century, the capital city made up approximately 40% of the entire Argentine production.[25]

Characterized by diverse population, Buenos Aires is a city divided into cultural neighborhoods, with areas clearly distinguishable by ethnicity, religion and socio-economic status. This ethnic and socio-economic distribution is believed to affect dengue distribution throughout the city.

Buenos Aires has remained ethnically diverse in the past 100 years, and migrants have continued to move there. Recently, immigrant populations have originated from Asia, inland Argentina, and within South America.[25] The economic growth experienced in Buenos Aires, especially with high poverty throughout the country after the economic collapse, has led many inland Argentinians to move to Buenos Aires in search of employment and education. Since 1991, the drastic changes in socio-demographic conditions in Buenos Aires are hypothesized to be partially a result of migration of rural farmers to the urban center.[26] Clinicians within Buenos Aires argue that people coming and traveling from dengue endemic countries and regions of Argentina are the main transmitters of dengue within Buenos Aires, due to regular and seasonal travels to their home countries where they contract dengue. [27]

3.2.2 Urban development in Buenos Aires

I analyzed urban growth and development within Buenos Aires to determine the spatial distribution of immigrant communities and the socio-economic divides. An understanding of how the city has developed, including socio-economic disparities and population density differences, is important to apply in analysis of the spread of dengue in these neighborhoods.

Buenos Aires has grown from the central urban core out to the periphery.[25] The federal capital buildings are centered within the main business district of Buenos Aires, the Microcenter, marked in the red circle in Figure 3. North of the Microcenter area are predominantly upper-income neighborhoods with up-scale apartment buildings and Western architectural design. The northern periphery of the city also experienced an explosion of gated communities in the 1990s for middle to upper class families looking to avoid the violence of the city inside the safety of these developments.[25] These developments were more westernized with shopping malls and New York City style high-rise apartment buildings surrounding them. [25] The center and northern areas of the city feel very Western in architecture and development; some parts are very reminiscent of the Upper West Side of New York City, or parts of Europe.

Recently, there has been significant urban development east of the Microcenter in Puerto Madero with gentrifying American and European developments. However, the poverty in Buenos Aires is evident especially on this eastern riverfront; directly south of the elite developments in Puerto Madero are some of the poorest communities in the city, commonly known as *villas miserias* (shanty towns). [25]

Figure 3: Map of Buenos Aires. [28]

The periphery of the city is comparatively less dense than the Microcenter, though the population density is still high enough to be considered an urban area. Immigrants moving to the city have settled in the periphery and suburbs of the city, primarily in the northern and southern areas, where there were small properties available for purchase.[25] Today, South American and domestic immigrants to Buenos Aires have settled in the periphery of the city. These areas, generally report higher cases of dengue than in the center core. Experts have argued that the disparity in dengue incidence between the periphery and core is due to the high concentration of immigrants in the periphery. However, their analysis often fails to consider the high poverty rates and other socioeconomic disparities that also affect these areas.

Significant increases in immigration in Buenos Aires have resulted in an huge population growth and rapid urbanization and led to serious issues of urban sustainability including sanitation, housing, provision of water and sewage, trash disposal, lack of access to health and education centers. These problems were only heightened after the economic crash of 2001.[29]

Of the approximately three million people within Buenos Aires, roughly 65,000 live in squatter settlements. [30] These shantytowns lack sanitation and social services and are home to many newcomers to the city. One shantytown has grown from roughly 350 citizens in 2001 to 1,500 in 2010. [30] Many people are forced to live in these areas due to the high property costs within the city. Plans were in place in 1998 to alleviate the poverty and lack of appropriate housing in these areas, but today, the populations in these areas continue to grow, and be the poorest areas of the city. [30] I argue that these poorer areas of the city are more likely to have higher levels of dengue incidence due to poor conditions compared to wealthier neighborhoods.

3.2.3 Economic Re-structuring

In line with neoliberal restructuring in Argentina and throughout Latin America, in the late 1990s, the Buenos Aires water and sewage systems were privatized. This change drastically affected access to these basic resources, and most likely increased people's use of water storage containers, especially for those who could no longer afford to pay for water and sanitation services. [31]

This privatization caused significant disparities in access to resources by different socio-demographic groups. Users who lived in higher socio-economic areas had greater purchasing power and benefitted disproportionately over those in areas with less purchasing power and greater poverty.[31] Increased market principles and regulation resulted in increased legislation and decreased tolerance for people obtaining water and electricity illegally.[31] Combined with the privatization policies, the 1990s resulted in a significant loss of resources for the urban poor in Buenos Aires. [31]

I argue the economic restructuring that occurred in the 1990s was a major contributor to increased inequality in Buenos Aires and would affect the spread of dengue throughout the city during the outbreak in 2009. The 2001-2002 crash and resulting economic policies overwhelmingly affected the poor living in Buenos Aires. Thousands of formal sector jobs were lost, resulting in a significant rise in the informal economic sector.[32] This change in the labor market would continue after the crash; in 2006, 40.8% of total wage earners were employed through the informal sector.[33] The percentage of the population lacking regular access to healthcare increased from 19.7% in 1991 to 26.2% in 2002.[26]

The economic decisions of this time limited the low-income population's access to basic resources, furthering their inequality and propensity to contract mosquito-borne diseases such as dengue fever. It is through policy shifts such as these in combination with existing socio-economic disparities in the city, that I argue Buenos Aires developed into an environment that catered more directly to the *Ae. Aegypti,* and spread of dengue.

3.3 BEYOND THE FEDERAL TERRITORY OF BUENOS AIRES

Issues of health and deep-set inequality extend beyond the federal borders of the capital city of Buenos Aires. Outside the poor southern periphery of the capital city, extensive networks of surrounding suburbs and municipalities also experienced the outbreak of dengue in 2009, and have similar health-based inequalities.

The outbreak of dengue in 2009 did not stop at the city limits, and largely appears to be connected to the outbreaks in the bordering localities. Similar environments are present in the municipalities La Matanza and 3 de Febrero. Lower-income communities in these areas made up primarily of immigrants represent larger trends in the development of the dengue outbreak in 2009. While the first initial autochthonous cases were diagnosed in patients living within the city limits, cases would later also originated from outside city limits. Political borders do not limit dengue.

During the outbreak of 2009, the neighboring municipalities of La Matanza and 3 de Febrero reported the highest numbers of indigenous cases in the localities outside of Buenos Aires.[27] These areas border the southwest areas of the federal capital, where high dengue spread also occurred.[27] Within these areas, there was high vector density, given greater proportions of people with the disease living in a small area. [27]

There are also stark socio-economic inequalities in this sub-urban area; municipalities have extreme poverty and high proportions of people living with unsatisfied basic needs, while neighboring municipalities have very low poverty rates.[34] This distinct geographic disparity based on living situation can be partially explained by the presence of gated communities or 'countries' (originating from the term "country club") in Buenos Aires, where upper-class families live in new developments designed to exclude them from the surrounding municipalities. Within these areas, poverty indicators demonstrate stark effects in the health of these communities. [34]

This study is limited to the federal capital city of Buenos Aires due to data availability and limited time to conduct this study. However, analysis of the larger metropolitan area of Buenos Aires, and the spread of dengue in this region both in 2009 and other years is also critical, due to movements of residents over the city limits affecting transmission.

4.0 PURPOSE

It is critical to address economic and social policy shifts and the relationship they have increased inequality. In this study, I analyze how these shifts may be associated with the spread of dengue fever, a tropical infectious disease, in a temperate area. The increased spread of dengue fever is not caused by one specific factor or change in society, but rather a conglomeration of factors that create an environment in which the *Ae. Aegypti* thrive, reproduce, and infect humans with the disease. Dengue fever is a disease that is thought to only be increasing in severity and geographic spread. Understanding the relationship between socio-demographic risk factors and increased dengue is crucial in developing prevention and treatment techniques.

The 2009 outbreak of dengue affected much of South America and since, the number of cases throughout the region has continued to remain high. While broader factors including the higher incidence levels regionally may have contributed to higher incidence levels in Buenos Aires, Argentina, I argue that socio-demographic inequalities throughout the city caused some regions of the city to be disproportionately burdened with the disease. This is especially apparent in disparities between the central core and northern periphery and the southern periphery.

Immigration is thought to cause increased dengue incidence in certain areas of Buenos Aires during this outbreak, because immigrants primarily reside in the southern periphery of the city. However, my data analysis conducted in this study does not show a relationship between areas of the city with high immigration and high dengue levels. I argue that the underdevelopment in areas of Buenos Aires, leading to high poverty and low population density influenced the spread of dengue during the outbreak in 2009 more so than immigration.

Prior studies on dengue in Buenos Aires have focused on case level analysis and looking at the geography of the area, but have not put the cases of dengue into an epidemiological framework that analyzes the dengue cases on the population level with available socio-demographic data. This study is unique and critical in understanding the role of urban planning and development within public health, especially in ultra-urban areas such as Buenos Aires. The following sections provide insight into the relationship between these two areas of study, and further statistical analysis of the dengue cases in 2009 in relation to socio-demographic data for the federal capital of Buenos Aires.

5.0 METHODOLOGY

The purpose of this investigation is to analyze the relationship between socioeconomic and demographic risk factors and dengue incidence in Buenos Aires during the outbreak of 2009. This study was conducted qualitatively and quantitatively over a fifteen-month period from November 2014 to March 2015. The initial topic for this work originated from research done for a public health methods class at the University of Pittsburgh on the Argentine health system, and was expanded upon during studies and research over a four-month period in Buenos Aires, Argentina in the spring of 2014. Data collection in Buenos Aires was made possible through the study abroad program SIT Argentina: Public Health in Urban Environments.

To conduct this study, I lived in Buenos Aires for four months, studying the health system, history and urban environment, applying my prior studies of the dengue situation, while continuing to collect more information. I worked with Dr. Wilbert van Panhuis prior to my departure and during my time in Argentina to design the work I planned to do while in Argentina, and the analysis that needed to be done afterwards. I conducted literature reviews using PubMed to find existing studies on dengue in Buenos Aires to understand the holes in current analyses and used these works to shape the structure of my interviews and determine the focal points of my analysis.

During the first three months in Argentina, I studied the Argentine health system and health demographics to garner a general understanding of the health situation in both Argentina and Buenos Aires specifically. This work was critical in providing a basis for my research. My individual observations of social inequalities within this city, and the gap in current literature in acknowledging this disparity in relation to the spread of dengue drove my thesis and development of this study. I then conducted interviews with dengue experts, and used this knowledge in my data analysis. My qualitative data was obtained through interviews, and my quantitative data was obtained through published bulletins and data sets by the Argentine government, and data summaries given to me by the Department of Epidemiology for the City of Buenos Aires.

The qualitative and quantitative approach to this study makes it particularly effective in understanding dengue in Buenos Aires, especially from an outsider's perspective. The information collected in interviews was used to organize and focus, using a snapshot approach, specifically on dengue cases in 2009, and only in the federal capital of Buenos Aires. Within the four-month period in Buenos Aires, preliminary data analysis suggested trends between risk factors and increased dengue incidence in the city. Upon return to the United States, these data were analyzed more in-depth using epidemiological and geo-statistical analytical tools.

This study is presented as the individual fieldwork of an undergraduate student who observed and studied infectious disease spread in urban areas, paying particular attention to the urban framework that may have contributed to spread. All experiences and analyses are my own. These interviews were conducted with the approval of both the SIT study abroad program and the University of Pittsburgh International Review Boards.

5.1 QUALITATIVE ANALYSIS: INTERVIEWS

Interviews were conducted with four dengue experts in the city of Buenos Aires who provided different perspectives on the relationship between the socio-demographic disparities and dengue in Buenos Aires. These interviews shaped the development of this study, the focus on the specific socio-demographic factors analyzed, and allowed for further interviews to take place. These interviews were also critical in providing data at the hospital area level for dengue, which was unavailable in online databases.

The study abroad program SIT: Public Health in Urban Environments assisted me in contacting dengue experts and potential interviewees and guided the development of my research. Initial interviews took place with Dr. Aníbal Carbajo, who has published many of the papers on which this study is based, and Marcelo Abril, who was recommended by program coordinators given Organización Mundo Sano's critical role in dengue prevention and treatment within Argentina.[15] The subsequent interviews emerged through the snowball effect after initial referrals to speak with Dr. Carbajo and Abril.

All interviewees were contacted via email in Spanish. All interviews were also conducted in Spanish. The interviewees decided place and time. Interviews were audio-recorded in Spanish, which I transcribed and later translated into English. Interviews were conducted at Hospital Muñiz, the infectious disease hospital where all dengue cases within the city were treated, as well as within the Buenos Aires Department of Epidemiology, where all cases are monitored and analyzed, and summaries presented to city officials, Organización Mundo Sano, and via email.

When conducting the arranged interviews, my study abroad program presented me for my interviews as an American college student conducting a research project. This position affected the power dynamics within these interviews. I was not taken as seriously as a researcher than I believe may have been the case had I been presented as a researcher from the University of Pittsburgh. The effort put into organizing these meetings by SIT staff also resulted in very structured questions being asked. In acknowledgement of the culture and respectful nature in which students address their superiors, I was limited in my ability to question the validity of statements experts made. When I asked these follow-up questions, answers generally provided limited explanation or merely defense of previous points.

This interview experience provided insight into how dengue, its treatment and investigation are viewed in Buenos Aires by experts. Some interviewees were more willing to discuss the controversial socio-demographic divisions within Buenos Aires, and their relationship to dengue, while other experts strongly argued that dengue affected Buenos Aires democratically in 2009. These interviews were critical in my understanding of dengue in Buenos Aires from a field perspective; I gained various opinions on the factors contributing to increased spread, as well as more general knowledge on dengue treatment and monitoring within the city. This holistic knowledge is important when considering broader prevention tactics in the future, and understanding how these policies may have contributed to increased spread of dengue during the 2009 outbreak.

5.2 STATISTICAL METHODS

5.2.1 Data Collection

This project required extensive data on cases of dengue in Argentina and the surrounding countries for reference, as well as city-specific data on dengue and socio-demographic factors for the city of Buenos Aires. Dengue data were collected from the PAHO, the Argentine Ministry of Health and the City of Buenos Aires Departments of Epidemiology. Data from PAHO and the Argentine Ministry of Health were obtained from weekly online bulletins published with statistics on the number of cases reported in that week. Dr. Esperanza Janeiro gave me data from the City of Buenos Aires Department of Epidemiology on the number of cases by hospital area in the city of Buenos Aires.

Cases of dengue can be categorized based on a determination of whether they are suspected, probable, or laboratory confirmed. Suspected cases of dengue are cases that are "clinically compatible cases of dengue that are epidemiologically linked to a case," meaning that patients are exhibiting symptoms of dengue, and may be from an area where other cases have been reported. [35] Probable cases of dengue are "clinically compatible cases with laboratory results indicative of presumptive infection."[35] Confirmed cases of dengue are "clinically compatible cases with confirmed laboratory results."[35] Using suspected cases of dengue can be beneficial for analysis because the larger margin of error is closer to accounting for cases that were never diagnosed, compared to the confirmed case measure. However, for this study, the most reliable data sources by hospital area in the city of Buenos Aires for 2009 had only data on the number of confirmed cases. As a result, only confirmed cases were used for statistical and geographical analysis.

Within Buenos Aires, district protocols are in place for clinics and hospitals for the detection of dengue cases. Within 24 hours, clinics are required to send samples out for laboratory testing, and obtain permission from the patient for this testing. [36] Cases are then registered by the result of the laboratory testing, and sent to the Department of Epidemiology for the City of Buenos Aires. [36] When these cases are detected, preventative measures are also taken to educating the patient on dengue and how it is transmitted, and also receiving more information about the area in which he or she lives. The city also takes measures to identify areas in which the mosquitos are laying their eggs, and fumigating these areas to prevent further spread. [36]

Socio-demographic data for the city of Buenos Aires and Argentina were collected through the 2010 census conducted by and distributed online by the Argentine government. Based on suggestions made by dengue experts and prior analysis done studying health-based inequalities in Buenos Aires, socio-demographic factors with data collected in the survey were chosen for analysis. These factors were suspected to have high values in the same areas that also had high dengue incidence. Per the Argentine census, all risk factors used were recorded by commune within the Buenos Aires.

These risk factors are:

1. Population Density (residents/km^2). Population density was selected to determine if denser areas had a higher propensity for the disease.

2. The proportion of the population born outside of Argentina, in a bordering country (i.e. Brazil, Uruguay, Bolivia, Chile, or Paraguay). This measure accounts for immigrant communities living in Buenos Aires.

3. The proportion of the population lacking adequate sanitation (i.e. running water and sewage systems). Lack of adequate sanitation accounts for the presence of water storage in areas.

4. The proportion of the population living with unsatisfied basic needs (UBN). This is a common poverty measure within Latin America, translated from 'necesidades básicas insatisfechas'. It is a comprehensive account of considerations including the number of homes with more than three people living in each room, living situation (homelessness, living in a permanent home), sanitary conditions, whether children are attending school, subsistence capacity (when the head of the household has not completed more than the third year of primary school).[37]

5.2.2 Data Management

Dengue data were organized by confirmed and unconfirmed cases by month or epidemiological week. For this study, due to data availability, only laboratory-confirmed cases were used for analysis. To account for differences in population between hospital areas, incidence rates (number of cases/100,000 people) were used for this study.

Within the city of Buenos Aires, dengue cases were analyzed on the hospital area level. There are 12 hospital areas in Buenos Aires, and each hospital area represents a district with one main hospital to which residents of that area report (Figure 4). All dengue cases were treated at Hospital Muñiz, the infectious disease hospital in Buenos Aires. Cases were recorded and separated by the hospital area of residence for each patient. The hospital in each of these hospital areas is responsible for cases and disease monitoring in its region. For simplification purposes, each hospital area was labeled with a number, as shown in Table 1, and labeled in Figure 4.

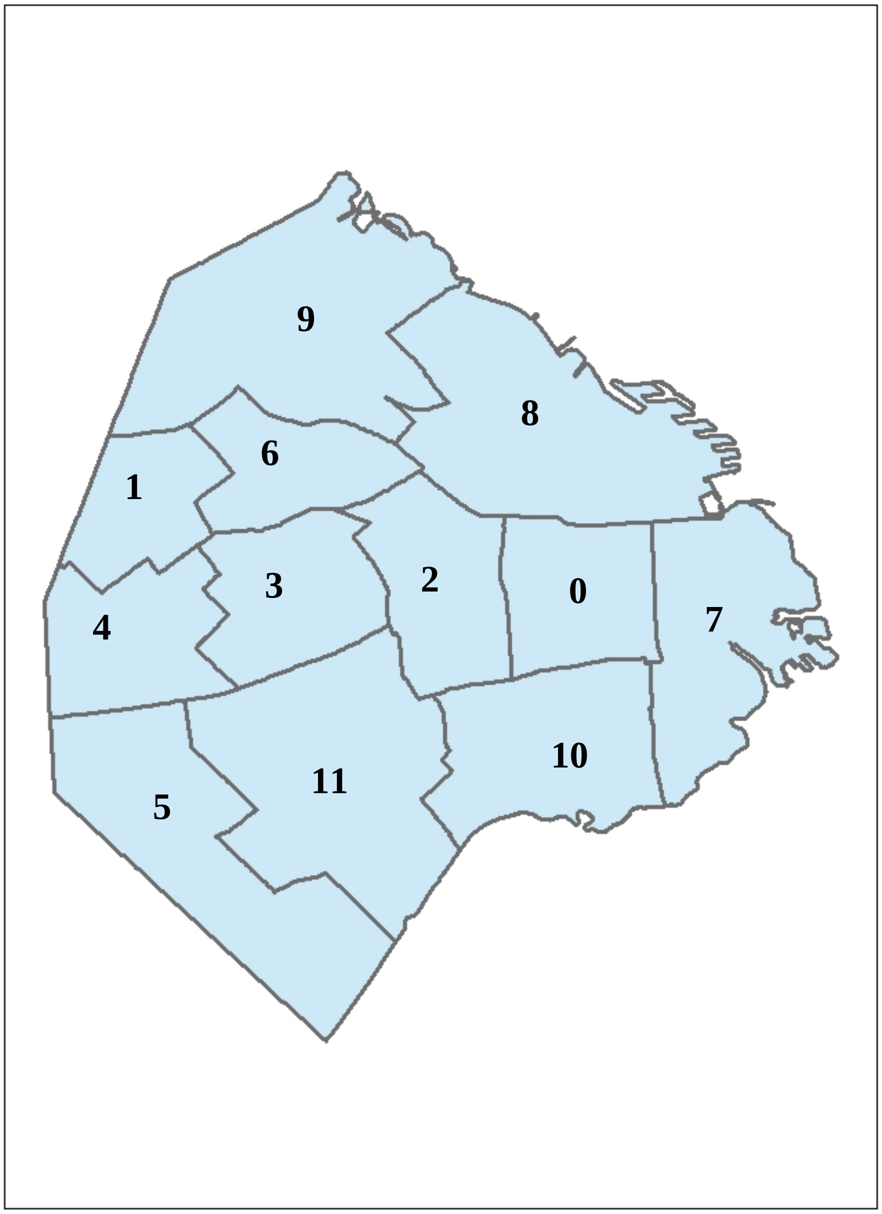

Figure 4: Map of Hospital Areas in Buenos Aires [38]

Table 1: Hospital Areas Assigned Values for Odds Ratio

Hospital Area	Label
Mejía	0
Zubizarreta	1
Durand	2
Alvarez	3
Vélez Sarsfield	4
Santojanni	5
Tornú	6
Argerich	7
Fernandez	8
Pirovano	9
Penna	10
Piñero	11

Data available on the hospital area level added complexity to this analysis. Census data is collected and categorized by city communes, which has a different geographic distribution within Buenos Aires than the hospital area. There are 15 communes in Buenos Aires, and 12 hospital areas. Hospital areas and communes overlapped in total geographic area within the city limits, but there is not a direct correlation between hospital area and communes. Geo-statistical analysis was required to determine the relationship between the hospital and communes. This analysis was necessary in order to conduct any direct quantitative study between socio-demographic factors from the 2010 census on commune level, and dengue rates collected in the 2009 outbreak by hospital area. Through geo-statistical analysis, census data on the commune level were converted to the hospital area level. Geographic data on the hospital area and commune coordinates were obtained through the City of Buenos Aires website.

Geographic Information System (GIS) software was used to determine correlation between hospital area and commune. Using textbook procedures, the intersection between hospital area and commune was calculated, yielding the proportional area of each commune within the hospital area, as shown in the table below.

To find the proportion of each commune area within respective hospital areas, I divided the area of intersection (of the hospital area and commune area) by the total commune area. This value gave me the proportion of each commune that is in the geographic region of each hospital area. This proportion was used to convert socio-economic factors from the commune scale to the hospital area scale through which I can directly analyze that data to dengue data, all on the hospital area scale.

I found the proportional socio-demographic variable for each hospital area by multiplying the proportion value calculated above by the socio-economic factor value for each commune. Given that each hospital contains more than one commune, I then added all of the proportions for each hospital area together to find the total socio-demographic variable for each hospital area. In this way, I converted data that was on the commune level scale to the hospital area scale. (Table 2)

The figure below demonstrates the distribution between hospital area and commune. (Figure 5) Each commune is displayed in a different color, with the hospital area borders displayed in black. This demonstration shows the unequal intersections of hospital areas with communes. While there are some communes that are entirely encompassed by a single hospital area, others overlap numerous hospital areas.

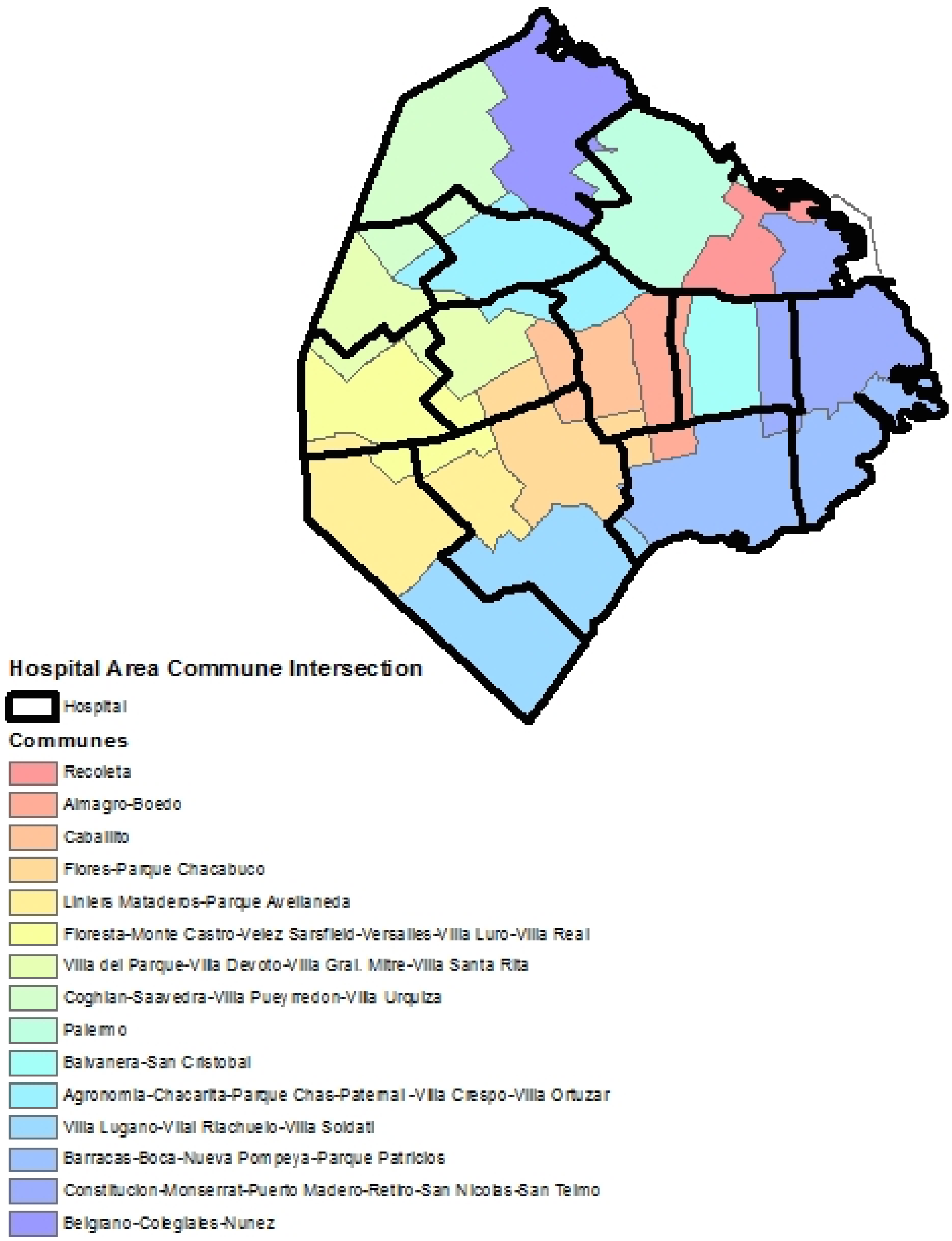

Figure 5: Intersection of Hospital Area and Commune in Buenos Aires [38]

5.3 ODDS-RATIOS

Odds ratios determine the odds that one risk factor leads to having a disease, or other factors. Using the following calculation, an odds ratio computes whether areas with exposure to a risk factor have higher odds of having high disease levels, compared to areas that are not exposed to a risk factor. If the odds ratio is greater than 1, it indicates that there are higher odds of exposed areas having high disease levels. If the odds ratio is less than 1, it indicates that there are lower odds of exposed areas having high disease levels. [39]

Table 2: Traditional Odds Ratio Format[40]

	Exposed	**Not-Exposed**	**Odds**
High Disease level	A	B	A/B
Low Disease level	C	D	C/D
Odds Ratio=	$\frac{(A/A+C) / (C/A+C)}{(B/B+D)/(D/B+D)}$ =**AD/BC**		

I chose to use odds ratios in this study because it is a calculation that does not require a large sample size. Other statistical tools, including regressions, require a much larger sample size to determine statistical significance and correlation. The odds ratio calculation can be used to suggest relationships in the data that can later be further analyzed with a larger sample size. This odds ratio does not explain risk, but can being to explain relationships between risk factors and disease levels.

Using the odds ratio with data available for socio-demographic risk factors and dengue data for 2009, I wanted to determine if areas with high levels of socio-demographic risk factors had higher odds of having higher dengue cases during the 2009 outbreak. I compiled data into a manner that could be used in the 2x2 tables used in odds ratio calculations. I determined what constituted an area that was “exposed” versus one that was “not exposed,” using the table above as a model. I then calculated the city average for each socio-demographic variable by hospital area, and used this value to split my data into an “exposed group” (hospital areas with above average rates of the socio-demographic risk factor) and an “unexposed group” (hospital areas with below average rates of the socio-demographic risk factor). In my analysis, I denoted above average hospital areas as “high” and below average hospital as “low.”

I also used this method to separate hospital areas with high levels of dengue from those with low levels of dengue. I first calculated the city average of all hospital areas dengue incidence, and used this value to separate areas with above the city-average dengue incidence from those with below-average dengue incidence. I denoted those with above average dengue incidence as “high dengue” and those with below average dengue incidence as “low dengue.” Thus, this method allowed me to divide hospital areas by socio-demographic risk factor and dengue incidence by the city average of each, for analysis in a 2x2 odds ratio table. I conducted these calculations for each socio-demographic risk factor, and created odds ratio tables for each, using the same dengue data for each.

Odds ratios were computed for each of the four socio-demographic risk factors. For each factor, the odds of an area with high levels of the risk factor (above city average) having high levels of dengue (above city average) were computed using the equation in Table 2. I also calculated the 95% confidence interval for each odds ratio. The confidence interval is used to show the range in which the odds ratio would fall 95% of the time if the same calculation were repeated 100 times. I used MedCalc software to calculate the confidence interval. [40, 41]

$$\ln(OR) \pm 1.96 * \sqrt{\frac{1}{a} + \frac{1}{b} + \frac{1}{c} + \frac{1}{d}}$$

For two odds ratio analyses done in this study, there were zero hospital areas that exhibited above average rates of the risk factor and above-average rates of dengue. This means that one of the cells in the 2x2 table had zero hospital areas, thus making the equation in Table 2 impossible to compute. To resolve this situation, I added one value to each cell, i.e. the cell of the odds ratio table that currently had zero hospital areas in it, now has one, and the other three other cells have an additional value added to them. Thus, the correct proportions were maintained within the table, and the calculations were now feasible. I made this adjustment for the odds ratios of dengue data and the immigration risk factor data (proportion of the population born in bordering countries to Argentina), and of dengue and population density data. This was done for the odds ratios on immigration and population density. In these 2x2 tables, the values for high factor and high dengue are simply denoted with a 1, and no hospital areas are listed in parenthesis.

5.4 CASE LEVEL TESTS

Given that the dataset used in this study is small, I used basic probability analysis to gain an additional perspective on the relationship between socio-demographic risk factors and dengue incidence in Buenos Aires during 2009. I used the calculation below to find the probability that a case of dengue was located in a hospital with a high risk factor. Using the equation below, the probability that a case was located in a hospital area with a high risk factor. The following equation was used:

$$= \frac{\text{\# cases of dengue in hospital areas with high risk factor}}{\text{Total number of cases of dengue in the city of Buenos Aires}}$$

Given that data on each case was not available, and the small sample size, this test can provide additional understanding of the data available. This analysis is important because it provides a closer case level analysis, compared to the population level analysis.

This method of analysis does not explain the characteristics of each patient diagnosed with dengue. Data on each of the patients was not available for this study. Rather it assists the understanding of how cases are distributed within the city in relation to the risk factor levels throughout the city.

6.0 RESULTS

6.1 QUALITATIVE ANALYSIS: INTERVIEWS

Interviews were conducted with experts across the scope of dengue research. Dr. Aníbal Carbajo is a researcher at the University of Buenos Aires, Marcelo Abril is a researcher with the Organización Mundo Sano, Dr. Esperanza Janeiro is the dengue expert for the Department of Epidemiology of Buenos Aires, and I also met with members of the medical team of Dr. Alfredo Seijo, from the Zoonosis Department of the Buenos Aires infectious disease hospital, Hospital Muñiz. The interview with Dr. Carbajo was conducted via email, while the three other interviews were held in person. In these interviews, dengue prevention and treatment, as well as dengue data, and cases of dengue in Buenos Aires were discussed.

All interviewers gave similar responses regarding dengue in Buenos Aires. Dengue is considered to be a "re-emerging pathology, that isn't the flu." [42] Interviewees supported the idea that socio-demographic factors were associated with increased dengue incidence, yet Dr. Janeiro argued dengue is a "democratic" disease, affecting socio-demographic groups equally. [42] They all believed that there was not a single factor that explained all of the cases of dengue, but rather a combination of temperature, demographic and socio-economic factors. These perspectives are organized into the two general areas under which socio-demographic factors from census data were chosen for analysis. These factors are related to urbanization, climate change, immigration, and poverty indicators.

6.1.1 Climate

Temperature change is often used to explain a spike in dengue incidence. During an outbreak, there are distinct causes for the spike in incidence compared to a normal year in a dengue endemic region. According to Carbajo, while temperature cannot account for steady increases in incidence over time, it may be a factor causing dengue outbreaks.[43] With an increase in temperature, the climate is more favorable for the mosquitos to reproduce, and thus there is a greater possibility of transmission of the virus exists.[43] However, other factors are more predominant in affecting dengue outbreaks.

6.1.2 Urbanization

Using Buenos Aires as the focal point, interviewees argued that urbanization has contributed to increased dengue incidence, with factors such as the availability and usage of running water, population increases, tourism and immigration changing the environment. The population increase recently in Buenos Aires has affected urban growth and development, with many aspects of urban life altered.

As Carbajo explained, increases in population can lead to unplanned growth in under-developed parts of the city, with fewer resources and poorer living conditions. [43] According to both Carbajo and Abril, these areas may have less access to running water in their homes, with residents storing water in their own water storage containers.[43, 44] These storage containers are ideal locations for *Ae. Agypti* reproduction.[44] An additional factor of unplanned growth is a less effective recycling removal system; rainwater can accumulate in materials waiting for recycling, increasing risk of mosquito reproduction and dengue transmission.[44]

Interviewees referenced large migrant populations from Bolivia and Paraguay to be another contributor to the 2009 dengue outbreak. Many immigrants travel back to their home countries during the summer months (during which Christmas and New Years fall in Argentina), when mosquito reproduction is at a yearly high. There are high rates of dengue in these bordering countries as well, and many immigrants return to Buenos Aires with the virus. The climate at this time contributes to easier spread of the disease to others upon return to Buenos Aires.[45] For the most part, these immigrant communities are concentrated in distinct parts of the city, increasing possibility of dengue transmission there.[45]

According to Drs. Romer, Correa and Abril, dengue cases in Buenos Aires were reported in both rich and poorer communities.[45] They said the higher dengue incidence is generally bimodal; it is associated with poor immigrant communities and in wealthier communities with vacations to tropical areas.[44, 45]

These experts suggested an association between dengue in the bordering countries to Argentina, Bolivia and Paraguay and the rising dengue incidence in Buenos Aires and Argentina. According to Dr. Romer, "when they [Bolivia and Paraguay] have dengue cases, we have dengue cases." [45]

6.2 STATISTICAL ANALYSIS

Buenos Aires, Argentina, experienced the highest levels of dengue in the past ten years in 2009, with 240 confirmed cases, more than twice the incidence in 2008. The majority of these cases were diagnosed in the first weeks of the year, between epidemiological weeks 1 and 23, the summer season. In 2009, the highest number of cases was recorded between weeks 10 and 17 (Figure 7). Data for every socio-demographic factor by commune were collected and are listed in Appendix B.

In table 3, confirmed cases of dengue are separated by hospital area of residence, and geographic region of these hospital areas (north, central or southern zone). Regional transmission indicates cases of dengue where patients contracted the disease outside of the city of Buenos Aires. Autochthonous cases are those that were transmitted locally within the city. Due to the small sample size, all confirmed cases were used for analysis, and incidence rates, rather than caseloads were analyzed because they give a relative measure of spread of dengue within the city, accounting for population fluctuation.

Table 3: Confirmed cases of dengue by Hospital Area in 2009.

City Zone	Hospital Area of Residence	Total Number of Confirmed Cases	Incidence level (Cases per 100,000 residents)	Cases of regional transmission	Regional Transmission Incidence (Cases of regional transmission per 100,000 residents)
Northern Zone	Zubizarreta	4.0	3.5	2.0	1.7
	Pirovano	12.0	2.8	5.0	1.2
	Tornú	4.0	3.8	1.0	0.9
	Fernandez	10.0	2.2	3.0	0.7
Subtotal: North		30.0	2.7	11.0	1.0
Central Zone	Velez	15.0	9.9	11.0	7.3
	Alvarez	18.0	8.3	15.0	6.9
	Durand	24.0	6.8	10.0	2.8
	R. Mejía	19.0	5.9	4.0	1.2
Subtotal: Central		76.0	7.3	40.0	3.8
Southern Zone	Santojanni	62.0	26.7	47.0	20.2
	Piñero	43.0	13	21.0	6.4
	Penna	43.0	13	21.0	6.4
	Argerich	9.0	5.9	5.0	3.3
Subtotal: South		134.0	15.1	86.0	9.7
Total: City		240	7.9	137.0	4.5

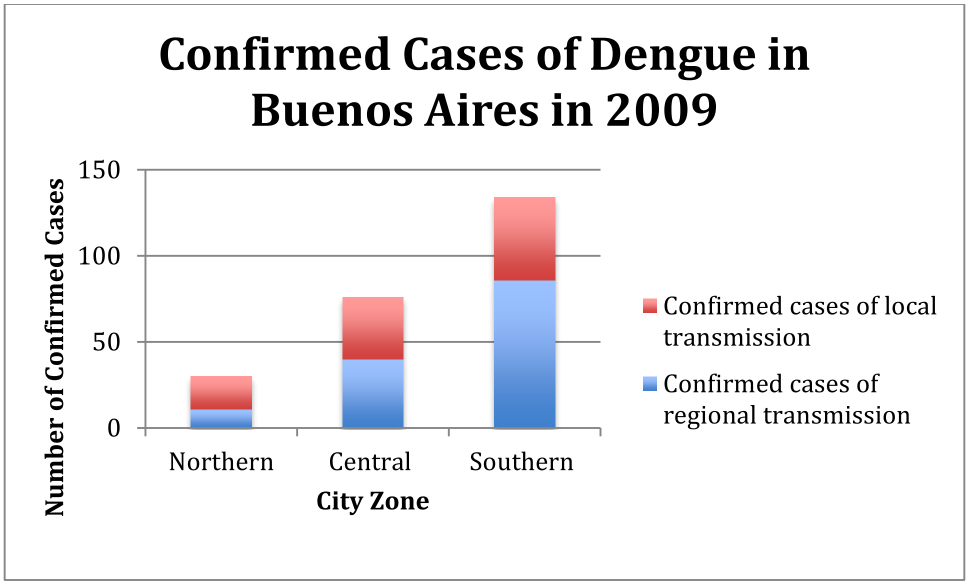

Figure 6: Confirmed Cases by Transmission Type in 2009. City of Buenos Aires. [46]

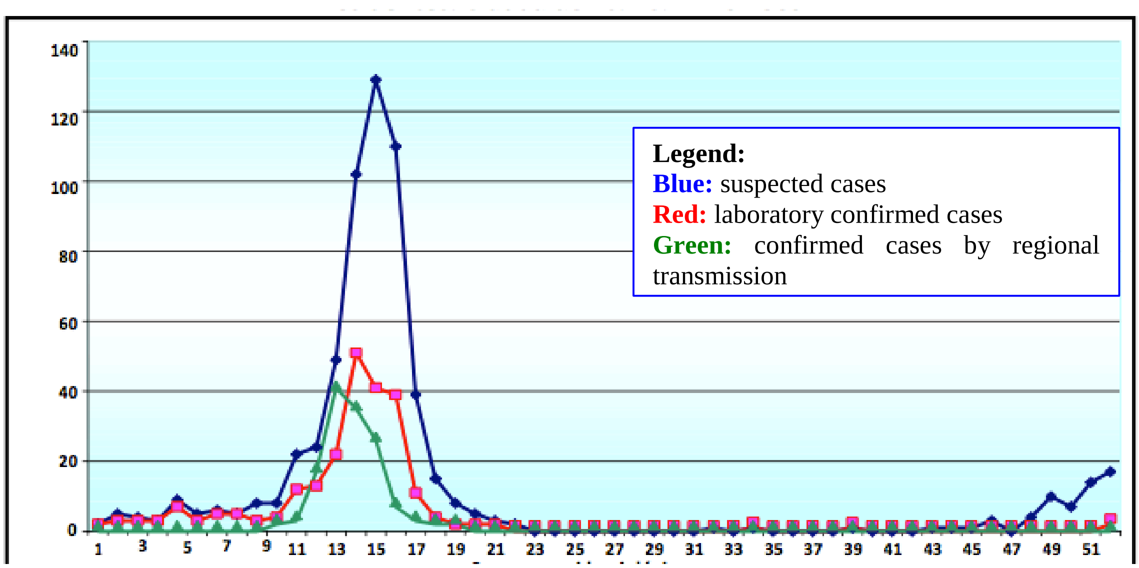

Figure 7: Suspected and Confirmed Cases of Dengue in by Epidemiologic Week. City of Buenos Aires 2009. [46]

6.2.1 Geo-statistical Distribution

Spatial distribution was used to better understand the relationship between socio-demographic factors in different areas of the city and dengue incidence. Certain areas of the city exhibit higher dengue incidence. Using basic geo-statistical mapping through GIS software, dengue incidence was mapped by hospital area. The map below provides a perspective to understand the basic geographic distribution in dengue cases throughout the city. This case distribution was used as a framework to then assess the relationship between this incidence rate, and socio-demographic factors in each of the hospital areas.

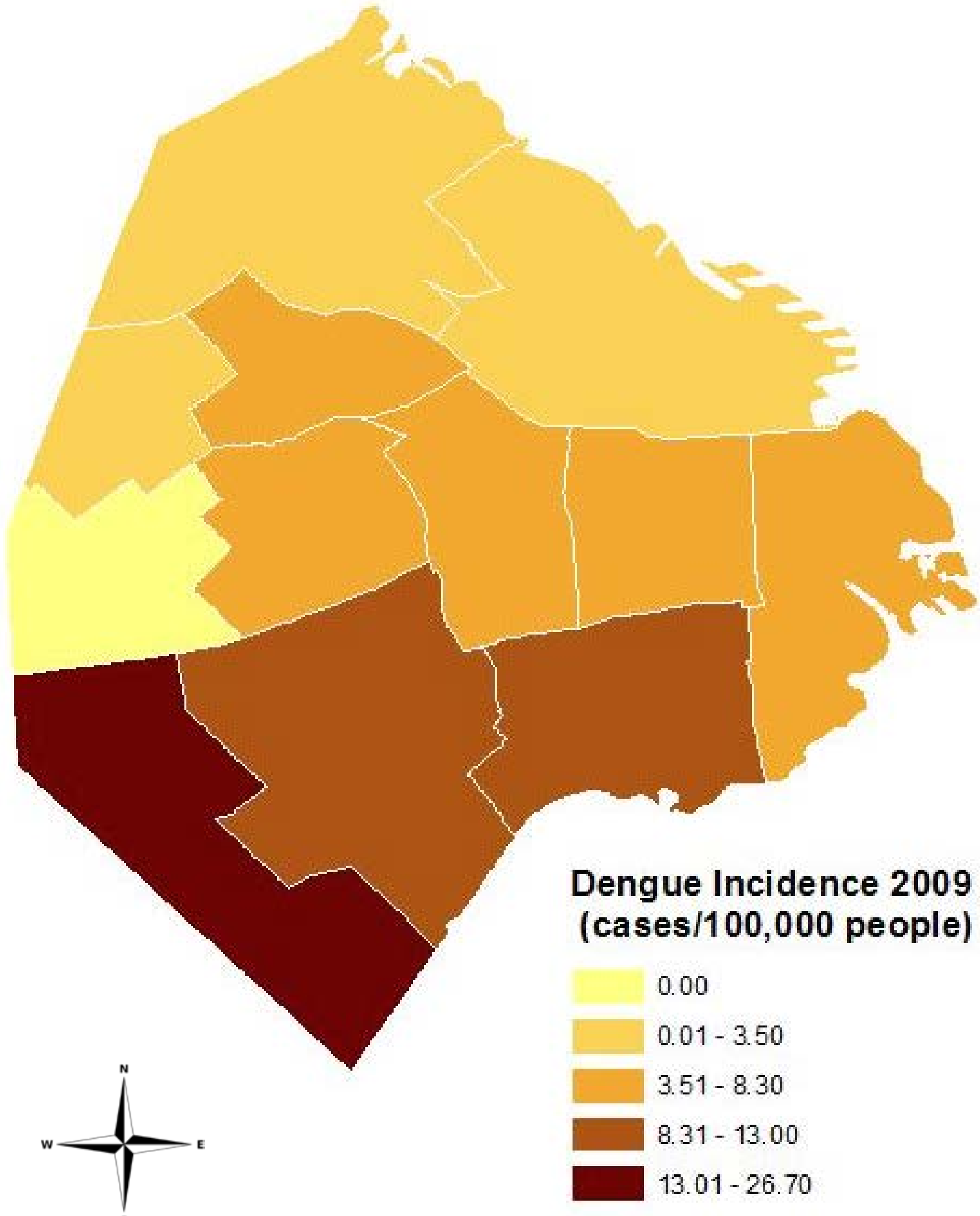

Figure 8: Geographical Distribution by Hospital Area of Dengue Incidence in Buenos Aires[38]

Figure 8 demonstrates that dengue cases are concentrated within the southern portion of the city. The areas with the darkest colors on the spectrum, in the south of the city, are Velez Sarsfield, Santojanni, Penna and Piñero, which have all been identified as poorer, less dense areas of the city as demonstrated below.

The maps below are a display of socio-demographic factors by hospital area. Spatial demonstrations of data confirm the concentration of dengue cases within the southern portions of the city. For each map below, the distribution of dengue is shown, followed by the distribution of each socio-demographic risk factor. Using the spectrum of color as a point of reference, it is clear that there is association between the areas in the south of the city (darkened areas) with high levels of dengue, and high poverty indicators. Further, the hospital areas with the highest dengue incidence have relatively lower population density, compared to the rest of the city. These maps thus indicate that areas in the periphery of the city that are generally poorer and less dense also have higher dengue incidence. However, as shown in Figure 12, the southern hospital areas do not have above average levels of people born in bordering countries. These data are important in developing a broader understanding of dengue and its spread, and the factors affecting it in Buenos Aires.

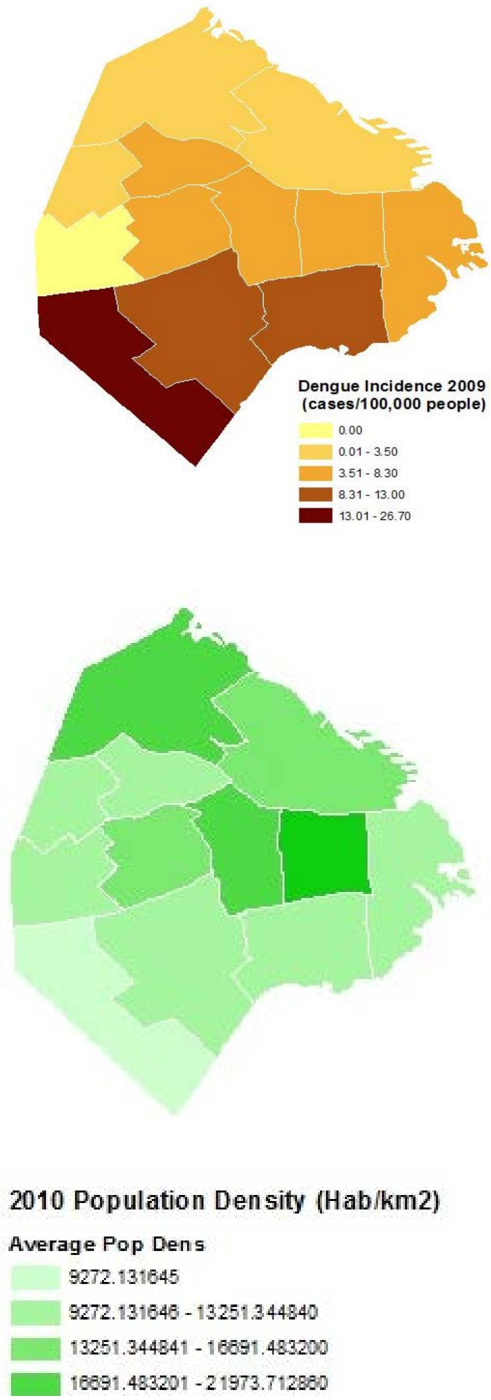

Figure 9: Geographical Distribution by Hospital Area of Dengue and Population Density (Appendix B)

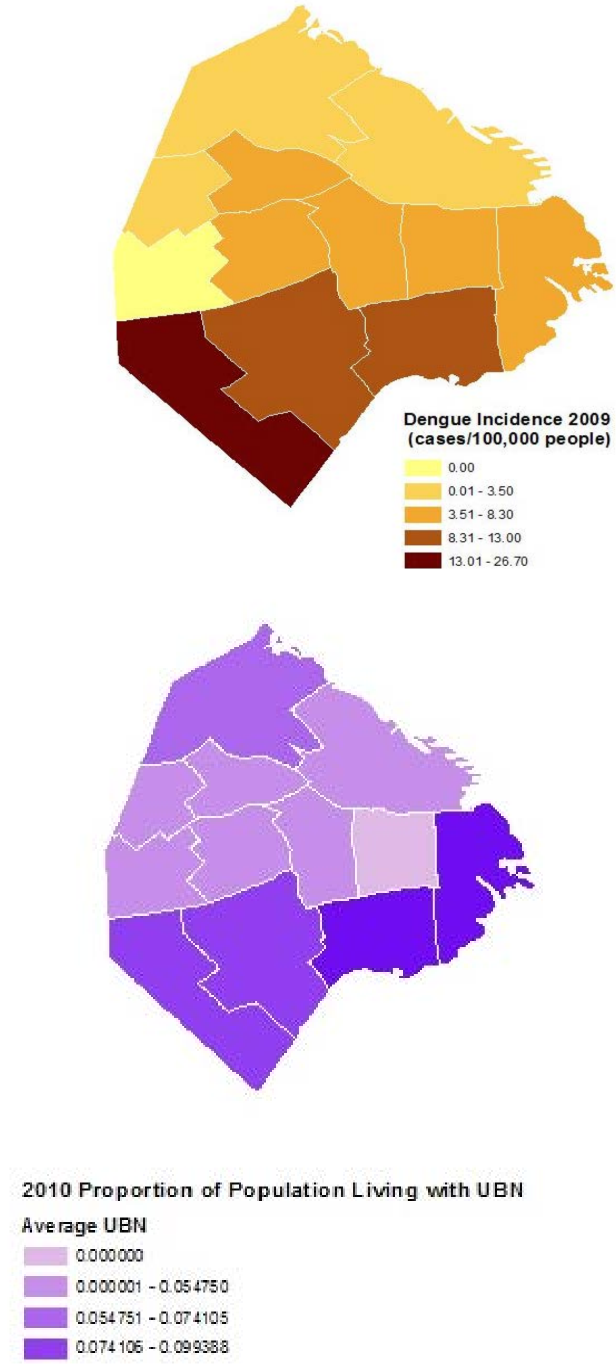

Figure 10: Geographical Distribution by Hospital Area of Dengue and Proportion w/UBN

(Appendix B)

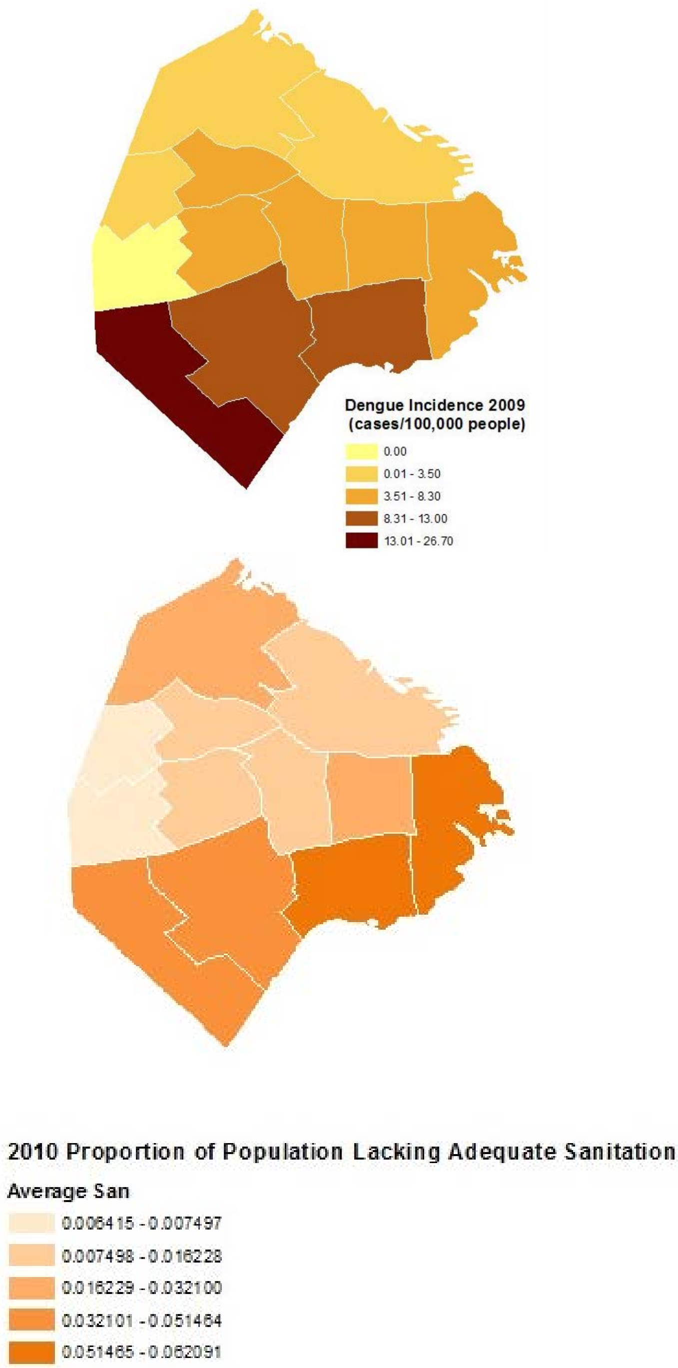

Figure 11: Geographical Distribution by Hospital Area of Dengue and Proportion w/ Adequate Sanitation (Appendix B)

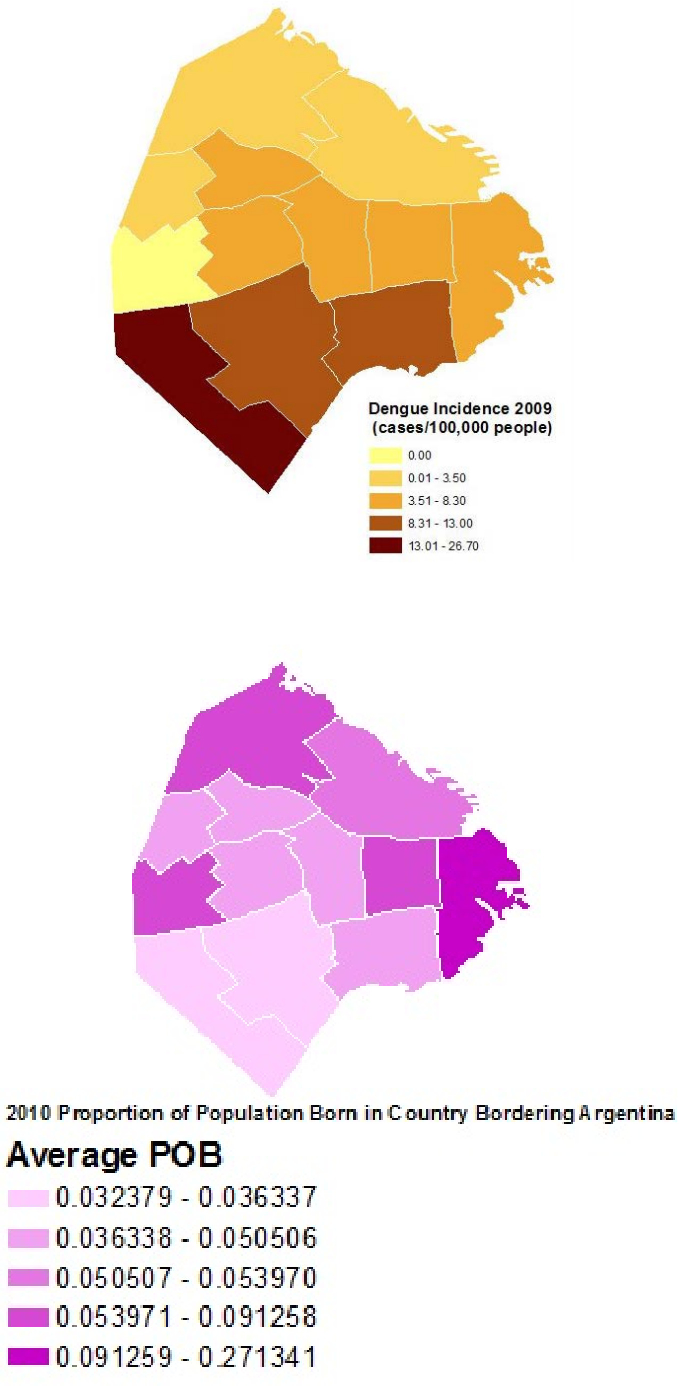

Figure 12: Geographical Distribution by Hospital Area of Dengue and Proportion born in Bordering Country (Appendix B)

6.2.2 Odds Ratio Analyses

Odds ratios were calculated for each risk factor. The results are separated based on socio-demographic factor and discuss initial distribution of the factor throughout the city using GIS analysis, and odds ratio tests conducted.

Table 4: Odds Ratio of Population Density

	Population Density	**Low (hospital areas)**	**High (hospital areas)**
Rate of dengue	Low (hospital areas)	5 (1,3,6,8)	5 (0,2, 7, 9)
	High (hospital areas)	5 (4, 5,10,11)	1 (null)
Odds Ratio	0.2		
95% CI	0.017 – 2.39		

Table 5: Odds Ratios of Proportion of Residents Born in a Country Bordering Argentina

	% People born in country bordering Argentina	**Low (hospital areas)**	**High (hospital areas)**
Rate of Dengue	Low (hospital areas)	7 (1,2,3,6,8,9)	3 (7,0)
	High (hospital areas)	5 (4, 5,10,11)	1 (null)
Odds Ratio	0.47		
95% CI	0.0369 – 5.90		

Table 6: Odds Ratio of People Living with Unsatisfied Basic Needs (UBN)

	% People living with unsatisfied basic needs (UBN)	Low (hospital areas)	High (hospital areas)
Rate of dengue	**Low (hospital areas)**	6 (1,2,3,6, 8, 9)	2 (0, 7)
	High (hospital areas)	1	3 (5,10,11)
Odds Ratio		9	
95% CI		0.5629 –143.90	

Table 7: Odds Ratios of Proportion of Homes Lacking Sanitary Installations

	% Homes Lacking Sanitary Installations	Below Average (hospital areas)	Above Average (hospital areas)
Rate of dengue	**Low (hospital areas)**	5 (1,23,6,9)	5 (0, 7,8)
	High (hospital areas)	1	3 (5,10,11)
Odds Ratio		3.00	
95% CI		0.22 – 39.61	

The odds ratios computed above show that the areas with high population density have odds 0.2 times higher to have above-average dengue incidence than areas with low population density. Areas with high proportions of people born in a bordering country have odds 0.47 times higher of having above-average levels of dengue than areas with low immigration levels. Areas with high proportions of people lacking adequate sanitation have odds three times higher of having high levels of dengue than areas with low proportions of people lacking adequate sanitation. Areas with high proportions of people living with UBN have odds nine times higher than areas with low proportions of people living with UBN.

Using the above odds ratio calculations, a summative odds ratio table was constructed (Table 8). This table identifies the risk factors of high dengue, and shows the odds of these high risk factors with high levels of dengue. To find these, the odds ratio tables were reversed for the original odds ratios of population density and proportion of people born in a bordering country, because here, the data suggest that there is higher risk of dengue with low presence of these risk factors. The calculations done for these new odds ratios are present in Appendix B. However, for the poverty indicators of sanitation and UBN, high levels of dengue are present in areas with the higher risk factors, as is shown in the tables above.

As shown in Table 8, the odds of having dengue are five times higher in hospital areas with low population density, 2.14 times higher in hospital areas with low immigrant populations, five times higher in areas with hospital areas with people lacking adequate sanitation, and five times higher in hospital areas with high proportions of people living with UBN. We then compared the odds ratios with the spatial distribution of cases and dengue, to determine that an environment with high poverty, low migrant populations and low population density in the south of the city is the environment that had the greatest odds for high dengue incidence.

Table 8: Risk Factors for Dengue in Buenos Aires

Risk Factor	Odds Ratio	95% CI
Low population density	5	0.42 – 59.66
Low population proportion of immigrants	2.1429	0.17 – 27.11
High proportion of people lacking adequate sanitation	5	0.22 – 313.86
High proportion of people living with UBN	9	0.35 – 548.99

The confidence intervals for all risk factor analyses are large, due to the small sample size, and prevent these findings from being statistically significant. However, the odds ratios calculated are extreme values using this scale; they all have a large difference from 1.00. According to effect size, the greater distance the odds ratio is from one suggests greater significance in the data. The large effect size for all odds ratios suggests that further studies need to be done, but that these factors are related to dengue incidence. [47]

When conducting the distribution of the risk factors across dengue cases, calculations revealed similar findings. Cases of dengue were:

- 76% more likely to be in areas of low population density;
- 89.4% more likely to come from areas with low proportions of people born in bordering countries;
- 71.5% more likely to come from areas with high proportions of homes lacking adequate sanitation; and
- 67% more likely to come from areas with high proportions of residents with UBN.

Furthermore, the areas of the city with low population density, low immigration rates, and high poverty indicators are generally in the south of the city. Piñero, Penna and Santojanni all exhibit the highest dengue incidence in the city, and low population density. This aggregate level data suggests an association between dengue and these risk factors.

Dengue experts stated that the majority of cases were from immigrants, yet the hospital areas with the highest proportions of immigrants, Argerich and Mejía, did not report high dengue incidence. While lack of dengue reporting is an obvious factor to be considered, these hospital areas are also above the city-average of population density, suggesting that the higher population density in these areas has limited the spread of dengue.

Overall, we see that population density and geographic spread, combined with poverty indicators, appears to be related to dengue trends throughout Buenos Aires. We see that three hospital areas in the south of the city demonstrate low population density, high poverty indicators and low immigrant populations. These hospital areas are Santojanni, Penna and Piñero, located in the south of the city. Though there is a large confidence interval, these findings suggest that dengue is more prevalent in the sub-urban areas in the southern parts of the city, outside of the ultra-dense city core.

7.0 DISCUSSION

This study is being conducted at a critical time, as infectious disease continues to spread worldwide, and our general understanding of how prevention methods are affected by urban environments and vice versa. Our world is only becoming more connected with time, making the health of one individual increasingly dependent on the health of the population. Increased travel, communication, and highly developed treatment resistant strains of bacteria and viruses only make health a more prevalent theme in the globalized world. Urban planners and public health workers need to approach designing and reinforcing urban environments with consideration to the spread of disease.

The clinicians and researchers at Hospital Muñiz emphasized that dengue crosses national boundaries, and has moved from Bolivia and Paraguay, and the north of Argentina to the temperate urban area of Buenos Aires. One physician noted “when Bolivia has dengue, we have dengue.”[45] However, my data analysis failed to show any correlation between areas associated with high immigrant populations in Buenos Aires and areas with high dengue incidence. Given that this analysis was conducted at the population level, these findings suggest a need to understand the characteristics of those who were diagnosed with dengue in each area, and whether these characteristics match the broader population based socio-demographic data analyzed in this study.

In interviews conducted with dengue experts, dengue was described as a "democratic disease," equally affecting those from all socio-demographic backgrounds.[42] However, the data analyzed in this study suggest otherwise in Buenos Aires; there appear to be distinct factors that influence the probability of contracting dengue.

It is clear that urban planning may have a significant role in the role of dengue in Buenos Aires. Relationships between socio-demographic factors and dengue incidence in 2009 by hospital area are related based on the geography of the city. There are clear divides by socio-economic standards within the city that are clear when analyzing the population level.

This data suggests a possible relationship between the areas exhibiting high poverty and areas with increased dengue incidence, implying that urban growth and developmental factors may have played a part in determining the spread of dengue during the 2009 outbreak. Further, with increased migration into the city, the unplanned, underdeveloped areas on the periphery of the city became home to people living in a lower economic quality of life that I argue puts them at risk for contracting dengue.

I argue the southern periphery has larger proportions of residents in higher states of poverty, and the highest number of residences lacking sanitary installments, where the highest number of dengue cases is also recorded. Many of the areas located on the periphery of the city are lower-income communities, at points labeled as 'slum cities.' [48] There have been 56 reported informal settlements within the city that lack sanitation systems, basic access to services, and governmental action to reduce the poverty.[48] Approximately 10% of the population in Buenos Aires is reported to live in these areas, with more moving there after the economic crash in 2002.[48] The government has committed resources to improving these areas, with little action actually taken. These areas on the periphery of the city are located close to higher socio-economic areas that emphasize the inequality within this city.[48] These disparities have been especially apparent within the last 20 years, with water privatization and neoliberal policies implemented, and a failure of city government to act to reduce disparities. [48] It is critical for poverty to be addressed in these areas in order for effective dengue prevention.

Studies done internationally on dengue and socio-economic factors have shown that areas with higher poverty indicators may be more at risk for dengue than in higher-income areas. [49] One example is in Recife, Brazil. Here, dengue infection rates were 3 times higher in deprived areas of the city than in privileged areas. [49] Living in a house rather than an apartment, higher number of persons living in a room, and higher age were all positively associated with increased risk for infection. [49] This investigation on Buenos Aires reinforces the work that Braga et al. conducted in Recife. In the less dense areas of Buenos Aires, that are identified as areas with higher dengue incidence levels, there are more houses than high rise apartment buildings, and given the high poverty levels, there may also be more people living in a smaller number of rooms. [49]

Data analyzed for this study reinforce the claim that the residences lacking sanitation and areas with extreme poverty lead to habits putting them at risk for *Aedes* aegypti reproduction and easier circulation of the mosquito and thus faster transmission. According to interviews, the lack of density in this area as well could be due to the lack of organized building and planning in this area, and higher poverty rates compared to other parts of the city.

Dengue is not compatible in extremely urban environments. This mosquito prefers an urban domestic environment that may not be immediately available in the high-rise apartment buildings that are much more prevalent at the core of Buenos Aires, where the use of open water containers are also more infrequent.[50] Areas in the southern periphery are different; residents may have more water containers due to lack of sanitary installments, and lower population density due to less urban planning and poorer populations. Both of these factors create a better environment for the disease in the periphery.

Looking at hospital areas Argerich and Mejía suggests that population density plays a potential role in determining dengue incidence; with a lower density, there may be more unplanned developments that provide water containers for the *Aedes aegypti* to lay their eggs. [48] Both areas report high poverty indicators but dengue incidence well below the city average. These hospital areas, especially Mejía, are located very close to the city core, with a much more urban environment and fewer opportunities for mosquito reproduction. Meanwhile, the hospital areas located in the south of the city, Penna, Piñero and Santojanni also have high poverty indicators, but high dengue incidence, along with below-average population density

Together, a larger picture is generated that outlines the geographic disparities, both socio-economic and dengue based, that identify larger trends in the data. Data suggest that as part of prevention and treatment of dengue, methods of addressing poverty and geographical inequalities need to be incorporated. Rather than approaching dengue as a disease in need of prevention, comprehensive urban development practices that improve the quality of life in poor areas with a higher propensity of dengue will provide a more sustainable model for dengue prevention in the long-term. I argue that in order for dengue to effectively be prevented and reduced in the future, sustainable poverty reduction tactics need to be enacted that addresses the poor living conditions in the southern periphery of the city. The current prevention tactics are not sufficient for long-term infectious disease reduction, especially when such diseases appear to be associated with poverty.

7.1 TREATMENT AND PREVENTION

The findings demonstrated in this study suggest a need for increased sanitary installments and poverty reduction in the south of the city. This study and others suggest that there is lower risk for dengue spread in areas with improved living conditions. Within Buenos Aires, measures taken to reduce the need for open water storage containers, develop permanent housing in slum areas and assist residents to no longer be in poverty are critical to address for long-term dengue prevention.

However, current prevention and treatment tactics used in Argentina, to my knowledge, do not include more holistic measures such as those mentioned above. Dengue is primarily treated rather than actively prevented. The prevention treatments currently are designed to address the immediate factors that increase spread of dengue, such as open water containers (i.e. removing flower pots, water storage containers, etc.). They are not designed to address the underlying issues of why much of the population may be using water storage containers originally. In this section, I analyze the limited information available on treatment and prevention methods in place in Buenos Aires, through which to suggest larger policy changes more comprehensive in addressing issues.

In Buenos Aires, according to Romer, there is not an "existing culture of dengue."[45] Thus, the efficacy of dengue prevention is dependent on the perspective of the population about the disease. However, when there is increased concern about dengue in the population, greater prevention measures are taken, with increased vigilance in the population and by physicians. During these periods, more people generally report suspected cases of dengue. Yet, when there are fewer cases in a year, there is generally less awareness of prevention methods and lower suspected case reporting.

Abril emphasized that dengue prevention is lacking due to poor understanding of the disease by medical practitioners and civilians.[44] Dengue is not commonly the first diagnosis considered by doctors when patients present fever and flu symptoms. Dengue symptoms are very similar to other sicknesses, including the common flu; many patients are misdiagnosed. Further, with mild symptoms similar to other diseases, many people do not go to the hospital with dengue symptoms, because they do not perceive them to be serious. The lack of adequate education in Buenos Aires, especially during years with low dengue incidence, leads to additional dengue transmission and failure to correctly implement treatment and prevention strategies [44]

Numerous protocols exist to prevent and treat dengue. According to Dr. Janeiro, the current Dengue Prevention and Control Plan for Buenos Aires aims to provide methods of control that integrate the public health laboratory, the environment, the patient, the vector, other epidemiologic indicators, and communication between public health officials and the population. Through this multifaceted approach, this plan aims at controlling dengue by focusing primarily on eliminating places where mosquitos reproduce.

This method is focused primarily on treatment and fumigation. The nationally approved protocol calls for fumigation of the area surrounding the home of a suspected or confirmed patient of dengue, eliminating mosquito transmission and reproduction.[44] Neighboring persons living close to the index patient are also monitored for symptoms. [44] While the prevention strategy can be effective, with a lack of knowledge about dengue, many people have the disease and are not diagnosed. As a result, there are many areas that do not receive fumigation, allowing additional transmission. Further, the weakness in this prevention strategy is the lack of mosquito elimination prior to an outbreak of dengue. These programs focus more on treatment of dengue rather than its prevention. According to Drs. Correa and Romer, this is a major problem needing to be addressed.

Behavioral prevention methods include advertising within public transportation systems, especially trains moving from the suburban municipalities into the city. However, field observations found few signs and warnings regarding dengue within the city of Buenos Aires. Observations and research of marketing tactics for dengue in Buenos Aires indicate that dengue prevention in the city appears to be more responsive when an increased number of cases are reported.

Ultimately, this research failed to identify existing comprehensive tactics that aimed at sustainably eliminating water storage containers or poverty conditions that may create better environments for mosquito reproduction and dengue transmission. I argue that long-term sustainable improvements in the southern periphery of the city are necessary to effectively reduce dengue transmission within Buenos Aires. If attention to dengue is only paid during times of outbreak, the disease will not be able to be well controlled in the future.

I propose that dengue prevention and treatment be reconsidered at a comprehensive level that works to understand the poverty indicators that are the underlying effectors of increased dengue incidence. Through addressing these demographic disparities throughout the city, I argue that dengue incidence will be able to be more effectively controlled during outbreaks, and other diseases will be reduced in the long run.

7.2 STRENGHTS AND LIMITATIONS

This investigation is beneficial because it provides an alternate perspective on the dengue situation in Buenos Aires in 2009 that can be applied to future prevention tactics. The majority of other studies done analyzing the dengue situation in Buenos Aires have focused on case level data. Primarily, these studies seek to understand the characteristics of patients diagnosed with dengue fever.

This study is unique because it studies the environmental and population level to understand broader factors that may have contributed to patients having dengue. Even if a patient is not struggling economically, living in a low-economic area where other residents lack running water may put them more at risk to contract dengue than a low-income resident living in a higher-income neighborhood. Therefore, a basic analysis of the population demographics and a comparison of this data to the distribution of dengue cases throughout this city can add to the understanding and prevention of dengue in the future.

However, there are limitations to this study, and much remains to be understood, both qualitatively and statistically to prevent future spread of dengue in Buenos Aires, Argentina. These limitations arise from time constraints of fieldwork in Argentina and data availability (both online and from public health workers in Buenos Aires). These limitations affect the statistical significance of this study and limit the conclusions we are able to make.

Firstly, my time in Buenos Aires, Argentina was limited to a four-month period, with one month dedicated entirely to intensive fieldwork. Due to acclimation periods, curricular requirements, and limited connections with dengue experts in Buenos Aires prior to my arrival, I was limited in the quantity of interviews I could conduct, and experts on dengue I could gather information and data from. Additional time in Buenos Aires could have allowed for further data collection, both qualitative and quantitative.

Data availability was another limitation in this study. As noted previously, the only available dengue data for this study was obtained from the national and city-level Ministries of Health. While the majority of data is provided online, I was only able to obtain the most valuable data for this study (dengue cases by hospital area) by meeting directly with a staff member from the City of Buenos Aires Department of Epidemiology, who coordinates all dengue reporting in the city. The data recording methods used in this office, and availability of detailed analysis of case-level data was limited due to what was given to me.

For this study, having data on suspected and confirmed cases of dengue by hospital area is preferred for analysis, because suspected cases are a more realistic measure of dengue, when accounting for a-symptomatic cases that are not part of the confirmed case count. However, the suspected cases of dengue published by the Buenos Aires Ministry of Health in weekly bulletins proved to be unreliable (i.e. the cumulative yearly count of dengue cases would decrease from one week to the next). Therefore, the only available data was laboratory confirmed cases, which was provided by the Department of Epidemiology for the City of Buenos Aires. Using a smaller number of cases (given that they are confirmed rather than suspected) affected data trends and created stronger outliers that shifted the data.

Another limitation in the quantitative data in this study is the possibility that there were cases of dengue within Buenos Aires that were never confirmed or diagnosed, thus affecting the quality of this dataset. I argue this issue may be true especially in the hospital areas Argerich and Mejía, where dengue incidence was low, but socio-demographic indicators were equivalent to the areas of the city with higher dengue. Future studies will benefit from a thorough study of socio-demographic factors in Buenos Aires in relation to suspected cases of dengue, that provide a more accurate picture of the situation.

Secondly, the major limitation is the sample size. Attempts were made to study hospital areas in Buenos Aires' surrounding municipalities in addition to those within the federal capital, in order to increase the sample size and significance of the data. However, data proved to be inconsistent in these areas with city data, in terms of reliable data collection throughout 2009. Further study of these surrounding areas will be important in the future, given the high dengue incidence in these areas as well, and the complex socio-demographic based inequalities present here as well.

Thirdly, the lack of controls throughout this study also limited this analysis. Here, it is important to address the issue of the "ecological fallacy" in my study, meaning ascribing attributes to individuals from population-based datasets. Based on the available data used in this study, I cannot make direct assumptions that the cases of dengue in each area were from patients who lived in high poverty or lower density areas, or were (were not) born in countries bordering Argentina. My dataset is limited to population level data, and I do not have information on the individual case-level. Therefore, a limitation of this study may be differing environmental and socio-economic conditions of the patients who contracted dengue in Buenos Aires, than the socio-economic data for their hospital area of residence.

To account for this issue, a control population sample living in each of these areas without contracting dengue would have been beneficial in both odds ratio analysis and general understanding of the situation in each of these areas. Secondly, there is not data detailing the spread of each socio-demographic factor on a smaller scale than the hospital area. Data based on the spread of the factors throughout the hospital areas would allow for socio-economic disparities within hospital areas, and further the understanding of areas of the city that affected the data.

Small sample size, lack of controls, and limited data availability provide numerous future studies to be conducted to analyze the dengue situation in Buenos Aires Argentina. From this study, I cannot make any risk inferences based on these findings, bur rather only suggest that trends may be present within the data between socio-demographic factors and dengue on the population level within the federal capital.

8.0 CONCLUSIONS

The aim of this study is to provide a comprehensive picture of the interrelated role between dengue and socio-demographic factors in the City of Buenos Aires. These findings suggest that immigration and climate are not the main factors contributing to increased dengue incidence during the outbreak of 2009; rather, areas with high poverty indicators and low population density within the city demonstrate higher propensity for dengue. Immigration was thought to be the main factor contributing to higher incidence in some hospital areas within the city. However, my findings suggest that socio-demographic factors are more strongly associated with areas with increased dengue than with immigration rates. This result is critical in understanding the spread of dengue within large urban areas, and the failure to consider the larger, holistic picture over singular cases of dengue.

Trends within the data between dengue incidence and socio-demographic data suggest that the outbreak in 2009 was not the result of one socio-demographic risk factor but rather numerous factors that create an environment for the *Ae. aegpyti*, to reproduce and for the disease to be transmitted. These factors (population density, place of birth, sanitary installments in homes, and unsatisfied basic needs) suggest that there are poorer neighborhoods in the southern regions of the city, with increased temporary and public housing lacking adequate sanitation, and higher proportions of residents lacking basic needs. Combined with a lower population density, these areas demonstrate higher dengue incidence than the central core. Ultimately, it can be stated that these socio-demographic factors, even with disparities in the data, suggest that poverty indicators and population density are critical in considering dengue incidence throughout Buenos Aires.

The outbreak of 2009 in Buenos Aires was significant because it introduced a largely tropical disease to a temperate area. Buenos Aires still appears to be severely lacking in the educational methods to treat and prevent dengue, and did not do enough to effectively target the most at-risk populations. Qualitative aspects of this study identify a lack of education and awareness of dengue throughout the city, by all people. Without adequate awareness of the disease, its symptoms and how its spread, by both the general population as well as medical experts and government officials, Buenos Aires appears to have increased propensity to develop an increased caseload of dengue in the future, if issues of inequality and prevention are not approached.

On a policy level, I argue that the prevention and treatment tactics for dengue must take place on a multi-level, multi-sided front, with poverty assistance and sanitation access more readily available to those living in underdeveloped areas with high levels of poverty. There should be more education regarding dengue and prevention methods in these areas as well, ensuring that people are aware of dengue and both reporting when cases are suspected and taking necessary precautionary measures. While these are obviously large-scale measures, steps towards addressing them are critical for the future of this city, and as a model for other temperate climates that are developing greater risk for dengue.

9.0 FUTURE DIRECTIONS

Much remains to be analyzed internationally about the role of socio-demographic factors in the spread and prevention of dengue. This study was limited by the small sample size and data sets of only confirmed cases in Buenos Aires, Argentina. For this existing hypothesis of correlation between poverty indicators and higher dengue incidence, the next steps of this study are to expand a similarly modeled analysis to other cities in this region, and within Argentina, to the surrounding municipalities of Buenos Aires. I want to further test my hypothesis to better analyze the relationship between poverty indicators and dengue incidence.

Additional data collection and analysis within major cities in Bolivia and Paraguay, as well as the southeastern regions of Brazil will be collected and analyzed in relation to census data from these regions, and compared with similar factors. Further, additional study will focus on the other cities within Argentina, especially in the northern region that have experienced much higher cases of dengue. This will provide an additional perspective of a tropical disease that has experienced increased incidence in past years. Together, the aim of these future directions is to garner a greater understanding of the role of socio-demographics in dengue, and utilize this understanding to shape further prevention and policy decisions.

APPENDIX A

A.1 INTERVIEW QUESTIONS

A.1.1 Interview Questions for Dr. Aníbal Carbajo

1. In your article published in 2012, you stated that climate was not the principal predictor of dengue distribution in Argentina. In your opinion, why do many dengue experts focus exclusively on climatic factors to explain dengue spread? What is the relationship between the three predictors that you used in your model?

2. You stated that temperature and demographic factors have importance in the geographic distribution of dengue in Buenos Aires. Can you provide an example of this relationship?

3. Can you expand upon the demographic factors you believe impact dengue in Buenos Aires, and what the impact is?

4. It is clear that in Argentina, the dengue spread is different depending on the geographic area. Why does the geography and factors relating to geography play such an impactful role here?

A.1.2 Interview Questions for Marcelo Abril

1. Your work from 2012 states that water storage containers are one of the containers that increase the reproduction of *Aedes Aegypti*, and as a result, can strengthen the transmission of dengue. Do you believe that there are also socio-economic factors that affect the transmission in other areas of Argentina such as Missiones? What factors do you believe play a role?

2. You stated that temperature and demographic factors have importance in the geographic distribution of dengue in Buenos Aires. Can you provide an example of this relationship?

3. Can you expand upon the demographic factors you believe impact dengue in Buenos Aires, and what the impact is?

4. It is clear that in Argentina, the dengue spread is different depending on the geographic area. Why does the geography and factors relating to geography play such an impactful role here?

5. In your opinion, what are the similarities and differences in the situation in Missiones and the Metropolitan Area of Buenos Aires?

6. Do you think that there is a relationship between the incidence of dengue in Buenos Aires and in Missiones?

7. What do you believe the reasons are for the increase in dengue in Buenos Aires?

8. In your opinion, what are the best methods for dengue prevention and reduction in areas of Argentina that have only recently experienced dengue?

9. Do you believe the prevention campaigns in Missiones and the rest of Argentina are effective? If not, what would make them more effective?

10. In the future, with temperature and climate changes, how do you think dengue incidence within Argentina will be affected?

11. Can you expand upon the methodology of studies on the quantity of mosquitos in an area and the cases of dengue?

12. What do you believe to be the prevalence of asymptomatic transmission Argentina? How can this be reduced?

13. I'm interested in the ages of people that have dengue. Are those infected with dengue in Argentina particularly adults or children?

14. What do you recommend to be the best resources for accessing data on dengue based on hospital area or commune?

A.1.3 Interview Questions for Dr. Esperanza Janeiro

1. What data does the Department of Epidemiology collect regarding cases of dengue? Is it possible to access data on the following factors:
    a. Dengue data based on the neighborhoods within the city of Buenos Aires
    b. Confirmed and suspected dengue cases by year?
    c. Dengue data by locality in the city?
    d. Dengue data divided by imported and indigenous cases of dengue
    e. Do you know the proportion of patients that are immigrants?
    f. Dengue data based on sex, age, level
    g. Dengue data by week for 2009

2. Can you explain the Dengue Prevention Plan and Intensive Monitoring?

3. How are these plans affected by factors that differ throughout the city, such as population density?

4. How do the prevention plans in place for Buenos Aires differ from those for other cities and countries?

A.1.4 Interview Questions for Dr. Seijo

1. In your paper published by the CDC, you stated that dengue risk is higher during the end of summer in the periphery of the city. Why are these areas more at risk than other areas of the city?

2. Are there specific populations that live here that you believe affect transmission of dengue?

3. In your experience, are there specific characteristics or differences in the autochthonous and imported cases?

4. Additionally, did you observe a higher percentage of people living with unsatisfied basic needs or lack of sanitation? Do you believe there is a correlation between these factors and dengue incidence?

5. Do you believe that changes in temperature and other factors affect dengue incidence in Buenos Aires?

6. Proportionally, how many cases of dengue are diagnosed? How can you improve this ratio in the future?

7. Do you believe that the Dengue Prevention Plan put in place in Buenos Aires is effective? What are the limitations of this program?

APPENDIX B

B.1 SUPPLEMENTARY DATA: ODDS RATIOS RE-ORGANIZED FOR RISK FACTOR ANALYSIS

Table 9: Odds Ratio of Population Density for Risk Factor Analysis

	Population Density	**Low (hospital areas)**	**High (hospital areas)**
Rate of dengue	High (hospital Areas)	5 (4, 5,10,11)	1 (null)
	Low (Hospital areas)	5 (1,3,6,8)	5 (0,2, 7, 9)
Odds Ratio	5		
95% CI	0.42 – 59.66		

Table 10: Odds Ratios of Proportion of Residents Born in a Country Bordering Argentina for Risk Factor Analysis

	% People born in country bordering Argentina	**Low (hospital areas)**	**High (hospital areas)**
Rate of Dengue	High (hospital areas)	5 (4, 5,10,11)	1 (null)
	Low (hospital areas)	7 (1,2,3,6,8,9)	3 (7,0)
Odds Ratio	2.14		
95% CI	0.17 – 27.10		

Table 11: Odds Ratios of Proportion of Homes Lacking Sanitary Installations for Risk Factor Analysis

	% Homes Lacking Sanitary Installations	Below Average (hospital areas)	Above Average (hospital areas)
Rate of dengue	Low (hospital areas)	5 (1,23,6,9)	5 (0, 7,8)
	High (hospital areas)	1	3 (5,10,11)
Odds Ratio	3.00		
95% CI	0.22 – 0.61		

Table 12: Odds Ratio of People Living with Unsatisfied Basic Needs (UBN) for Risk Factor Analysis

	% People living with unsatisfied basic needs (UBN)	**Low (hospital areas)**	**High (hospital areas)**
Rate of dengue	Low (hospital areas)	6 (1,2,3,6, 8, 9)	2 (0, 7)
	High (hospital areas)	1	3 (5,10,11)
Odds Ratio	9		
95% CI	0.5629 <x<143.8949		

B.1.1 Census Data

Table 13: Residences with Sanitary Installations by Commune for the City of Buenos Aires census [46]

Commune	Total number of homes	Sanitary Installation	
		With flushing toilets [percentage of total]	Without flushing toilets [percentage of total]
1	84,468	78,339 [92.74]	6,129 [7.256]
2	73,156	72,695 [99.37]	461 [0.630]
3	80,489	79,169 [98.36]	1,320 [1.640]
4	76,455	71,433 [93.43]	5,022 [6.569]
5	76,846	76,066 [98.99]	780 [1.015]
6	75,189	74,862 [99.57]	327 [0.435]
7	81,483	78,124 [95.878]	3,359 [4.122]
8	58,204	52,003 [89.346]	6,201[10.653]
9	56,495	55,409 [98.078]	1,086 [1.922]
10	61,453	60,934 [99.155]	519 [0.845]
11	71,460	71,004 [99.362]	456 [0.638]
12	78,547	78,160 [99.507]	387 [0.492]
13	100,506	100,102 [99.598]	404 [0.402]
14	102,918	102,449 [99.544]	469 [0.456]
15	72,465	71,479 [98.639]	986 [1.361]
Total	**1,150,134 [100.000]**	**1,122,228 [97.574]**	**27,906 [2.426]**

Table 14: Population Distribution by Place of Birth per Commune (%), City of Buenos Aires, 2010. [46]

Commune	City of Buenos Aires (%)	Province Buenos Aires (%)	Other provinces in Argentina (%)	From Bordering Country to Argentina (%)	Non-bordering country to Argentina (%)
1	45.3	13.8	22.6	10.8	7.5
2	56.6	16.7	19.2	2.1	5.2
3	49.0	16.2	19.4	4.8	10.5
4	58.2	10.8	14.0	12.0	5.0
5	58.5	15.4	15.8	3.4	6.8
6	69.1	13.5	12.2	3.4	1.8
7	65.9	8.9	9.8	10.7	4.6
8	65.7	6.8	10.6	14.7	2.2
9	71.0	8.1	9.9	6.9	3.9
10	69.4	10.6	7.6	4.8	7.5
11	72.3	10.3	10.0	2.1	5.4
12	65.6	17.5	11.4	2.6	2.8
13	68.4	13.1	10.9	2.5	5.1
14	58.0	17.7	17.3	2.2	4.7
15	62.2	13.0	15.3	4.2	5.3
Total	**62.1**	**13.0**	**13.8**	**5.8**	**5.2**

Table 15: Total Population by Sex, Surface Area and Population Density by Commune.

City of Buenos Aires 2010[46]

Commune	Population			Surface area (km2)	Population Density (res./km2)
	Total	Men	Women		
1	**205886**	107789	98097	17.37	11849.66
2	**157932**	89890	68042	6.29	25100.49
3	**187537**	101936	85601	6.39	29365.20
4	**218245**	115079	103166	21.70	10059.29
5	**179005**	98199	80806	6.66	26876.94
6	**176076**	97206	78870	6.85	25700.65
7	**220591**	118110	102481	12.43	17753.38
8	**187237**	97692	89545	22.29	8398.26
9	**161797**	85590	76207	16.50	9803.36
10	**166022**	89050	76972	12.64	13134.93
11	**189832**	101363	88469	14.09	13471.86
12	**200116**	107589	92527	15.56	12859.92
13	**231331**	127499	103832	14.58	15869.11
14	**225970**	125389	100581	15.78	14324.16
15	**182574**	98089	84485	14.32	12747.40
Total	**2890151**	**1560470**	**1329681**	**203.5**	**14205.58**

Table 16: % Population Lacking Basic Needs by Commune. City of Buenos Aires 2010. [46]

	Sex			Homes Lacking Basic Needs					
				Sex (abs.)			Sex (%)		
Commune	Male	Female	Total	Male	Female	Total	Male	Female	Total
1	89,024	100,315	**189,339**	17,403	16,908	**34,311**	19.5	16.9	**18.1**
2	65,652	86,604	**152,256**	1,787	1,906	**3,693**	2.7	2.2	**2.4**
3	83,212	98,659	**181,871**	11,605	11,292	**22,897**	13.9	11.4	**12.6**
4	102,082	113,547	**215,629**	16,109	16,048	**32,157**	15.8	14.1	**14.9**
5	79,547	95,791	**175,338**	5,532	5,547	**11,079**	7.0	5.8	**6.3**
6	77,749	95,066	**172,815**	2,104	2,115	**4,219**	2.7	2.2	**2.4**
7	101,248	115,707	**216,955**	10,488	10,862	**21,350**	10.4	9.4	**9.8**
8	89,407	97,470	**186,877**	12,849	12,995	**25,844**	14.4	13.3	**13.8**
9	75,629	84,263	**159,892**	4,305	4,199	**8,504**	5.7	5.0	**5.3**
10	76,196	87,489	**163,685**	3,145	3,103	**6,248**	4.1	3.5	**3.8**
11	86,165	99,667	**185,832**	2,255	2,220	**4,475**	2.6	2.2	**2.4**
12	92,044	106,113	**198,157**	1,959	1,894	**3,853**	2.1	1.8	**1.9**
13	102,647	125,217	**227,864**	2,323	2,103	**4,426**	2.3	1.7	**1.9**
14	98,534	122,716	**221,250**	3,014	2,859	**5,873**	3.1	2.3	**2.7**
15	83,302	96,473	**179,775**	4,528	4,657	**9,185**	5.4	4.8	**5.1**
Total	**1,302,438**	**1,525,097**	**2,827,535**	**99,406**	**98,708**	**198,114**	**7.6**	**6.5**	**7.0**

B.1.2 Hospital Area/Commune Intersection Calculation

Table 17: Conversion from Commune Area to Hospital Area[38]

Hospital Label	Commune	Commune Area	Intersection Area	Multiplier (Intersection Area/Commune Area)
0	1	6660526	1483329	0.133
	9	6385991	6385991	0.573
	13	17802807	3275665	0.294
1	6	14120042	5904720	0.661
	7	15570927	2028247	0.227
	10	14322897	994603	0.111
2	1	6660526	4124296	0.332
	2	6851029	3983335	0.321
	3	12422901	923112	0.0744
	10	14322897	3376056	0.272
3	2	6851029	2027168	0.165
	3	12422901	2131062	0.174
	5	12656557	1370790	0.113
	6	14120042	5249649	0.428
	10	14322897	1474258	0.120
4	4	16505306	922590	0.0767
	5	12656557	8557378	0.711
	6	14120042	2547725	0.212
5	4	16505306	10850008	0.470
	5	12656557	1037452	0.0450
	11	22192611	11181619	0.485
6	6	14120042	417949	0.0430
	7	15570927	1269473	0.130
	8	15772496	98887	0.0102
	10	14322897	7942272	0.816
7	12	21701236	8126099	0.462
	13	17802807	9463654	0.538
8	0	6140873	6140873	0.239
	8	15772496	14664106	0.571
	13	17802807	4501855	0.175
	14	14571813	384514	0.0150
9	7	15570927	12273206	0.438
	8	15772496	1009504	0.0360
	10	14322897	535708	0.0191
	14	14571813	14187299	0.501
10	1	6660526	1052901	0.0638
	3	12422901	718259	0.0435
	11	22192611	760517	0.0461
	12	21701236	13436433	0.814
	13	17802807	542534	0.0329
11	2	6851029	840527	0.0321
	3	12422901	8650468	0.330
	4	16505306	4732708	0.180

	5	12656557	1690937	0.064480465
	11	22192611	10250475	0.390881146
	12	21701236	58905	0.002246223

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