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An Examination of Infectious Disease and Public Health Response in Argentina (1867-2013)

by
Alison Ohringer

Bridgette Gunnels, Ph.D.
Adviser

Human Health

Bridgette Gunnels, Ph.D.
Adviser

Michelle Lampl, M.D., Ph.D.
Committee Member

Hernán Feldman, Ph.D.
Committee Member

Jennifer Feldman, M.A.
Committee Member

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a thesis submitted to the Faculty of Emory College of Arts and Sciences
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Abstract

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Argentina's experience with infectious disease and public health intervention helps illuminate the country's history through the lens of politics, medicine, and social change. With epidemics of historic infectious diseases (such as smallpox, yellow fever, and cholera) as well as modern infectious diseases (including vaccine-preventable diseases, HIV/AIDS, and neglected tropical diseases), Argentina has seen both social and medical interventions in public health at the government, community, and individual levels. However, these interventions vary in nature with each different type of disease; a strategy that is successful for vector-borne diseases is not necessary applicable to vaccine-preventable diseases. Following the ratification of its Constitution in 1853, Argentina has experienced large waves of immigration and, simultaneously, epidemics of infectious disease. During the last decades of the 20th century, half of all deaths in Buenos Aires were attributable to epidemic disease. The question of provincial versus federal authority in implementing public health interventions was complicated, and is still an issue in the country today. Compulsory vaccination was introduced into Argentina in 1886 and, presently, vaccines are still free for all Argentines, as delineated on their Vaccination Calendar. In examining epidemics, data analysis was performed using total death rates for historic epidemic diseases and incidence per 100,000 for modern diseases. T-tests were performed for modern diseases to establish significance in evaluating the decrease of disease rates pre- and post-public health interventions. All death and incidence rates were graphed, all relevant references—including historical epidemiological data—were translated, and rates were averaged during and after epidemics. Argentina's response to historic infectious disease can assist in the development of additional policies to control epidemics of modern diseases. The interventions that have been broad in scope have lasted and those that are multi-faceted in nature have been the most successful in controlling epidemics of infectious disease.

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Table of Contents

Tables and Figures

Chapter 1: Introduction

Argentina has a unique perspective on health when compared to other countries in Latin America—and around the world—for many reasons, including its three-pronged healthcare system, extensive history of immigration and large foreign population, and its broad network of ministries of health that resulted after centuries of modifications. Its history with infectious disease in particular helps shine a light onto not only Argentina's history through the lens of public health, but also onto its history of politics, medicine, and culture. Some of the country's most notable historical infectious disease epidemics include smallpox, yellow fever, and cholera in the later decades of the 19th century, following a massive wave of immigration from 1850-1870 (Alsina 1898), and polio in the early- to mid-20th century (Testa 2012). With this influx of immigration, epidemics were essentially commonplace in Argentina; between 1872, the year after the largest yellow fever epidemic, and 1906, nearly half of all deaths in Buenos Aires were attributable to epidemic diseases (Recalde 1993). Some older epidemics included the bubonic plague in the 16th century, but there is a lack of evidence that these epidemics resulted in lasting public health interventions that contributed to a decrease in incidence of the disease (Veronelli and Veronelli 2004). During Argentina's earlier epidemics, it was generally unclear who had jurisdiction between the capital, Buenos Aires, and the different provinces, so public health interventions were often only enacted on a provincial, not national, level (Di Liscia 2011). Countless public health interventions came as a result of the spread of these diseases, including, eventually, the creation of a concrete, federal public health governing body (Di Liscia 2011), immigration reform (Scobie 1974), the mandate for compulsory vaccination (Veronelli and Veronelli 2004), the implementation of various health-related laws (Salessi 1995), and the creation of a water and sewage system (Murray 2004). Vaccination served as a perfect opportunity to open the door for discussions on the legitimacy of public intervention in the daily lives of Argentines, and it was ultimately decided that the collective good took precedence over individual autonomy (Di Liscia 2011). Following these changes in public health, all four historical diseases examined here experienced a decrease in incidence. In fact, Argentina has not seen a case of smallpox, cholera, or polio in decades (Fenner, Isao et al. 1988, Burgos, Elkik et al. 2010, Berger 2014). There have recently been a number of small outbreaks of yellow fever, attributable to the resurgence of its mosquito vector *Aedes aegypti,* though in not nearly the same epidemic proportions (Barrett and Higgs 2007). Complex public health interventions, aimed at curbing the spread of these diseases, appear to have been successful in their efforts. Argentina's experience with modern infectious diseases can serve as a model for other similar countries.

Argentina has a three-pronged health care system to ensure coverage for all citizens: the public sector, social health insurance, and the private sector (Cavagnero, Carrin et al. 2006). In the public sector, individuals have free access to care, but they often have to pay out-of-pocket. In social health insurance, a payroll tax that is matched by employers funds about 50% of the population, and pools its members' risk. Lastly, in the private sector, individuals voluntarily pre-pay for their benefit packages, which range in coverage (Cavagnero, Carrin et al. 2006). While the federal Ministry of Health (*Ministerio de Salud*) controls national health policy, the health ministries of individual provinces are responsible for public health services including preventive care, education, and health promotion in their region (Cavagnero, Carrin et al. 2006).

Vaccination has been compulsory in Argentina since 1886 (Di Liscia 2011) and the country follows a strict calendar of vaccination for its citizens. Rates of vaccine-preventable diseases are low (Pan American Health Organization 1950-2012) as Argentina has utilized global resources, including the World Health Organization (WHO), to increase the national rate of vaccination (Fenner, Isao et al. 1988). However, rates of neglected tropical diseases, for which there is no vaccine—including Chagas and dengue—are high (Pan American Health Organization 1950-2012). The state has taken various public health measures to help curb the spread of these diseases, as well as HIV/AIDS. The strategies utilized in preventing the spread of HIV have been some of the most diversified (Ministerio de Salud 2014), and the country has experienced a decrease in incidence since the epidemics of the 1990s. Argentina's continued response has set a standard that could be implemented in countries with similar outbreaks. This study will utilize case studies of both historical and modern infectious diseases to examine how public health interventions following epidemics have impacted disease death rates and incidence—the number of new cases in a time period—by analyzing these figures in a historical context.

Certainly, every infectious disease creates an effect in the country where it occurs. However, with 238 infectious diseases present in some capacity in the country of Argentina (Berger 2014), it would not be advantageous to discuss them all. Rather, the case studies discussed in the following chapters seem to have triggered some of the major public health reforms throughout the country, with changes that are still seen today that could be modeled in other countries. For the historic diseases, those that were the most deadly—smallpox, yellow fever, and cholera—were selected. For the modern diseases, pernicious illnesses from various categorizes were chosen to examine a broad range of diseases: polio, tuberculosis, and diphtheria were selected from the list of vaccine-preventable diseases; HIV/AIDS was selected as a chronic disease with no vaccine or cure; and Chagas and dengue, which have a large burden in the country, were selected from the seventeen neglected tropical diseases.

Argentina’s public health response to infectious disease has been successful in significantly lowering disease incidence due to the combination of multifaceted medical interventions with simultaneous social changes.

Chapter 2: Methods

Disease death rates, for historical diseases, and disease incidence rates per 100,000 individuals, for modern diseases, were obtained for the years during and after epidemics in Argentina from historic Argentine epidemiologists' studies, the Pan American Health Organization (PAHO) archives in Health in the Americas, the Ministry of Health (*Ministerio de Salud*) archives, and peer-reviewed manuscripts. For older diseases with insufficient incidence records, total deaths were compared during and after the epidemic[1]. These incidence and death rates were graphed accordingly in Microsoft Excel® to observe epidemic trends. For modern diseases, one-tailed, independent sample t-tests were performed in Microsoft Excel®, comparing rates of disease before and after major public health reforms. A p value of less than 0.05 was established to be significant in determining whether the mean incidence of the disease in the years following the public health intervention was lower than the years before.

[1] Unfortunately, disease reporting was not mandated by law during the time of three of the four historical disease case studies in this paper (the law mandating the reporting of infectious diseases was passed in 1936), so reports of disease incidence are inconsistent and reports of total deaths must be used instead.

Chapter 3: Historical infectious diseases

Argentina's history with infectious disease helps illuminate the myriad of public health strategies implemented throughout the country's history, many of which are still in practice today. Some of the first notable epidemics included smallpox, cholera, and yellow fever during the second half of the 20th century (Veronelli and Veronelli 2004). Before the time of these epidemics, there was no concrete public health system in Argentina. For that reason, there are no discussions in this paper of the diseases that occurred in centuries and decades prior, as epidemiological data was unreliable and it seems that no lasting public health interventions resulted.

The creation of Argentina's public health system was spearheaded independently in each province, as it was often unclear if the capital of Buenos Aires or the individual provinces had jurisdiction (Di Liscia 2011). For example, in 1822, the court of the province of Corrientes approved the Settlement of Medicine (*Arreglo de Medicina*), stating the powers of the Court of Medicine in reference to physicians who were to dedicate time working in the countryside[2]. According to this document, Physicians of the Countryside

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[2]"Physicians of the Countryside: had similar functions to medical police in rural zones, and also in the medical section. But further added is the dual mission of spreading the use of the vaccine and advice about animal diseases" (translation by A. Ohringer, 2015).
"*Médicos de Campaña: tenían funciones similares a los médicos de policía, en la zona rural, y también las del médico de sección. Pero se le agregó además la doble misión de propagar el*

(*Médicos de Compaña*) were responsible for promoting the use of vaccines and helping the population of the countryside learn about animal diseases—a very well-known vector for smallpox (Wynggard and Ariasgago 2012). While this was perhaps a useful strategy in curbing the spread of infectious disease, it was not widespread throughout Argentina. Furthermore, in 1822—in Corrientes and the rest of Argentina—vaccination was not yet compulsory. Vaccination was, however, an excellent opportunity to open the door for discussions on the legitimacy of public intervention in the daily lives of Argentines (Di Liscia 2011). There was a question of what the state could force people to do, and what individuals had the power to refuse. Ultimately, vaccination was not made compulsory throughout the country until 1886. Under that new legislation, babies were to immediately receive birth certificates, and each district had to send the registered birth address of all newborns to the Directorate of Public Assistance (*Dirección de Asistencia Pública*) every six months so that vaccinators could be sent to households to award certificates stating the child had received its obligatory vaccinations (Di Liscia 2011). Furthermore, children entering school had to have their vaccination certificates: "In primary schools supported by

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uso de la vacuna y asesorar sobre enfermedades de animales." Wynggard, A. and O. Ariasgago (2012). "El Médico de Policía en la Legislación Correntina." Jornadas de comunicaciones científicas y tecnológicas de la facultad de derecho 8.

public money, no child who has not been vaccinated, or has not had smallpox, will be admitted"[3] (Longoni 1945). If these rules were followed, all vaccines were free (Di Liscia 2011). Ultimately, this system helped create the vaccination calendar that is still in use in Argentina today.

With the ratification of the Constitution in 1853 and subsequent changes to legislation in 1876, waves of immigrants entered the country. Between 1857 and 1914, immigration grew at a rate of 3% per year, with 1,830,214 inhabitants in 1869 and 7,885,237 inhabitants by 1914 (Otero 2006). Around 75% of these immigrants settled in cities—mainly Buenos Aires—and lived in inadequate tenement housing that was dirty, without toilets, and cramped. Epidemics were spreading in these poor neighborhoods (Di Liscia 2011), and with new epidemics of smallpox, cholera, yellow fever, and polio came new public health interventions, as well as a significant decrease in the incidence of smallpox, yellow fever, cholera, and polio throughout the country.

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[3] (English translation by A. Ohringer, 2015). Original text: "*Art. 1: En las escuelas primarias sostenidas por el Erario Público, no se admitirá ningun joven que no haya sido vacunado o que no haya tenido viruelas*." Longoni, G. E. (1945). Origen de la obligatoriedad de la vacunación antivariólica de los escolares. El Monitor de la Educación Común. Buenos Aires, Consejo Nacional de Educación: 57-61.

Smallpox

Background

Smallpox, also known as *variola*, was one of Argentina's many deadly epidemics. Named after the Latin word *varus* ("mark on the skin")[4], smallpox's origins date back as far as 10,000 BC, where it spread from Egypt to India while also making its way through Asia (Riedel 2005). It later spread through Europe and the New World with vigor, affecting members of all social classes. The fatality rate at the time ranged from 20% to 60%, and it was especially pernicious with infants, killing those infected at a rate of around 80% and even as high as 98% (Riedel 2005). The illness is the result of a virus, caused by *Variola major* and *minor* that produces a characteristic maculopapular rash and then fluid-filled blisters—pocks—that disfigure the skin, leaving clearly identifiable marks of smallpox on the faces of those who survived (Méndez Elizalde 2011). Smallpox first arrived in South America after Cortés and his followers sailed from Cuba to Mexico with an infected African

[4] One of the two terms for smallpox, variola, is thought to have come from Bishop Marius of Avenches in Switzerland in 570 AD from one of two Latin words: either varius, meaning "stained," or from varus, meaning "mark on the skin." The term smallpox is thought to have come from England in the 1400s, where the characteristic disfiguring marks were referred to as small pockes, meaning small sacks. Moore, J. C. (1815). The History of the Small Pox. London, Longman, Hurst, Rees, Orme, and Brown.

slave in 1519.[5] About half the population of Mexico died as a result (Fenner, Henderson et al. 1988). When Spanish soldiers invaded Colombia, Venezuela, and Chile in the mid 1500s, smallpox erupted in epidemic proportions throughout the entire continent of South America (Fenner, Henderson et al. 1988).

In 1796 in the United States, British physician Edward Jenner demonstrated the benefits of vaccines with the first vaccination against smallpox (Roggero 2006). His method took pus from someone ill with cowpox—not smallpox—and inserted it into a small slice in the arm of a healthy person to confer immunity to smallpox (Riedel 2005). This Jennerian method of vaccination would spread throughout the world and ultimately end the smallpox epidemic (Méndez Elizalde 2011). Variolation (where the pus from the scab of a person infected with smallpox is inserted into a small slice in the arm of a healthy person, causing an attenuated form of smallpox which occasionally kills, but more often confers immunity in the future (Greenough 1980)) was used until the safer, Jennerian method came into Argentina years later.

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[5] A report from a Spanish friar who was in Mexico in 1525 states: "At this time New Spain was extremely full of people, and when the smallpox began to attack the Indians it became so great a pestilence among them that throughout the land that in most provinces more than half the population died; in others the proportion was a little less" Fenner, F., et al. (1988). "The history of smallpox and its spread around the world." Smallpox and its eradication. OMS Suiza: 209-243.

Smallpox first arrived in Argentina with the Europeans in the 16th century; however, variolation and vaccination against the illness was not common until the late 19th century (Di Liscia 2011). Some of the first reports of variolation (using a scab from someone infected with smallpox, not cowpox) occurred in Buenos Aires in 1802: the pastor Don Feliciano Pueyrredón inoculated the coastal community (Méndez Elizalde 2011). On July 28th, 1805, the vaccination method, using cowpox, arrived in Buenos Aires. Initially, vaccination was offered at Santa Catalina Hospital in Buenos Aires, but months passed where no people were vaccinated. It was an underutilized, inefficient system that did not widely help curb the spread of the disease (Méndez Elizalde 2011). In 1810, one of the first government efforts to try to mandate smallpox vaccination occurred in Buenos Aires—there was a proposal to make vaccination compulsory following a lecture on vaccination practices that June (Méndez Elizalde 2011)—but political and military matters took precedence and the efforts were thwarted. Without a firm system in place to vaccinate, distribution of the cow pocks to perform vaccination was difficult (Di Liscia 2011). Recognizing this problem in the mid-1820s, as well as the advantages of wide-spread vaccination, governor Martín Rodríguez and President Bernardino Rivadavia (who was the son of a physician) created a Commission for the Vaccine (*Comisión para la vacuna*) to administer, generalize, and continue smallpox vaccination (Di Liscia 2011). They created the Academy and Faculty of Medicine (*la Academia y la Facultad de Medicina*) and the Court of Medicine (*el Tribunal de Medicina*), and regulated the health-related tasks of the medics, as well as army, hospital, and port authorities. Rodríguez and Rivadavia also aided various provincial governments in establishing vaccination offices in their respective areas. However, without a defined system in place with regard to vaccination, very little progress was made in the goal to vaccinate all citizens (Di Liscia 2011). In 1822, Rivadavia created a Board of Health (*Consejo de Higiene*) in Buenos Aires, which took over the function of the former health council (established in the colonial era) to monitor health and hygiene. It was composed of an elite group of physicians who undertook the tasks of urban hygiene as well as the professional regulation of both the medical and pharmaceutical industries (Di Liscia 2011).

These smallpox epidemics of the late 19th century were especially fatal because of the demographic growth of the city and province of Buenos Aires, rapid urbanization, and a failure to vaccinate the entire population (Di Liscia 2011). The need for mandatory vaccination arose, but the population initially resisted for two main reasons: 1) the population's fear of a "live" vaccine, and 2) the physicians' unwillingness to operate under an inefficient, cumbersome, and costly system. The peoples' fear of both the vaccine and the virus[6] coincided with the authorities' struggle to isolate those who were infected to further prevent the spread of disease (Di Liscia 2011).

In 1878 and 1882, petitions enforcing compulsory vaccination were denied by various governing bodies who cited a lack of necessity for these measures (Di Liscia 2011). Finally, in 1886, the Buenos Aires legislature approved compulsory vaccination for the country based on a project presented by epidemiologist Emilio Coni, showing that three quarters of children born in Buenos Aires at the time were not vaccinated (Di Liscia 2011).

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[6] An Argentine physician in 1871 shared in a popular medical journal of the time that he had: "encountered more resistance in adults and parents of children to agreeing to receive the benefits of this true and incontrovertible discovery of Jenner. Some argued as proof to their cause, to agree to this procedure, the doubt as to whether the smallpox with which they were being inoculated was of good quality, others the futility of the procedure, since if it were intended by God that their children be attacked by the scourge and perhaps die for their consequences, all would be useless. Sad disappointment to the commissioned one who in the name of science and the experience of many centuries received a no, founded on illogical reasoning, as if based on ideas of such savagery and ignorance!" (translation by A. Ohringer, 2015).
"encontrado mayor resistencia en las personas adultas y en los padres de los niños para prestarse a recibir los beneficios de este verdadero e incontrovertible descubrimiento de Jenner. Unos aducían como causa, para prestarse a esta pequeña operación, la duda que si la viruela que se les trataba de inocular sería de buena calidad, otros la inutilidad del profiláctico, pues que si estaba previsto por Dios que sus hijos debían ser atacados por el flagelo y morir quizás por sus consecuencias, todo sería inútil. ¡Triste desengaño para el comisionado que en nombre de la ciencia y de la experiencia de tantos siglos recibía un no, fundado en un raciocinio tan ilógico, como basado en ideas de tanto salvagismo e ignorancia!" Meléndez, L. (1878). "La viruela en la campaña: causas de su propagación y de la excesiva mortalidad." *Revista Médico-Quirúgica* ***15****(392).*

It was under this legislation that babies immediately received birth certificates, became registered with the state so that vaccinators could come to their households, and had to bring their proof of immunizations to enroll in school—all of which was free to the individual. Furthermore, in addition to newborns, immigrants were to be revaccinated (Di Liscia 2011). By 1889, massive vaccinations had taken place, and 18,349 people had been registered and consequently vaccinated (Di Liscia 2011). However, disputes over the identification of the provinces[7] made it difficult to know which territories had to abide by the laws from Buenos Aires (Veronelli and Veronelli 2004). Other provinces had similar laws, but not all enforced compulsory vaccination (Wynggard and Ariasgago 2012). The municipal Boards of Health (*Consejeros de higeiene*) oversaw the public health of their respective regions. It was unclear what the federal government had the power to do, and which regulations each territory was obliged to follow (Di Liscia 2008). The National Department of Hygiene (*Departamento Nacional de Higiene*) did not have the authority to intervene in the provinces' health issues, which all utilized their respective Boards of

[7] Law 1532, passed in 1884, identified nine legally distinct districts: Misiones, Formosa, Chaco, La Pampa, Neuquén, Río Negro, Chubut, Santa Cruz, and Tierra del Fuego. Los Andes was added to that list in 1900. Di Liscia, M. S. (2011). "Marcados en la piel: vacunación y viruela en Argentina (1870-1910) Marked on the skin: vaccination and smallpox in Argentina (1870-1910)." SciELO.

Health (*Consejeros de Higiene*). Recognizing this problem, Emilio Coni worked to make the expansion of health and medical services from the capital extend to the rest of the country (Di Liscia 2011). Furthering the process of the nation's medicalization, Law 4202 was passed in 1903, clarifying authority in mandating compulsory vaccination and revaccination of immigrants in all provinces (Veronelli and Veronelli 2004). By 1910, 48,368 individuals in the National Territories—nearly half the population—were newly vaccinated and Emilio Coni confirmed that about three million people across the entire country were vaccinated (Di Liscia 2011). Within the next few decades, smallpox was nearly completely eliminated in the country, with only 31 dying in 1954 and 65 dying in 1960 (Veronelli and Veronelli 2004).

Following the implementation of the vaccination strategy outlined in the 1886 ordinance, resistance to vaccination seemed to subside. One physician tasked with traveling to houses to vaccinate (and mark all vaccinations on the newly-registered children's birth certificates) noted: "The opposition in the old tenement houses was not insurmountable. It has not been necessary to enforce the penalties set forth in the ordinance, suffice persuasion in the majority of cases and the presence of the municipal inspector or a watchman causes the opposition to disappear completely”[8] (Coni 1891).

Results

An analysis of smallpox deaths during and after the epidemics reveals a decrease in the number of deaths per year: the average was 1308.75 from 1868-1883 and only 7.60 from 1950-1965 (**See Table 1 in Appendix**). The total number of smallpox deaths grew tremendously in 1871, with 4873 deaths that year and 3974 the year after (**See Figure 1**). The number of deaths decreased in 1873 to 716, and reached its highest number post-epidemic of 1776 deaths in 1875 (Figure 1). Between 1868 and 1883, a total of 23,301 Argentines died from smallpox (Figure 1).

By the mid-1950s, the number of annual smallpox deaths decreased drastically. There were 46 reported deaths in 1950, 26 in 1952, 12 in 1953, and 0 the following year (**See Figure 2**). The number of deaths then never passed 5 (Figure 2).

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8 (English translation by A. Ohringer, 2015). Original quote: “*las resistencias opuestas en las antiguas casas de inquilinatos no han sido insuperables. No se ha llegado el caso de hacer efectivo las penas establecidas en la ordenanza, bastando la persuasión en el mayor número de los casos y excepcionalmente la presencia del inspector municipal o de un vigilante para que la oposición desaparezca por completo*” Coni, E. R. (1891). Código de higiene y medicina legal de la República Argentina.

The total number of reported cases of smallpox decreased in a similar manner as the total number of deaths. There were 4462 reported cases in 1950, 1404 in 1951, 982 in 1952, then just 309 in 1953 (**See Figure 4**). Besides a small spike of 335 in 1957, the number of reported cases never passed 90 (Figure 4).

Discussion

It has been argued that smallpox vaccination is one of the earliest and best examples to observe medicalization, especially in Argentina (Di Liscia 2011). Smallpox vaccination raised the question of the legitimacy of public mandates about citizens' bodies and individual autonomy. It is interesting that perceptions on vaccination changed during these epidemic years, shifting from fear to acceptance, even of the vaccinators working in the peoples' homes. This lends credence to the strategy of organized, compulsory vaccination in reducing infectious disease incidence.

Reports indicate that the countryside fared far worse to smallpox than did the city of Buenos Aires. Of the 23,301 people that died in Argentina from smallpox between 1860 and 1883, 14,632 lived in the countryside and 8,669 lived in the city (Penna and Ramos Mejía 1885). It is possible that the initial disorganization between provincial and federal authority in mandating vaccination contributed to these vast differences.

During an earlier epidemic of smallpox, epidemiologist Emilio Coni noted 2,400 deaths between 1858 and 1867 (Coni 1895). In the epidemics recorded here, there were a total of 20,940 deaths from 1878 through 1883 (Figure 4). With a combined total of 25,340 deaths, the toll would have been extremely significant in a society of only a few hundred thousand; it may have seemed overwhelmingly obvious that interventions were necessary. The resulting legislation in 1886, mandating vaccination and the revaccination of immigrants was a beneficial result of this devastating disease. The additional laws clarifying the role of provincial and federal authority in making public health decisions of this nature were additionally necessary; these guidelines are still followed in the country today (Cavagnero, Carrin et al. 2006).

Yellow Fever

Background

One of Argentina's large epidemics occurred in the 19th century as a result of yellow fever, a viral illness resulting from the bite of the infected mosquito *Aedes aegypti* leading to hemorrhage, and even death. When the intestines or stomach rupture, the vomited blood is black—indicative of gastrointestinal bleeding—thus giving the name *vómito negro*[9] or black vomit (Avilés, Cecchini et al. 1997).

The first case of yellow fever in Argentina's province of Corrientes was diagnosed in December of 1870. Corrientes was the meeting point for the allies of the Triple Alliance who fought in Asunción, Paraguay, which experienced a yellow fever outbreak in 1870 (Jankilevich 1999). The disease spread so quickly in Corrientes that more than half of the population deserted the area, including the authorities (Jankilevich 1999).

The effects of the Constitution of 1853 regarding immigration were especially noticeable in Buenos Aires, as waves of immigrants came into the country and settled in the city[10] (Alsina 1898). The first three cases of yellow fever in the city of Buenos Aires were

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[9] "The term 'vomito negro' was used in those days to describe clinical aspects of this pathological condition, because death was frequently preceded by black vomit or by partially digested blood." Kaliyaperumal, K. (2013). Yellow Fever Encephalitis: An Emerging and Resurging Global Public Health Threat in a Changing Environment, INTECH Open Access Publisher.

[10] In 1869, the foreign population in Buenos Aires totaled 88,126 people, with 89,661 Argentines, and was classified as follows: 44,233 Italians; 14,609 Spaniards; 14,180 French; 6,177 Uruguayan; 3,174 Englishmen; 2,070 Germans; 1,401 Swiss; 798 Portuguese; 733 Brazilians; 611 North Americans; 606 Paraguayans; 544 Austrians; 471 Chileans; 163 Belgians; 151 Bolivians and Peruvians; and 2,297 others Jankilevich, A. (1999). "La gran epidemia de fiebre amarilla. 1870.1871." Hospital y Comunidad: De la Colonia a la Independencia y de la Constitución a la república corporativa. Buenos Aires: 105-116.

reported in January of 1871 by the Public Health Council (*Consejo de Higiene Pública)* in a densely populated immigrant tenement neighborhood of San Telmo (Jankilevich 1999) and one of the biggest epidemics of yellow fever occurred in Argentina from the end of that month until May 1871 (Salessi 1995). This epidemic was so severe that nearly 10% of the city's population died (Scobie 1974). The normal death rate was 20 people per day; however, there were days when the disease killed 500 people (Jankilevich 1999). Ultimately, there were 13,761 deaths and around 40,000 cases in this outbreak alone (Del Ponte 1959). The epidemic nearly shut down the city. All hospitals and makeshift infirmary facilities were filled, but the city was deserted; the national government moved locations, all public offices were put on public holiday, the banks, schools, churches, and businesses were closed (Jankilevich 1999).

At the time, physicians were unsure of the cause of the disease, so they were unable to control its spread or treat it effectively (Salessi 1995). In fact, in an article about the meat salting houses (*saladeros*)—contributors to the dirty conditions implicated in the spread of disease—that he published in 1871, future president Nicolás Avellaneda stated that the cause of yellow fever was "the water that serves us for the uses of life, altered by blood and fluids that are mixed with it"[11] (Salessi 1995). There were no specific strategies to address the mechanism for disease transmission, because it was not yet known. Towards the end of the 1871 epidemic, both the public and the government supported the need to build a water management network for the port, with a potable water supply and wastewater drains to maintain control, separation, and segregation during this time of increased immigration, and epidemic disease (Salessi 1995). These sentiments came to fruition in 1874 with some common health interventions that were mainly social—not medical—in nature.

In May of 1874, English engineer John F. La Trobe Bateman began to expand the work of Irish engineer John Coghlan[12], who had drafted a system to provide potable water to the city and, at the same time, to centralize the location of trash (Murray 2004). This is a very popular and historically successful strategy for promoting public health; similar

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[11] (English translation by A. Ohringer, 2015). Direct quote: "*las aguas que nos sirven para los usos de la vida, alteradas por la sangre y los líquidos que con ella se mezclan*" Salessi, J. (1995). Médicos maleantes y maricas: higiene, criminología y homosexualidad en la construcción de la nación argentina (Buenos Aires, 1871-1914). Rosario, Viterbo.

[12] John Coghlan was an Irish engineer who worked in Argentina and is credited with helping create the Argentine railway system and flood drainage system for the Río de la Plata. His contribution to history was not unnoticed; there is a barrio in Buenos Aires called Coghlan. Hutchinson, T. J. (1865). Buenos Ayres and Argentine Gleanings: with extracts from a Diary of Salado Exploration in 1862 and 1863, Edward Stanford.

measures of cleaning the water supply were taken in major cities like Paris, New York, and London to curb the spread of disease (Duffy 1968). Bateman's expanded plans included an underground city with tunnels and sewers for the maximum control of the water supply (Salessi 1995).

Results

An analysis of yellow fever deaths during and after the epidemics reveals a noticeable decrease in the number of deaths per year: there were 1000 deaths in 1870, 13,761 deaths in 1871, and only 14 deaths in 1872 (**See Figure 5**). After the epidemic in 1871, the highest number of yellow fever deaths in one year occurred in 1898, with 21 recorded deaths. Most other years have 0 deaths (Figure 5). The average number of deaths during epidemic years 1870-1871 was 7,380; that figure dropped to 1.095 for the years 1872-1892 (**See Table 2**).

Discussion

The death toll in 1871, with 13,761 perishing, was massive. The significant decrease in death rate after the two-year epidemic, however, meant that very few died after the period from 1870 to 1871. It is interesting that the disease never made an epidemic resurgence—until modern years at least. The yellow fever vector *Aedes aegypti* still exists in Argentina today and is a major contributor to yellow fever and dengue fever (Avilés, Cecchini et al. 1997). The yellow fever vaccine is still included in the Argentine Vaccination Calendar (*Calendario de Vacunación*) in its recommendations for all citizens. The vaccine currently utilized, YF-17D, has proven extremely effective in preventing any major incidence of the disease, but there are still occasional cases, especially in the northern provinces (Monath 2005).

The peoples' reaction to this historical epidemic was notable. There are reports that the government response to the historical epidemic was inadequate. In Corrientes, the utter lack of authorities and public health action (the city was nearly deserted) during the 1870 outbreak forced a group of neighbors to take over the Central Commission of Public Health (*Comisión Central de Salud Pública*) (Jankilevich 1999). In Buenos Aires during the 1871 outbreak, the newspapers called the public to action and discussed the possibility of an epidemic. The journalists called the public to a meeting on March 13th—a time of extreme terror, fear, and hysteria as a result of the epidemic—at Victory Square in the famous Plaza de Mayo, and drew a crowd of about 8,000 to address the confirmation of the appointment of a People's Committee (*Comisión Popular*) that was headed by Dr. Pérez Roque and to ask the nation's president to prevent immigrants from entering the country during the epidemic (Jankilevich 1999). That day, the governor banned immigration to the country, and earmarked 18,000 pesos to fight the epidemic. The City Commission (*Comisión Municipal*) realized that Buenos Aires' health facilities were insufficient to meet the needs of this epidemic, so the Commission leased a large hospital and created make-shift healthcare facilities in places like educator Pedro Scalabrini's school *Florencio Varela* (Jankilevich 1999).

This outbreak of yellow fever was so remarkable that artists began to represent it in their work. Juan Blanes Manual painted "*Un episodio de la fiebre amarilla en Buenos Aires*"—"An Episode of Yellow Fever in Buenos Aires"—that depicts a grim scene of a baby searching for milk from a mother who is dead on the floor while a male figure, presumably the father, lies dead near the door (**See Figure 4**).

The yellow fever vaccine—a medical intervention—was not around for this historical epidemic; the public health interventions here were mostly social in nature. Immigration, in a city whose population was half foreign, was temporarily banned (Hutchinson 1865). Water management systems were implemented to provide potable water to the citizens of the country, and drain their sewage adequately (Salessi 1995). The people in Corrientes, in a time of desperation, took over a public health governing body (Jankilevich 1999). The success in decreasing the number of deaths from yellow fever, in spite of a lack of vaccine, lends credence to the potential for interventions that are social, not medical, in nature, to help prevent the spread of disease.

Cholera

Background

Cholera is an acute bacterial illness caused by *Vibrio cholerae* in humans, frequently through fecal-oral transmission, and also through contaminated water, seafood, and vegetables (Berger 2014). The symptoms include abdominal pain and severe diarrhea, which is often referred to as "rice water stool," and the illness results in extreme, rapid dehydration (Berger 2014). The acute disease can kill within hours (American Medical Association 1892).

Cholera spread rapidly throughout the rest of the world, causing outbreaks in numerous countries before reaching Argentina (Veronelli and Veronelli 2004). The disease was extremely deadly; in military hospitals in South America, the fatality rate was reported to be as high at 78% during the later 1860s (Veronelli and Veronelli 2004). Initially, the cause of the disease was not well understood, and it was often attributed to bad air—miasma. In 1854, epidemiologist John Snow found that an outbreak of cholera in London had resulted from one contaminated water pump (Koch and Denike 2009). By 1866, a study in London concluded that it was likely contaminated water that was causing all cholera infections (Veronelli and Veronelli 2004).

Argentina's cholera epidemics occurred in 1868 and 1886 (Di Liscia 2011), simultaneously with the epidemics of smallpox and yellow fever. The epidemics of cholera and yellow fever resulted from inadequate water supply and sewage disposal, and improving these public necessities provided an opportunity to protect the health of the people from more than just these two diseases (Veronelli and Veronelli 2004).

When cholera reached Argentina in epidemic proportions in 1867 and 1868, the Public Health Council (*Consejo de Higiene Pública*) took immediate action with the Maritime Central Board of Health (*Junta Central Marítima de Sanidad*), which had just been created by the captain of the Buenos Aires port, to promote volunteerism among physicians to help these ill patients (Veronelli and Veronelli 2004). The government also encouraged the publication of advice in periodicals about hygiene, to help educate the public about the dangers of contaminated water in spreading cholera, encouraging the people to boil or filter their water while also taking extreme caution in handling their excrement (Veronelli and Veronelli 2004). Furthermore, it became generally accepted that the insufficient water and sanitation systems were contributing to the spread of disease. In his booklet "The Sanitation of Buenos Aires" ("*El saneamiento de Buenos Aires*") published later in 1895, epidemiologist Emilio Coni noted: "Buenos Aires, the city of 'good air,' as christened by its founders, has become an unhealthy place, where contagious diseases have acquired rights of citizens…the city has been lacking until now an evacuation system of sewage and water distribution has been totally inadequate for the needs of the population"[13] (Coni 1895). Addressing this problem, in 1869, the city of Buenos Aires received a system of running water with drains and sewers in addition to paved streets (Veronelli and Veronelli 2004). By 1874, public works projects to fix the water supply, established during the yellow fever epidemics, began to take shape throughout the country (Murray 2004). In 1876, the Immigration Act (*la Ley de inmigración*) was enacted, designed to help prevent the spread of yellow fever and cholera by encouraging immigrants to settle outside of the city of Buenos Aires on 100 hectare plots of land that would be obtained for free by the first hundred families, and then sold at a discounted rate (Alsina 1898). These interventions were part of a larger effort of hygienism (*higienismo*) from 1875 until 1885, following the discoveries of bacteria by Joseph Lister and of vaccination by Louis Pasteur (Salessi 1995).

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[13] (English translation by A. Ohringer, 2015). Original text: "*Buenos Aires, la ciudad de los 'buenos aires,' como la bautizaron sus fundadores, se convirtió en un lugar malsano, donde las enfermedades contagiosas habían adquirido derecho de ciudadanía…La ciudad ha estado desprovista hasta ahora de un sistema de evacuación de inmundicias y la distribución del agua ha sido absolutamente insuficiente a las necesidades de su población*." Coni, E. R. (1895). Saneamiento de Buenos Aires. Buenos Aires, Imprenta de Pablo E. Coni È Hijos.

These interventions were insufficient in preventing the spread of cholera throughout the country. A second epidemic occurred in 1886, after being introduced in Buenos Aires by the ship *Pesco* that had come from Genoa, Italy (American Medical Association 1892). This epidemic, however, was less severe in Buenos Aires—the origin of the first epidemic and the place of introduction of this epidemic (Álvarez 2012). It has been hypothesized that Buenos Aires was less susceptible to contracting the disease because of its access to clean water from their new running water and sewage system (Álvarez 2012).

Results

An analysis of cholera deaths during and after the epidemics reveals a decrease in the number of deaths per year: there were 1653 deaths in 1867, 993 deaths in 1868, 790 deaths in 1874, another 1092 from 1886 to 1887, and then only 3 total deaths from 1889 to 1894 (**See Figure 6**). There was a small outbreak in 1895 with 181 deaths, but the death toll never again passed 15 (Figure 6). All years from 1907 to 1916 have 0 deaths (Figure 6). The average number of deaths during epidemic years 1867-1887 was 808; that figure dropped to 12.95 for the years 1888-1908 (**See Table 3**).

Discussion

The cholera epidemics in Argentina of 1868 and 1886 occurred during two of the six global cholera pandemics. The first Argentine epidemic took place during the fourth global pandemic (1863-1879), and the second Argentine epidemic was during the fifth global pandemic (1881-1896) (Barua and Greenough 1992). A total of 5,037 Argentines died from 1867 until the end of the second global cholera pandemic in 1896 (See Figure 6). Argentina did not, however, experience a cholera epidemic during the sixth global pandemic, which occurred from 1899 to 1923 (Barua and Greenough 1992). In fact, a total of only 70 Argentines died from cholera during this last pandemic, with 0 recorded deaths from 1907 until 1923 (See Figure 6). By this time, non-medical public health interventions in Argentina, like clean water and sewage, had been in the country for about two decades. The link between contaminated water and cholera was widely accepted at this point; those who did not have constant access to perfectly clean water were advised to boil or filter it (Veronelli and Veronelli 2004). Much like yellow fever, there was no vaccine for cholera, so public health interventions were more social than medical in nature. The decrease in mortality was significant, likely due to these interventions.

Polio

Background

Poliomyelitis was an infectious disease of global concern in the mid-20th century. Polio is caused by a virus and exists in three strains, all of which can cause paralysis, and it is spread from person to person, most often orally through exposure to feces (Bloom and Lambert 2002). When the virus multiplies in the host's cells, it destroys nerve cells and can ultimately lead to paralysis. The initial symptoms are typical of a minor illness, and include fever, muscle pains, headache, nausea, vomiting, and stiffness of the neck and back. Paralysis can occur in some cases, and most often affects the legs, developing usually within four days of onset (Bloom and Lambert 2002). Polio was considered an infectious disease with epidemic characteristics by 1912 (Bloom and Lambert 2002). The first vaccine was created in 1954 (Testa 2012) and became available in 1955 (Bloom and Lambert 2002). By 1991, the disease was nearly eradicated from the western hemisphere as a result of the availability of the vaccine and its effective use (Bloom and Lambert 2002).

Argentina experienced its first polio outbreak in 1906, but the disease was not considered to be an epidemic in the country until 1936, following an outbreak in the city of Buenos Aires. Public health interventions followed immediately (Testa 2012). On September 30, 1936, Law 12317 was enacted, which made it mandatory for the physician or his or her assistant to report contagious or transmittable infectious diseases to the nearest health authority (Guido, Monjardin et al. 1960). This law was updated in 1960 to include both physicians and veterinarians in an effort to increase the number and diversity of diseases tracked, and to clarify measures of confidentiality for the patient, physician, and laboratory technicians associated with the cases. According to the law, diseases classified in "Group A"—cholera, yellow fever, plague, smallpox, typhus, and louse-borne relapsing fever—must be reported whenever they are suspected due to extremely high risk of transmission (Guido, Monjardin et al. 1960). Those in Groups B and C[14] must be reported once they are confirmed. Diseases in Group D, of unknown etiology or those not mentioned by name in the law, must be reported when they are observed in an unusual manner—in high quantities, collectivity, gravity, or other characteristics as determined by the physician[15] (Guido, Monjardin et al. 1960). This law helped begin some of Argentina's first

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[14] Group B: Botulism, Acute infectious encephalitis, Chagas, Typhoid and paratyphoid fever, Hidatidosis, Leprosy, Malaria, Acute anterior poliomyelitis (paralytic), Human Rabies: People bitten by animals, Syphilis, Tuberculosis, Tetanus, Trichinosis, Viral haemorrhagic disease. Guido, J. M., et al. (1960). Enfermedades contagiosas o transmisibles - medidas. Ley 15465. H. C. d. l. N. Argentina.

[15] "The exotic diseases and those of unknown etiology and those not listed on the list of this law, when present as unusual or collectively, or characteristics of gravity. The National Executive is empowered, after a report from the Ministry of Social Welfare and Public Health to add other diseases, delete any of the specified or modify their grouping" (translation by A. Ohringer, 2015).

systematic statistical record keeping for public health and epidemiology (Testa 2012). These records showed that the most severe outbreaks of polio occurred in Argentina in 1936, 1953, and 1956 with incidences of 10, 14, and 33 cases per thousand, respectively (Testa 2012).

Polio was so disabling that the public began implementing measures to try to curb the spread of the disease. They used camphor in clothes (based on urban legend) and cleaned the sidewalks and streets themselves (Testa 2012). Furthermore, a group of women in Buenos Aires created a philanthropic group—The Fight Against Child Paralysis (*Asociación para la Lucha contra la Parálisis Infantil [ALPI]*)—in 1943, dedicated to finding solutions of the disabling effects of polio. The Ministry of Health recruited ALPI in 1957 to help with the overwhelming cost of vaccination to raise funds in the community, to eventually make a large immunization less financially burdensome; ALPI, in turn, created the First Pro-Vaccination Funding Campaign (*Primera Campaña de Recaudación Pro*

"*Las enfermedades exóticas y las de etiología desconocida y aquellas no indicadas en la nómina de esta ley, cuando se presente en forma inusitada o colectiva, o con caracteres de gravedad. El Poder Ejecutivo nacional está facultado, previo informe del Ministerio de Asistencia Social y Salud Pública para agregar otras enfermedades, suprimir alguna de las especificadas o modificar su agrupamiento* (ibid.

Vacunación) to raise these funds and later fully paid to vaccinate those who could not afford it (Testa 2012).

Results

An analysis of the incidence per 100,000 of polio during and after the epidemics reveals a significant decrease in the number of new cases per year following the massive vaccination campaign of 1967: there were 33.3 new cases per 100,000 in 1956, 4 to 5 new cases per 100,000 from 1957 until 1963, and then only 0.3 new cases per 100,000 in 1967 (**See Figure 7**). Following 1966, the incidence never again passed 1.1 new cases per 100,000 (Figure 7). Many years from 1973 to 1984 have 0 new cases (Figure 7). The average number of new cases per 100,000 during epidemic years 1953-1966 was 6.7; that figure dropped to 0.411 for the years 1967-1984 (**See Table 4**). A p-value less than 0.05 indicates a significant decrease in the number of new cases per 100,000 per year after the 1967 intervention (Table 4).

Discussion

Poliomyelitis was a very disabling disease that was conquered very quickly. The vaccine was created the year after Argentina's second polio epidemic, but its use was not immediately widespread due to its high cost (Testa 2012). The extremely infectious nature of the disease led to the creation of Law 12317, mandating the reporting of infectious diseases, which is an extremely crucial component of Argentina's public health response currently (Pan American Health Organization 1950-2012). The country is able to easily monitor disease incidence and prevalence, comparing rates in different provinces at different times to do extensive epidemiological studies. Like smallpox, polio was overcome through the implementation of a vaccine (Testa 2012). Also like smallpox, disease incidence was not significantly decreased until use of the vaccine was more widespread (Di Liscia 2011). The elimination of polio through vaccination helps illustrate one of the many methods in overcoming infectious disease.

Chapter 4: Modern infectious diseases

Argentina's experience with modern infectious disease is a direct result of the actions taken during the periods of historical infectious disease. Numerous public health interventions from centuries ago are still seen in action today. There is a federally-run Ministry of Health (*Ministerio de Salud*) and provincial health departments that run their own respective public health programs (Cavagnero, Carrin et al. 2006). The Ministry of Health analyzes the extensive epidemiological data reported by each province about various illnesses, and uses this data to create public policy (Ministerio de Salud 2014). Vaccination is compulsory, and vaccines are free for all citizens (Roggero 2006).

In 2000, Argentina's Ministry of Health (*Ministerio de Salud*) created the National Immunization Commission (*Comisión Nacional de Inmunización*) to serve as Argentina's National Immunization Technical Advisory Group (Stecher, Gaiano et al. 2014)—a term used by the World Health Organization to refer to a resource that guides policy-makers in making evidence-based decisions regarding national immunizations (World Health Organization 2014). The commission consists of experts from the fields of infectious disease, immunization, internal or family medicine, microbiology, and nurses, as well as representatives from different scientific societies, laboratories, the Ministry of Health, and each regional immunization program. These individuals make transparent immunization recommendations based on technical, programmatic, and social criteria—all evidence-based decisions; they examine the burden of different diseases, vaccine safety and efficacy, and cost-benefit in determining the vaccination schedule (Stecher, Gaiano et al. 2014). The commission's goal is to protect the health of the population through recommendations with the greatest impact on vaccine preventable diseases, and to generate policies that achieve control, elimination, and eradication of vaccine-preventable diseases[16] (Dirección Nacional de Control de Enfermedades Inmunoprevenibles 2014). The National Vaccine-Preventable Disease Control Program (*Programa Nacional de Control de Enfermedades Inmunoprevenibles*) of the Ministry of Health (*Ministerio de Salud*) is responsible for procuring and distributing the vaccines chosen by the commission (Stecher, Gaiano et al. 2014).

Like many other nations, Argentina has experienced its share of HIV epidemics as no vaccine exists to prevent its onset. They have, however, implemented numerous public

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[16] Translated from: "*La visión de la CoNaIn asesorar a las autoridades para generar políticas que logren el control, eliminación y la erradicación de las enfermedades inmunoprevenibles." La misión de la CoNaIn es contribuir a proteger la salud de la población mediante la formulación de recomendaciones que tengan el mayor impacto en las enfermedades prevenibles por vacunación" Dirección Nacional de Control de Enfermedades Inmunoprevenibles (2014). "Comisión nacional de inmunización." Reglamento Conain. Retrieved February, 2015, from http://www.msal.gov.ar/dinacei/index.php/conain/reglamento-de-la-comision-nacional-de-inmunizaciones-conain*

health reforms to try to curb the spread of the disease (Falistocco, Manzur et al. 2013). Furthermore, they have passed several laws in regard to HIV/AIDS, some of which are aimed at reducing discrimination (Dirección de Sida y ETS 1990). This public health intervention is perhaps the most diversified in its efforts to reduce the incidence of HIV/AIDS.

Vaccination Calendar: Preventing modern diseases like tuberculosis and diphtheria

The basic vaccination standards created in the nineteenth-century are still followed today by the Argentina's Ministry of Health with their Vaccination Calendar (**See Figure 8**). The Argentine public health strategy utilizes various types of vaccines, including live attenuated vaccines against varicella and yellow fever and inactivated vaccines against polio, Hepatitis B, and some types of influenza virus. For many years, the Argentine vaccination schedule did not change (Roggero 2006). In 1998, the Ministry of Health (*Ministerio de Salud*) began to include additional vaccines as part of a primary prevention strategy, including the triple viral and anti-Haemophilus B. In 2000, they included the vaccine for Hepatitis B, and added Hepatitis A in 2005 (Roggero 2006). As a result, they have seen dramatic declines in the prevalence of these infectious diseases. For example, vaccination against tuberculosis has been very successful: the prevalence is only 2.5%. A similarly low prevalence exists with hepatitis B (2.1%), polio (1%), and diphtheria (0%) (Roggero 2006). This calendar serves as an excellent model for other countries to simply and effectively maintain a low incidence of vaccine-preventable diseases, like tuberculosis and diphtheria.

Results: Tuberculosis

An analysis of the incidence per 100,000 of tuberculosis during and after the epidemics reveals a significant decrease in the number of new cases per year following the 1968 vaccination campaign: there were 80 to 100 new cases per 100,000 per year from 1953 to 1962, a peak with 110.9 cases per 100,000 in 1963, and then a downward trend from 1966 through 2013 (**See Figure 9**). Following 1968, the incidence never again passed 80 new cases per 100,000 and decreased in a somewhat linear manner with time (Figure 9). The average number of new cases per 100,000 during epidemic years 1952-1967 was 88.61; that figure dropped to 66.43 for the years 1968-1983 (**See Table 5**). A p-value less than 0.05 indicates a significant decrease in the number of new cases per 100,000 per year after the public health intervention of 1968 (Table 5).

Results: Diphtheria

An analysis of the incidence per 100,000 of diphtheria during and after the epidemics reveals a significant decrease in the number of new cases per year following the 1968 vaccination campaign: there were 33.3 new cases per 100,000 in 1956, 4 to 5 new cases per 100,000 from 1957 until 1963, and then only 0.3 new cases per 100,000 in 1967 (**See Figure 10**). Following 1966, the incidence never again passed 1.1 new cases per 100,000 (Figure 10). Many years from 1973 to 1984 have 0 new cases (Figure 10). The average number of new cases per 100,000 during epidemic years 1953-1966 was 6.7; that figure dropped to 0.411 for the years 1967-1984 (**See Table 6**). A p-value less than 0.05 indicates a significant decrease in the number of new cases per 100,000 per year after the public health intervention of 1968 (Table 6).

Discussion

Tuberculosis and diphtheria are excellent examples in demonstrating the power of vaccination in controlling or eliminating infectious diseases. Towards the end of the 19th century, tuberculosis was killing thousands of Argentines per year; from 1860 until 1883, tuberculosis killed 24,079 people throughout the country (Recalde 1993). During that same time, diphtheria was taking hundreds per year, and killed a total of 6,268 Argentines from

1860 until 1883 (Recalde 1993). The vaccines for tuberculosis and diphtheria were discovered in the years after these outbreaks, and then began to be more widely used in the following decades of the 20th century (Bloom and Lambert 2002). Still experiencing epidemics of both diseases, Argentina turned to the Pan American Health Organization for help. In 1966, the PAHO signed an agreement with Argentina (as well as nine other countries) to promote a national vaccination campaign, with the goal of eliminating smallpox (Fenner, Henderson et al. 1988). Over the next five years, the World Health Organization and Pan American Health Organization invested a total of US$236,000 in Argentina's national vaccine campaign, and Argentina expanded its campaign massively, especially in 1966 and 1967 (Fenner, Henderson et al. 1988). Interestingly, 1966 and 1967 are the last years of epidemics of tuberculosis and diphtheria, which both had a significant decrease in the incidence per 100,000 in the following years (See Tables 5 and 6). Diphtheria, in fact, has been eliminated in Argentina since the mid 1980's (See Figure 10). One could hypothesize that the increase in vaccination coverage correlates with the resulting significant decrease in incidence of these diseases, but further studies would have to analyze that notion.

HIV/AIDS

Background

AIDS is a disease that compromises the immune system, caused by the Human Immunodeficiency Virus. HIV is spread from the bodily fluids—blood, semen, vaginal secretions, and breast milk—of an infected individual, mainly through sexual contact, sharing of injection equipment, and from infected mother to infant (Long 1998), a process referred to as vertical transmission (Gomez Carrillo, Avila et al. 2002). The majority of patients who become infected with HIV experience flu-like symptoms within one to four weeks following infection (Hecht, Busch et al. 2002). Positive diagnosis is conducted through an RNA based assay for the presence of antibodies (Hecht, Busch et al. 2002). Following infection with HIV, it can take up to ten years for the illness to progress to AIDS, and although the symptoms during this incubation period may be unnoticeable, a person with HIV can infect another person at any time (Long 1998). As the HIV infection progresses, common symptoms include fever, rash, mouth sores, sore throat, joint pain, diarrhea, night sweats, headaches, loss of appetite, weight loss, malaise, muscle pain, and fatigue (Hecht, Busch et al. 2002). Patients who adhere to antiretroviral therapy treatment can reduce their risk for illness and death, as these drugs lower their viral load and allow cells of the immune system like helper T cells to survive and fight off infections (d'Arminio

Monforte, Sabin et al. 2005). However, no drug can cure HIV or AIDS and there are currently no HIV vaccines available (Fauci, Johnston et al. 2008).

The country's first HIV/AIDS case appeared in Buenos Aires in 1982 in a heterosexual man, and the first pediatric AIDS case appeared in 1986. By the end of 1986, there were 39 total reported cases of AIDS in the country (Gomez Carrillo, Avila et al. 2002). In 1990, Argentina passed the National Law of AIDS (*Ley Nacional de Sida*)—Law 23,798—declaring the fight against AIDS to be of national interest[17] under the authority of the Ministry of Health and Social Action of the Nation (*Ministerio de Salud y Acción Social de la Nación*) and stating that the infected people were not to be marginalized, stigmatized, degraded, or humiliated and would remain anonymous through a system of coding

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[17] "ARTICLE 1 – It is declared of national interest the fight against acquired immunodeficiency syndrome, defined as the detection and investigation of its causal agents, diagnosis and treatment of disease, prevention, care and rehabilitation, including their derived pathologies, as well as measures designed to prevent its propagation in the first place, through education of the population" (translation by A. Ohringer, 2015). *("ARTICULO 1 — Declárase de interés nacional a la lucha contra el Síndrome de Inmunodeficiencia Adquirida, entendiéndose por tal a la detección e investigación de sus agentes causales, el diagnóstico y tratamiento de la enfermedad, su prevención, asistencia y rehabilitación, incluyendo la de sus patologías derivadas, como así también las medidas tendientes a evitar su propagación, en primer lugar la educación de la población"). Dirección de Sida y ETS (1990). Ley Nacional de Sida y su Decreto reglamentario. Ley 23798. H. C. d. l. N. Argentina: 22.*

(Dirección de Sida y ETS 1990). The law specified the goals of the education campaigns[18] they would utilize in this public health intervention. Additional efforts in 1991 were targeted at confidentiality and additional education, with Decree number 1244/91 (*Decreto nro. 1244/91*) stating that AIDS prevention would be included in the curricula of primary, secondary, and tertiary schools. However, Argentina suffered with the implementation of these goals. By 1993, Argentina had the second-highest incidence of AIDS in South America at 41 cases per million (Betts, Astarloa et al. 1996). The incidence of HIV rose in epidemic proportions until 1997, when the Ministry of Health (*Ministerio de Salud*) reached out to the World Bank to co-fund a project to help reduce the spread of the epidemic (Lara and Hofbauer 2004). The Ministry of Health requested (and received) USD$15.0 million for an HIV/AIDS control project called LUSIDA to reduce the rate of growth of the incidence of HIV by 15% and improve both the quality and efficiency of care for HIV/AIDS through four

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[18] "f) The Executive Branch will arbitrate measures to bring to the attention of the population the characteristics of AIDS, possible causes or means of transmission and contagion, advisable measures of prevention and appropriate treatments for healing, in a way that avoids unscrupulous broadcast news" (translation by A. Ohringer, 2015).
(f: El Poder Ejecutivo arbitrará medidas para llevar a conocimiento de la población las características del SIDA, las posibles causas o medios de transmisión y contagio, las medidas aconsejables de prevención y los tratamientos adecuados para su curación, en forma tal que se evite la difusión inescrupulosa de noticias interesadas.) Ibid.

key strategies[19] aimed at further reducing stigma and improving care and monitoring facilities (LUSIDA 1997).

Results

An analysis of the incidence per 100,000 of HIV/AIDS during and after the epidemics reveals a significant decrease in the number of new cases per year following the implementation of LUSDIA in 1998: there were 8.3 new cases per 100,000 in 1996, 9.3 new cases per 100,000 in 1997, 5 to 6.8 new cases per 100,000 from 1998 until 2008, and then 3.6 to 4.4 new cases per 100,000 from 2009 to 2011 (**See Figure 11**). The average number of new cases per 100,000 during epidemic years 1993-1998 was 7.16; that figure dropped to 5.45 for the years 1999-2011 (**See Table 7**). A p-value less than 0.05 indicates a

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[19] (i) Improved information for decreased misconceptions about HIV transmission and prevention;
(ii) More effective adoption of preventive measures against HIV;
(iii) Improved facilities for diagnosis, treatment and care of HIV/Sexually Transmitted Diseases (STD);
(iv) Improved monitoring and evaluation of HIV and STD infection, diagnosis, treatment and care.
LUSIDA (1997). Project Appraisal Document on a Proposed Loan in the Amount of US$15.0 Million to the Argentine Republic for an AIDS and Sexually Transmitted Diseases Control Project (LUSIDA). Human and Social Development Group**:** 10.

significant decrease in the number of new cases per 100,000 per year following the implementation of LUSIDA in 1998 (Table 7).

An analysis of the total number of cases of vertically-transmitted HIV during this period a downward trend in the number of new cases per year (**See Figure 12**). There were 309 and 311 cases in 2001 and 2002, respectively, and that number decreased with a linear trend to a low of 57 cases in 2012 (Figure 12).

Discussion

The rate of HIV incidence has continued to decline. There are now 110,000 Argentineans living with HIV/AIDS, with a prevalence of around 3 per 100,000 in 2010 (Christian, Alicea et al. 2014). According to the Argentine Ministry of Health, the rate of HIV/AIDS has stabilized over the last five years, with about 5,550 new cases being diagnosed annually. Approximately 90% of new infections are attributed to unprotected sex, and many of the rest to intravenous drug users (Ministerio de Salud 2014). The number of cases of vertical transmission—from mother to newborn—has also decreased tremendously, following numerous education campaigns.

A crucial public health intervention in the treatment of HIV/AIDS was the adoption of computerized medical records in 2011 (Falistocco, Manzur et al. 2013). Many studies have shown the benefits of using computerized medical records for streamlining prescriptions, monitoring labs, and improving quality, safety and efficiency in healthcare (Bates, Ebell et al. 2003) that could potentially contribute to the decreased incidence in Argentina.

As part of an effort to lower HIV incidence, the government pays for and distributes condoms, lubricant gels, and outreach materials from the nearly 3,000 health centers throughout the country which also provide antiretrovirals to about 50,000 people (Ministerio de Salud 2014). Of the 110,000 infected Argentines, about 70% know their diagnosis, and around 52,000 take antiretrovirals, which are completely free as a result of legislation (Falistocco, Manzur et al. 2013). The Ministry of Health also sponsors strategies aimed at promoting adherence to treatment, including educational brochures, especially for the LGBTQ+ community, pillboxes for those taking antiretrovirals, and a free hotline. Furthermore, journalists and other contributors to the media are being educated by the Ministry of Health about how not to stigmatize HIV/AIDS through training on proper language and treatment of patients (Falistocco, Manzur et al. 2013). The four goals outlined in LUSIDA are still utilized by the Ministry of Health (*Ministerio de Salud*) today in their campaigns to prevent HIV and AIDS.[20]

The public health approach to HIV/AIDS has been one of the most complex. Many of the interventions are social in nature—education, reduction of stigma, and outreach. As there is no vaccine or cure, it seems appropriate that some interventions are biomedical in nature. The strategy utilized in controlling HIV and AIDS is perhaps the most applicable to other diseases, as public health intervention here consists of medical and social reform.

Neglected Tropical Diseases

Presently, there are 17 diseases categorized by the World Health Organization as "neglected tropical diseases"[21] that cause serious illness for more than one billion people

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[20] From the Ministerio de Salud: *"a) mejora en la accesibilidad a información y recursos preventivos; b) mejora en la accesibilidad al diagnóstico del VIH y otras ITS; c) mejora en la calidad de atención de las personas con VIH; y d) reducción del estigma y la discriminación" Falistocco, C., et al. (2013). Boletín sobre el VIH-sida e ITS en la Argentina. Dirección de SIDA y ETS. A. Ostrowski. Buenos Aires, Ministerio de Salud.* ***30***.

[21] The 17 neglected tropical diseases: Chagas, dengue, rabies, Human African trypanosomiasis, leishmaniases, cysticercosis, guinea-worm disease, echinococcosis, foodborne trematodiases, lymphatic filariasis, onchocerciasis, shistosomiasis, soil-transmitted helminthiases, buruli ulcer, leprosy, trachoma and yaws. World Health Organization (2014). "The 17 neglected tropical diseases." Neglected tropical diseases. Retrieved November, 2014, from http://www.who.int/neglected_diseases/about/en/.

globally but do not receive much attention in the world of pharmaceutical research (World Health Organization 2014). Neglected tropical diseases are considered to be “neglected” because they generally affect the global poor and frequently receive less attention compared to other diseases, despite their large burden (National Insitutes of Health 2014). Normally, these diseases affect the poorest people, damaging their physical and cognitive development and resulting in reduced productivity. Many of these diseases affect Argentina, including Chagas disease and dengue (World Health Organization 2014), the most concerning of which—due to its extreme burden—is Chagas.

Chagas disease

Background

Chagas disease, also referred to as American trypanosomiasis, is of growing concern around the world, especially in Latin America. Currently, approximately eight million people in Mexico, Central America and South America have Chagas disease, and most do not know they have been infected (World Health Organization 2014). In Argentina, Chagas is most common in the north-west, and is considered endemic in the regions of El Chaco, Jujuy, La Rioja, Salta, and Santiago del Estero, where prevalence is estimated to be between 16 and 21% (Schmunis 2007).

The characteristics of Chagas disease are not unlike those of many neglected tropical diseases: Chagas is vector-borne and prevalent in impoverished areas, but no vaccine exists to prevent it (World Health Organization 2014). In the asymptomatic acute phase, Chagas can be successfully treated with no lingering health impairments. However, without early intervention, Chagas can progress to a chronic, painful form for the remainder of the patient's shortened lifespan, contributing greatly to global disability adjusted life years (Rassi and Marin-Neto 2010). The acute phase of Chagas begins when the parasite enters the body, and only lasts up to two months. The chronic phase begins if the acute phase is left untreated, and lasts the patient's lifetime. The acute phase is often completely asymptomatic, and is therefore very difficult to diagnose. An indication of the acute phase is the presence of a "chagoma," a reaction at the location of the bite on the body, or "Romaña's sign," a swollen eyelied, neither of which present with every case. Both are painless. The acute phase can also present with vague, flu-like symptoms, including malaise, fever, and enlarged lymph nodes, and it can also cause enlargement of the liver and spleen (Moncayo and Ortiz Yanine 2006). If the acute phase is left untreated, the flu-like symptoms will go away and at that point, the chronic phase begins. Then, the number of parasites present in the patient's blood falls, making diagnosis even more difficult (Moncayo and Ortiz Yanine 2006). Therefore, the initial presentation of chronic Chagas is indeterminate, and often completely asymptomatic. There has not yet been any organ damage, and the patient likely feels healthy. There are slightly varying estimates of the number that remain in this indeterminate form, ranging around 50-70% (Moncayo and Ortiz Yanine 2006). Some, however, do not stay in this indeterminate form and develop severe forms of chronic Chagas disease, which can affect the heart, digestive system, nervous system, and even result in death (Moncayo and Ortiz Yanine 2006).

Chagas disease can only be cured when it is in the acute phase by killing the parasite with an antitrypanosomal treatment like Benzinidazole or nifurtimox. However, the drug is often still given to those with chronic disease to reduce the parasitic load. Like most neglected tropical disease, Chagas primarily affects the poor, and pharmaceutical companies have little incentive to invest in expensive therapies for patients who can't afford their product (Moncayo and Ortiz Yanine 2006). It can be prevented through insecticide spraying and community involvement—the most cost-beneficial approach—but it is most prevalent in impoverished areas where those types of projects can be difficult to fulfill (Gürtler, Kitron et al. 2007).

Chagas disease is spread through the protozoan vector *Trypanosoma cruzi,* which is present in the intestines of most triatomine bugs of the species *Panstrongylus megistus*, *Rhodnius prolixus*, *Triatoma brasiliensis*, *T. dimidiata*, *and T. infestans.* These bugs, also referred to as "kissing bugs," are common in the grasslands, forests, deserts, valleys and man-made ecotopes of Central and South America (Moncayo 1991). Infection with Chagas disease usually occurs after the infected triatomine punctures the human's skin to suck its blood while simultaneously leaving behind feces containing *T. cruzi* (Moncayo and Ortiz Yanine 2006). However, transmission can also occur after a transfusion of blood or transplant of an organ from an infected individual, from mother to child through the placenta, through ingestion of contaminated foods, or through laboratory exposure, though these are rare (Moncayo 1991).

Human infection with Chagas disease first occurred after the triatomine's natural environment was disturbed mainly by deforestation; the bugs were forced to relocate to human dwellings (Moncayo 1991). The bugs that survived the relocation reproduced, and those that were able to withstand the changes adapted to urban environments. These bugs had increased access to food and better protection from climate change as they lived inside and were therefore able to flourish. While the triatomine population increases in summer, they are now present year-round (Moncayo 1991). They form permanent colonies in houses in the cracks in the walls and floors, under loose plaster, and anywhere else they can nestle. They thrive in poor, man-made housing—areas of poverty. Therefore, the biggest risk factor for contracting Chagas, other than living in an endemic area, is being impoverished (Moncayo and Ortiz Yanine 2006). For these reasons, Chagas exists almost exclusively in the poorer provinces of El Chaco, Jujuy, La Rioja, Salta, and Santiago del Estero.

Results

An analysis of the incidence per 100,000 of Chagas during and after the epidemics does not reveal a decrease in the number of new cases per year: there were 2.3 new cases per 100,000 in 1993, 0.4 to 0.65 new cases per 100,000 from 1994 to 2004, a peak from 2005 to 2008 with 0.75, 1.3, 0.8 and 1.2 new cases per 100,000 per year, respectively, before the incidence returned to 0.45 to 0.6 per 100,000 from 2009 to 2013 (**See Figure 13**). The average number of new cases per 100,000 during epidemic years 1993-2006 was 0.701; that figure dropped to 0.650 for the years 2007-2013 (**See Table 8**). With no major interventions for this disease, no t-test was performed.

Discussion

Chagas is so common in the poorer provinces of Argentina that it is still considered an epidemic; the incidence of Chagas is not continually decreasing every year. There are many factors contributing to the continuation of this epidemic. There is no vaccine to prevent Chagas; the federal Ministry of Health (*Ministerio de Salud*), therefore, cannot mandate vaccination to try to prevent the disease. Each provincial board of health is responsible for public health interventions (Cavagnero, Carrin et al. 2006). The interventions have been inconsistent: in Amamá, a region of north-west Argentina where Chagas is, and has been, considered to be endemic, there had not yet been an insecticide spraying done by official control services in 1993 (Gürtler, Petersen et al. 1994). A study found that nearly 90% of homes in that area were infested at the time (Gürtler, Petersen et al. 1994). Efforts to prevent *T. cruzi* infestations in northern Argentina have not been overly successful in recent years. Other studies have found that spraying infested dwellings with pyrethroid insecticides can be effective, but is useless without continued monitoring (Rassi and Marin-Neto 2010). Argentina has encountered this exact problem. There have been insecticide sprayings in the dry Chaco region, but the bug continues to infest the sprayed areas as there is no community participation or education (Cecere, Vazquez-Prokopec et al. 2006) which would be required to eliminate the pest. One study in Gran Chaco, Argentina, found that bug colony reestablishment was suppressed, leading to interruption in human transmission, following sustained, unsupervised, community-based interventions that emphasized community involvement and education (Gürtler, Kitron et al. 2007). However, these interventions have not come from each province's board of health, and the disease continues to thrive in epidemic proportions. It seems likely that this will continue until a control strategy similar in scope to that of HIV/AIDS is implemented throughout all of Northern Argentina.

Dengue

Background

Dengue is unique among neglected tropical diseases in that it is an acute disease—not chronic—and it can occur in three forms: dengue fever, dengue hemorrhagic fever (DHF), or dengue shock syndrome (DSS). Dengue fever is widespread globally and debilitating. With one third of the world's population living in areas considered to be at-risk, approximately 400 million people are infected annually (Centers for Disease Control 2014). Dengue is currently endemic in over one hundred countries and has potential to become a global epidemic because it is the fastest-spreading vector-borne viral disease (World Health Organization 2015). Argentina had not seen a case of dengue for 80 years until it was reintroduced in 1998 as a result of insufficient mosquito control (Natiello, Ritacco et al. 2008).

The symptoms to diagnose dengue include a high fever and at least two of the following: severe headache, severe eye pain, joint pain, muscle and/or bone pain, rash, mild bleeding manifestation, and low white cell count (Berger 2014). To diagnose dengue hemorrhagic fever or dengue shock syndrome, more severe and potentially deadly manifestations of the disease, health care professionals look for severe abdominal pain or persistent vomiting, red spots or patches on the skin, bleeding from the nose or gums, black stools, drowsiness or irritability, pale/cold/clammy skin, and difficulty breathing (Berger 2014). There are currently no vaccines to treat dengue, nor drugs to cure it. The only "treatments"—acetaminophen, hydration, rest—try to reduce the debilitating discomfort and prevent the infected patient from becoming dehydrated (Centers for Disease Control 2014). The virus incidence, globally, is approximately 5% per year, which can be broken down into 75% asymptomatic cases and 25% symptomatic cases. The symptomatic cases can be subdivided even further into the 98-99% that experience dengue fever, while 1-2% experience either dengue hemorrhagic fever or dengue shock syndrome, of which 0.5-5% die. All three subsets of the disease are caused by mosquito vectors *Aedes aegypti and Aedes albopictus.* Although the vectors have been identified, integrated vector control has been unable to prevent or stop an epidemic. New attempts at integrated vector control have included releasing "genetically modified, sterile mosquito vectors" (Choffnes and Relman 2011). However, this is not feasible in the low-income countries where the disease is endemic. In fact, low-cost vector-control measures have also proven to be ineffective.

Bed nets, though useful at combating malaria, do not prevent dengue as the dengue-causing mosquitoes bite during the day, not at night (Maron 2013). Attempts have also been made to create vaccines that encapsulate all four distinct but related serotypes of the disease—DEN 1, DEN 2, DEN 3 and DEN 4—which has been extremely difficult. These four serotypes complicate the disease by causing more severe forms of dengue after the first infection with one serotype (Idrees and Ashfaq 2013). Therefore, a vaccine to prevent dengue seems highly improbable; the vaccine would have to work against all four different serotypes.

Results

An analysis of the incidence per 100,000 of dengue during and after the epidemics does not reveal a sustained decrease in the number of new cases per year: there were 4.59 new cases per 100,000 in 2000, a peak with 8.77 cases per 100,000 in 2004, a return to 0.11 to 0.50 cases per 100,000 from 2006 to 2008, and then a massive outbreak in 2009 with 71.06 cases per 100,000, and a smaller outbreak in 2013 with 23.18 cases per 100,000(**See Figure 14**). The average number of new cases per 100,000 during epidemic years 2000-2013 was 8.15; that figure was 0 in 1999 (**See Table 9**). With no major interventions for this disease, no t-test was performed.

Discussion

Dengue is a complex, mosquito-borne disease. Even if a vaccine were to prevent its onset, it would not necessarily be completely effective, as has been the case with a similar disease: malaria. Another mosquito-borne disease, malaria has been extremely deadly around the world. Attempts at making a vaccine have actually proven deleterious: when using an imperfect vaccine against malaria, the more virulent pathogens are selected for, and while those who are vaccinated might be protected, those who are not vaccinated can end up with an even more severe form of the disease (Gandon, Mackinnon et al. 2001). Vector control has shown to be the most effective way to prevent these kinds of vector-borne diseases.

The problems related to preventing dengue are similar to those of preventing Chagas: there is no vaccine to prevent dengue, and each provincial board of health performs its own public health interventions, which are not necessarily consistent with each other (Cavagnero, Carrin et al. 2006). While dengue had not appeared in Argentina for 80 years (Natiello, Ritacco et al. 2008), increased globalization in society likely would have changed that if insufficient vector control had not. One study noted that the conditions in Buenos Aires were perfect for dengue virus circulation because of its abundance of mosquitoes, population growth, and, perhaps most importantly, “deficient public health infrastructure and basic services (and) unregulated immigration from neighboring countries" (Natiello, Ritacco et al. 2008). An epidemic of a mosquito-borne disease is reminiscent of the yellow fever epidemic of 1871; public health investments in clean water and sewage, as well as a temporary ban on immigration, seemed to help contribute to the decrease in incidence of the disease (Veronelli and Veronelli 2004).

Dengue is extremely painful and can be very deadly. As dengue incidence is now on the rise, it seems imperative that a multi-faceted plan targeted at outreach and education—much like the public health strategy to control HIV/AIDS—spread throughout the country, before the vector *Aedes aegypti* does.

Chapter 5: Conclusion

Examining Argentina through the lens of infectious disease and public health elucidates many aspects of its history through the lenses of politics, public opinion, and medicine. Furthermore, utilizing a retrospective view with case studies as examples helps clarify the country's triumphs and failures in its attempts to control infectious disease. These public health interventions should be examined while creating and improving public health measures in Argentina, and elsewhere.

Argentina's history with immigration seems to have played a major role in its experience with infectious disease. In 1869, about half the population in Buenos Aires was foreign (Jankilevich 1999). This was thought to be a major contributor to disease, and immigration was temporarily suspended as a result of the peoples' demands during the yellow fever epidemic (Jankilevich 1999). It is understandable, however, that the people panicked during this time period. From 1872 to 1906, half of all the deaths in Buenos Aires were attributable to epidemic disease (Recalde 1993). The government tried to change immigration trends as well, by encouraging new immigrants to move out of the dirty city and into the countryside (Alsina 1898). However, it was the interventions in the realm of public health that really affected these diseases. With the introduction of a clean water supply and sewage system came a decrease in the annual deaths of cholera and yellow fever. With the mandate for vaccination in 1886 came a decrease in the annual deaths of smallpox and later the incidence of polio. With the widespread vaccination campaigns in 1966 to 1967, paid in part by the Pan American Health Organization and World Health Organization, came a decrease in the incidence of vaccine-preventable tuberculosis and diphtheria, which have not reached epidemic levels since. With the vast campaign to control HIV/AIDS, paid in part by the World Bank, through education, outreach, prevention reduction of stigma, came a decrease in the incidence of HIV and AIDS.

Argentina is extremely successful in overcoming epidemics of vaccine-preventable diseases and preventing further outbreaks, as demonstrated by its history with smallpox, yellow fever, polio, tuberculosis, and diphtheria. After the country mandated compulsory vaccination in 1886 and received financing to perform wide-spread vaccination campaigns, there have been few epidemics of vaccine-preventable infectious diseases (Pan American Health Organization 1950-2012). Globally, the implementation of a national immunization program has been one of the most successful strategies in preventing disease (Stecher, Gaiano et al. 2014) and Argentina, as a case study itself, supports this hypothesis. Argentina has demonstrated a sustainable model that could be implemented in other countries.

Argentina's experience with modern infectious disease is a direct result of the actions taken during the periods of historical infectious disease. Numerous public health interventions from centuries ago are still seen in action today. There is a federally-run Ministry of Health (*Ministerio de Salud*) and provincial health departments, which run their own respective public health programs. The Ministry of Health analyzes the extensive epidemiological data reported by each province about various illnesses, and uses this data to create public policy (Ministerio de Salud 2014). These serve as concrete examples of how non-medical interventions can change the health profile of a nation.

There are examples of modern infectious diseases that are still epidemic, including Chagas and dengue. These cases demonstrate some of the difficulties in attempting to control a disease that thrives in poverty, for which there is no vaccine or cure (World Health Organization 2014). Argentina's interventions have been insufficient thus far in controlling—let alone eliminating—the vectors *T. cruzi* and *A. aegypti*, some of the crucial first steps in lowering the incidence of the diseases they cause. These diseases show that public health interventions must be multi-factorial to be effective. With the success in the control of HIV/AIDS—a disease that is also common in impoverished areas and does not have a vaccine or drug—it seems that a similarly comprehensive, educational, goal-based public health intervention would be optimal for the control of Chagas and dengue.

This study analyzed the incidence of diseases following epidemics in a historical context. Limitations in this study included comparing total number of deaths instead of always comparing disease incidence. The population changes year to year, and that could affect the significance of the results. Furthermore, it is not possible to compare the control of all the diseases if they are not all viewed through the same frame of incidence per 100,000 per year. An additional weakness was the limitation in not being able to compare interventions to each other—the study was not framed in a way that one could conclude that Intervention A was more successful in lowering disease incidence than Intervention B.

There are many directions to turn for future research. A comparison of the incidence of each disease with the coverage of vaccination each year could shine some light into the effectiveness of vaccination alone in preventing infectious disease. Furthermore, a comparison of incidence before and after public health interventions could help clarify which policies are most effective in controlling disease, thereby helping policy makers decide how to invest in their attempts to control infectious disease.

Appendix

Smallpox

Table 1: Comparison of Years and Average Annual Deaths of Smallpox During and After Epidemics

Smallpox	Years	Average annual deaths
Epidemic	1868-1883	1308.75
Non-epidemic	1950-1965	7.60

This table shows the average annual deaths in Argentina for smallpox, compared between epidemic years 1868 through 1883 and non-epidemic years 1950 through 1965. Yearly breakdown of these epidemic deaths can be seen in Figure 1 and yearly breakdown of these non-epidemic deaths can be seen in Figure 2.

Data: (Penna and Ramos Mejía 1885),
(Pan American Health Organization 1950-2012).

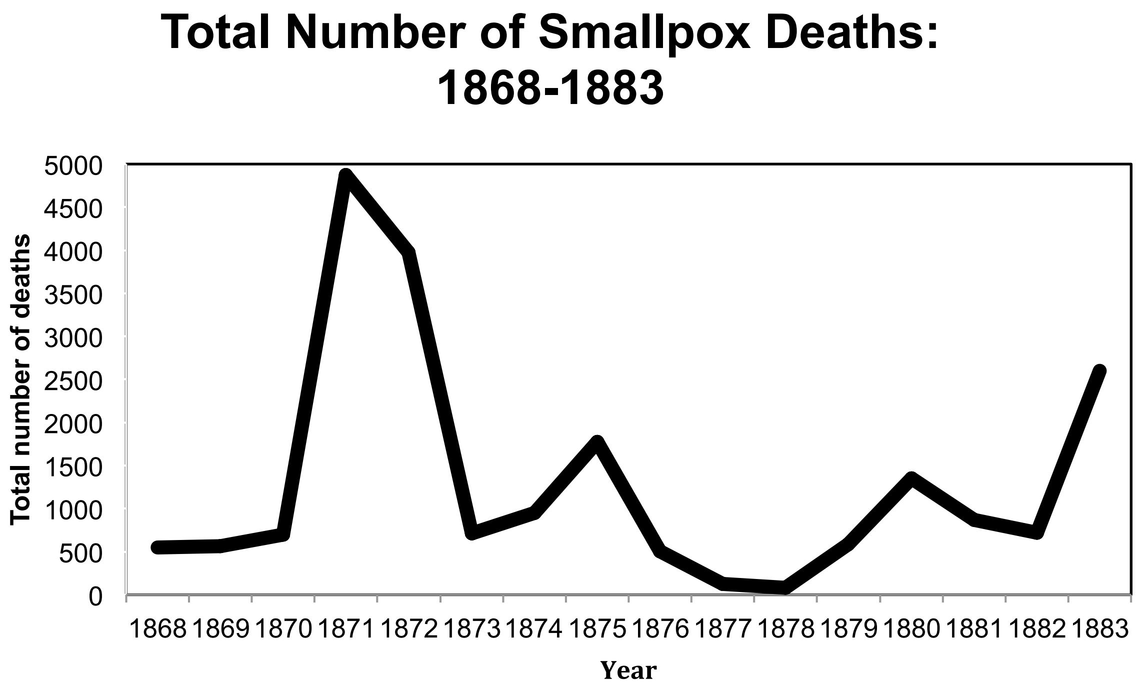

Figure 1. Total number of smallpox deaths in Argentina from 1868 until 1883.

This graph shows the total number of smallpox deaths in the country of Argentina per year during its epidemic period 1868 through 1883.

Data: (Penna and Ramos Mejía 1885).

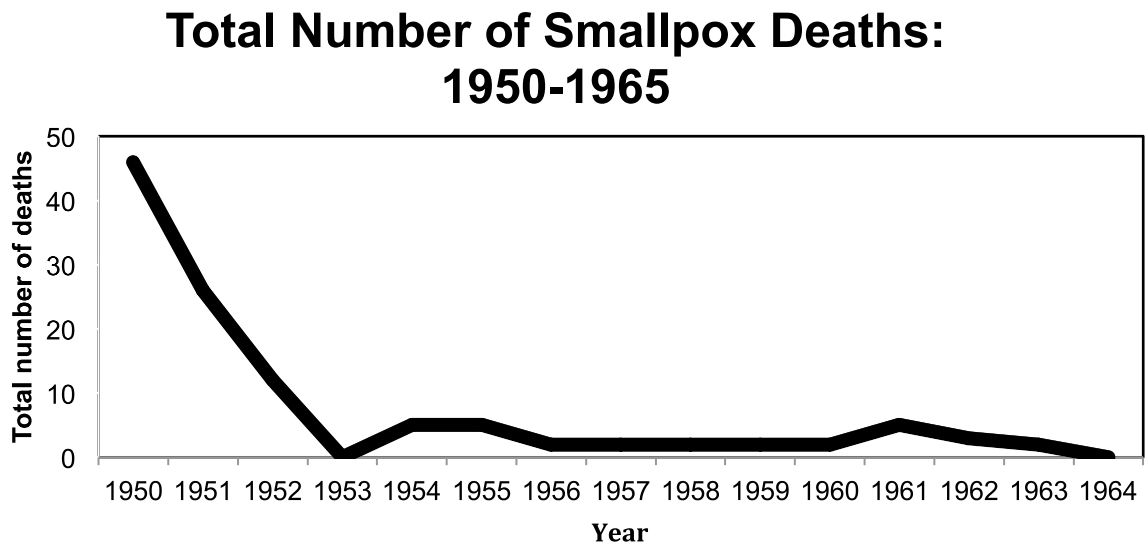

Figure 2. Total number of smallpox deaths in Argentina from 1950 until 1965.

This graph shows the total number of smallpox deaths in the country of Argentina per year during its non-epidemic period 1950 through 1965. The disease was eliminated from the country in 1966.

Data: (Pan American Health Organization 1950-2012).

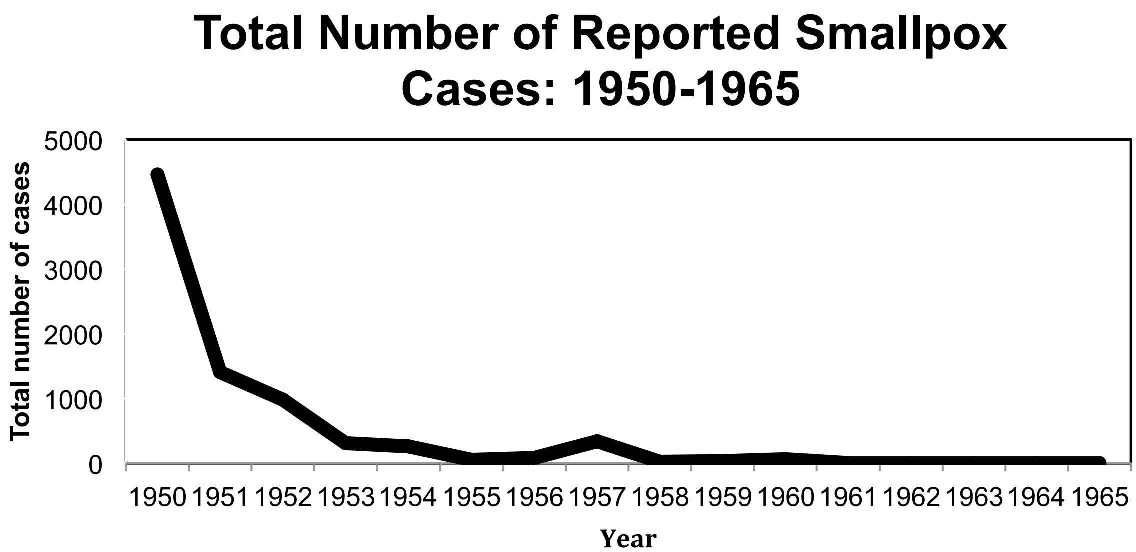

Figure 3. Total number of reported cases of smallpox from 1950 until 1965.

This graph shows the total number of smallpox cases reported in the country of Argentina per year during its non-epidemic period 1950 through 1965. The disease was eliminated from the country in 1966.

Data: (Pan American Health Organization 1950-2012).

<u>Yellow Fever</u>

Figure 4: "An Episode of Yellow Fever in Buenos Aires" (*"Un episodio de fiebre amarilla en Buenos Aires"*).

Painted by Juan Manuel Blanes in 1871, this chilling painting reflects the sentiment of the yellow fever epidemic at the time, depicting a young child draped over the body of his lifeless mother, as doctors look on. Another figure lies dead behind the door, presumably the child's father (Blanes 1871). http://es.wikipedia.org/wiki/Fiebre_amarilla_en_Buenos_Aires#/media/File:Juan_Manuel_Blanes_Episodio_de_la_Fiebre_Amarilla.jpg.

Table 2: Comparison of Years and Average Annual Deaths of Yellow Fever During and After Epidemics

Yellow Fever	Years	Average annual deaths
Epidemic	1870-1871	7,380.000
Non-epidemic	1872-1892	1.095

This table shows the average annual deaths in Argentina for smallpox, compared between epidemic years 1868 through 1883 and non-epidemic years 1950 through 1965. Yearly breakdown of these deaths can be seen in Figure 5.

Data: (Recalde 1993)
(Veronelli and Veronelli 2004).

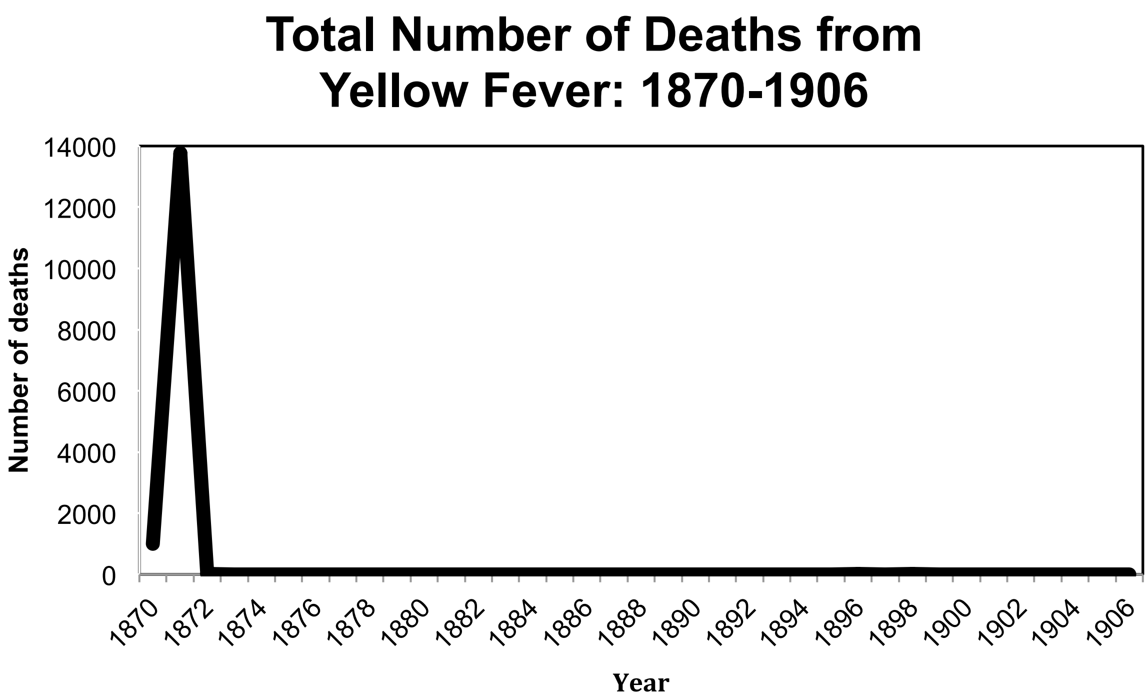

Figure 5. Total number of yellow fever deaths in Argentina from 1870 until 1906.

This graph shows the total number of smallpox deaths in the country of Argentina per year from 1870 through 1906, including its epidemic period from 1870 through 1871. The worst epidemic was considered to be in 1871 with 13,671 deaths.

Data: (Recalde 1993)
(Veronelli and Veronelli 2004).

Cholera

Table 3: Comparison of Years and Average Annual Deaths of Cholera During and After Epidemics

Cholera	Years	Average annual deaths
Epidemic	1867-1887	807.83
Non-epidemic	1888-1908	12.95

This table shows the average annual deaths in Argentina for cholera, compared between epidemic years 1867 through 1887 and non-epidemic years 1896 through 1916. Yearly breakdown of these deaths can be seen in Figure 6.

Data: (Álvarez 2012),
(Recalde 1993).

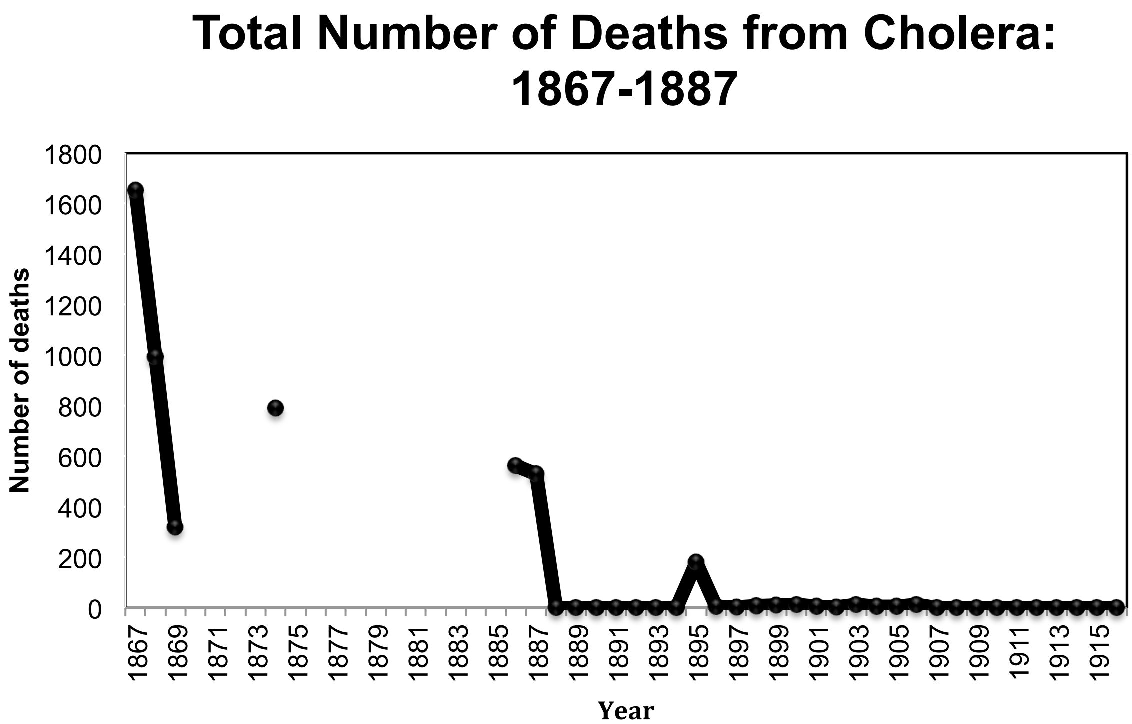

Figure 6. Total number of cholera deaths in Argentina from 1867 until 1887.

This graph shows the total number of cholera deaths in the country of Argentina per year, from 1867-1906, including its epidemic period from 1867 through 1887.

Data: (Álvarez 2012),
(Recalde 1993).

Polio

Table 4

Comparison of Years and Average Annual Incidence per 100,000 of Polio During and After Epidemics and Calculated P-value

Polio	Years	Average annual incidence per 100,000	p-value
Epidemic	1953-1966	6.700	
Non-epidemic	1967-1984	0.411	
			0.00143637

This table shows the average annual incidence per 100,000 in Argentina for polio, compared between epidemic years 1953 through 1966 and non-epidemic years 1967 through 1984. A major vaccination campaign with the help of the NGO *ALPI* began in 1967. A p-value<0.05 indicates a significant decrease in annual incidence. Yearly breakdown of these incidences per 100,000 be seen in Figure 7.

Data: (Pan American Health Organization 1950-2012).

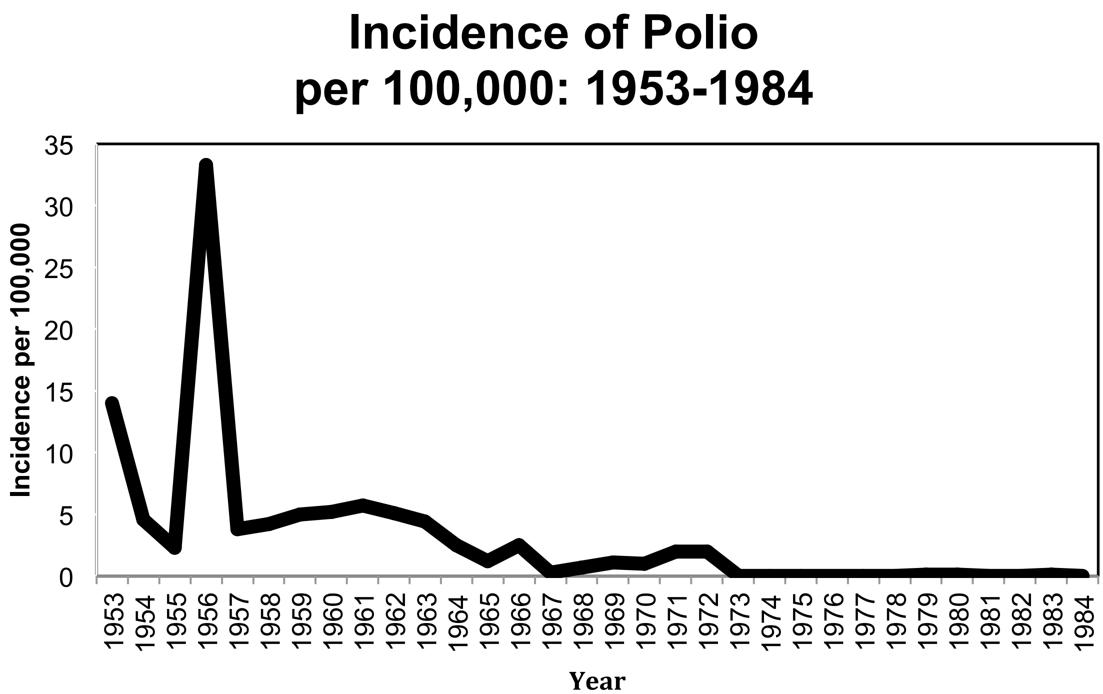

Figure 7. Incidence of polio per 100,000 in Argentina from 1953 until 1984.

This graph shows the incidence of polio per 100,000 in the country of Argentina per year from 1953 through 1984, including its epidemic period 1953 to 1966.

Data: (Pan American Health Organization 1950-2012)

Vaccination Calendar

Image redacted due to copyright restriction.

Please see

http://www.msal.gov.ar/index.php/component/content/article/46-ministerio/184-calendario-nacional-de-vacunacion-2014

Figure 8. Argentina's current Vaccination Calendar (*Calendario de Vacunación*).

Next to the title, the vaccination calendar says: The National Government guarantees free vaccines in health centers and public hospitals across the country. Along the vertical axis, the ages at which each individual should receive vaccines is listed: newborns; two, four, six, twelve, fifteen, fifteen to eighteen, eighteen, and twenty four months; five to six, eleven, and beginning at fifteen years; adults; pregnant women; postpartum; health care personnel. Along the horizontal axis, the chart detail the eighteen administered vaccines: BCG (Tuberculosis), Hepatitis B, Pneumococcal Conjugate (prevents Meningitis, Pneumonia and sepsis), Quintuple pentavalent DTP-HB-Hib (Diphtheria, Tetanus, Whooping Cough, Hepatitis B, Haemophilus influenzae b), Quadruple or Quintuple pentavalent, Sabin OPV (Oral Polio), MMR (Measles, rubella, Mumps), Influenza, Hepatitis A, Double Bacterial dT (Diphtheria, Tetanus), Human Papilloma Virus, Viral Double SR (measles, rubella), Yellow Fever and Argentine Hemhorrhagic Dengue. (Ministerio de Salud 2014) http://www.msal.gov.ar.

Tuberculosis

Table 5

Comparison of Years and Average Annual Incidence per 100,000 of Tuberculosis During and After Epidemics and Calculated P-value

Tuberculosis	Years	Average annual incidence per 100,000	p-value
Epidemic	1952-1967	88.61	
Non-epidemic	1968-1983	66.43	
			0.000000059

This table shows the average annual incidence per 100,000 in Argentina for tuberculosis, compared between epidemic years 1952 through 1967 and non-epidemic years 1968 through 1983. A massive vaccination campaign occurred throughout the country beginning in 1968. A p-value<0.05 indicates a significant decrease in annual incidence. Yearly breakdown of these incidences per 100,000 be seen in Figure 9.

Data: (Pan American Health Organization 1950-2012)

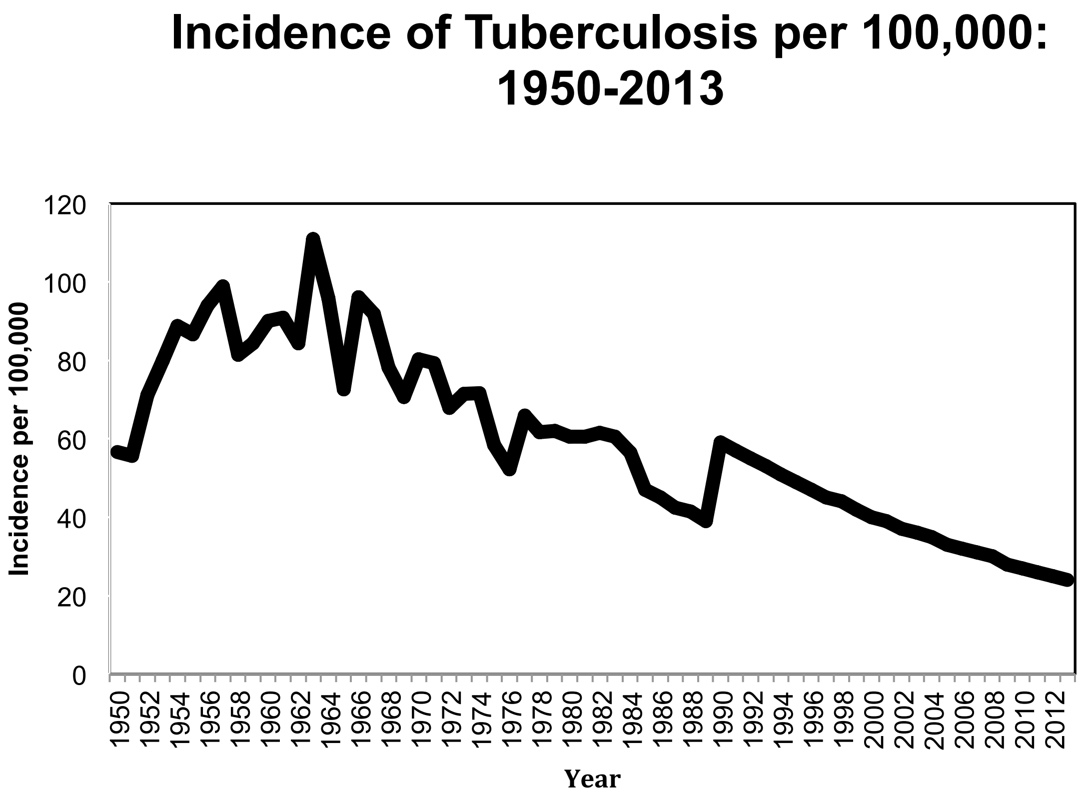

Figure 9. Incidence of tuberculosis per 100,000 in Argentina from 1950 until 2013.

This graph shows the incidence of tuberculosis per 100,000 in the country of Argentina per year from 1950 through 2013, including its epidemic period 1952 to 1967. Widespread vaccination campaigns began in 1968.

Data: (Pan American Health Organization 1950-2012)

Diphtheria

Table 6

Comparison of Years and Average Annual Incidence per 100,000 of Diphtheria During and After Epidemics and Calculated P-value

Diphtheria	Years	Average annual incidence per 100,000	p-value
Epidemic	1950-1967	12.094	
Non-epidemic	1968-1984	1.089	
			1.07E-13

This table shows the average annual incidence per 100,000 in Argentina for diphtheria, compared between epidemic years 1950 through 1967 and non-epidemic years 1968 through 1984. A massive vaccination campaign occurred throughout the country beginning in 1968. A p-value<0.05 indicates a significant decrease in annual incidence. Yearly breakdown of these incidences per 100,000 be seen in Figure 10.

Data: (Pan American Health Organization 1950-2012).

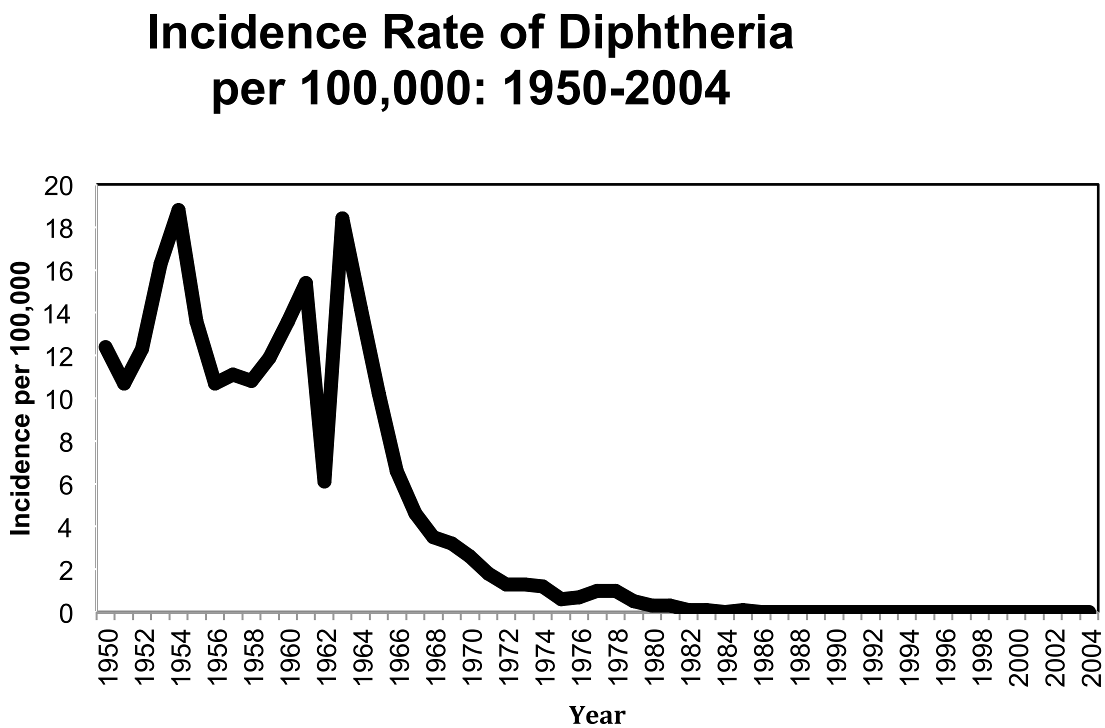

Figure 10. Incidence of diphtheria per 100,000 in Argentina from 1950 until 2004.

This graph shows the incidence of diphtheria per 100,000 in the country of Argentina per year from 1950 through 2004, including its epidemic period 1950 to 1967. Widespread vaccination campaigns began in 1968.

Data: (Pan American Health Organization 1950-2012).

HIV/AIDS

Table 7

Comparison of Years and Average Annual Incidence per 100,000 of HIV/AIDS During and After Epidemics and Calculated P-value

HIV/AIDS	Years	Average annual incidence per 100,000	p-value
Epidemic	1993-1998	7.16	
Non-epidemic	1999-2011	5.45	
			0.0065

This table shows the average annual incidence per 100,000 in Argentina for HIV/AIDS, compared between epidemic years 1993 through 1998 and non-epidemic years 1999 through 2011. The LUSIDA program was funded in 1997 and began to be implemented in 1998. A p-value<0.05 indicates a significant decrease in annual incidence. Yearly breakdown of these incidences per 100,000 be seen in Figure 11.

Data: (Falistocco, Manzur et al. 2013).

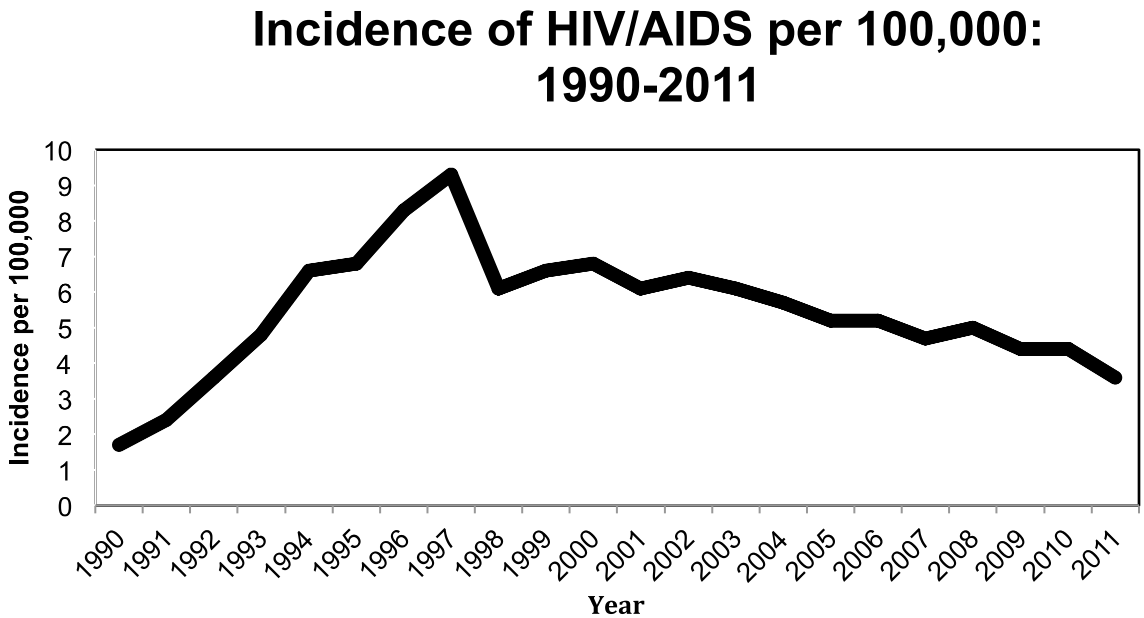

Figure 11: Incidence of HIV/AIDS per 100,000 in Argentina from 1990 until 2011.

This graph shows the incidence of HIV/AIDS per 100,000 in the country of Argentina per year from 1990 through 2011, including its epidemic period 1993 to 1998. Widespread education campaigns, made possible by a loan for LUSIDA from the World Bank, began in 1998.

Data: (Falistocco, Manzur et al. 2013).

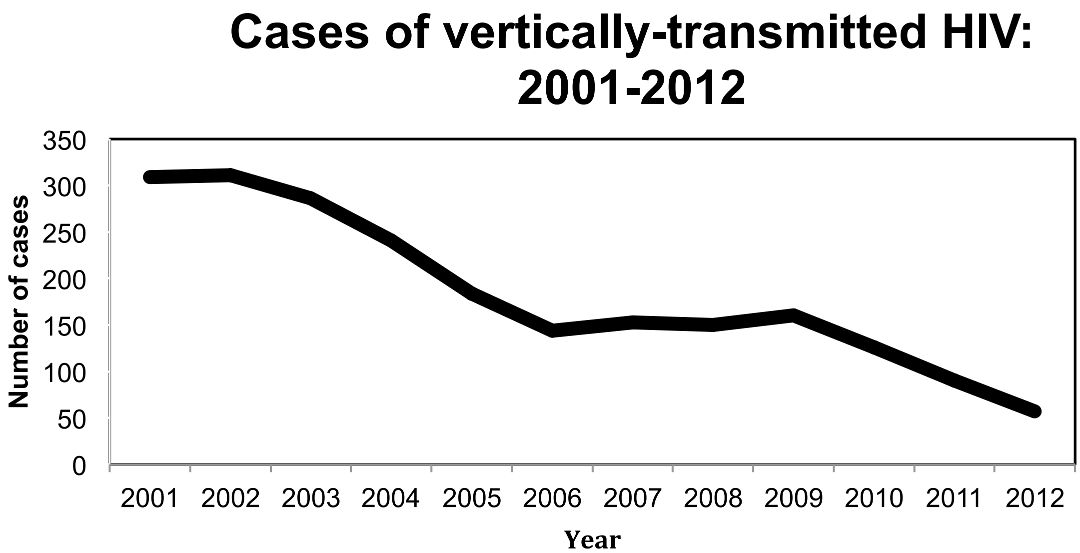

Figure 12. Cases of vertically transmitted HIV in Argentina from 2001 to 2012.

This graph shows the total number of cases of vertically-transmitted HIV in the country of Argentina per year from 2001 through 2012.

Data: (Falistocco, Manzur et al. 2013).

Chagas

Table 8

Comparison of Years and Average Annual Incidence per 100,000 of Chagas During and After Epidemics

Chagas	Years	Average annual incidence per 100,000
Early Epidemic	1993-2006	0.701
Late Epidemic	2007-2013	0.65

This table shows the average annual incidence per 100,000 in Argentina for Chagas, compared between early epidemic years 1993 through 2006 and late epidemic years 2007 through 2013. Yearly breakdown of the annual incidence values can be seen in Figure 13.

Data: (Berger 2014).

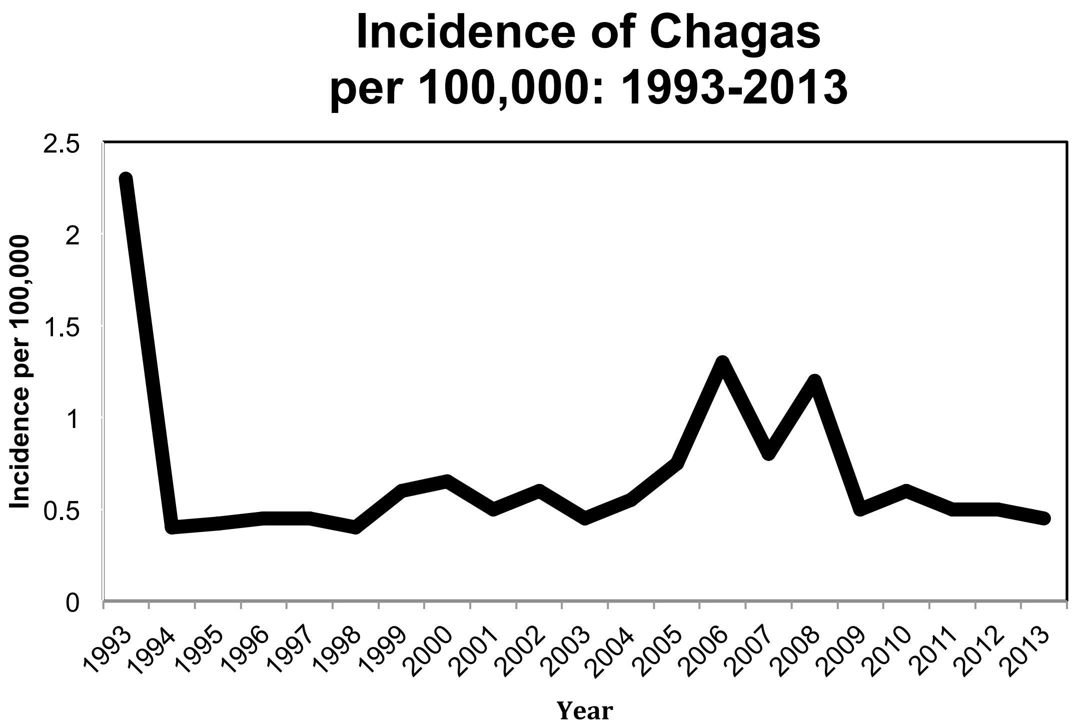

Figure 13: Incidence of Chagas per 100,000 in Argentina from 1993 until 2013.

This graph shows the incidence of Chagas per 100,000 in the country of Argentina per year, from 1993 through 2013.

Data: (Berger 2014).

Dengue

Table 9

Comparison of Years and Average Annual Incidence per 100,000 of Dengue During and After Epidemics

Dengue	Years	Average annual incidence per 100,000
Epidemic	2000-2013	8.15
Non-epidemic	1999	0

This table shows the average annual incidence per 100,000 in Argentina for dengue, compared between epidemic years 2000 through 2013 and non-epidemic year 1999. The *Aedes aegypti* mosquito vector was reintroduced into the country in 1998, following 80 years of elimination. Yearly breakdown of the annual incidence values can be seen in Figure 14.

Data: (Pan American Health Organization and World Health Organization 1999-2013).

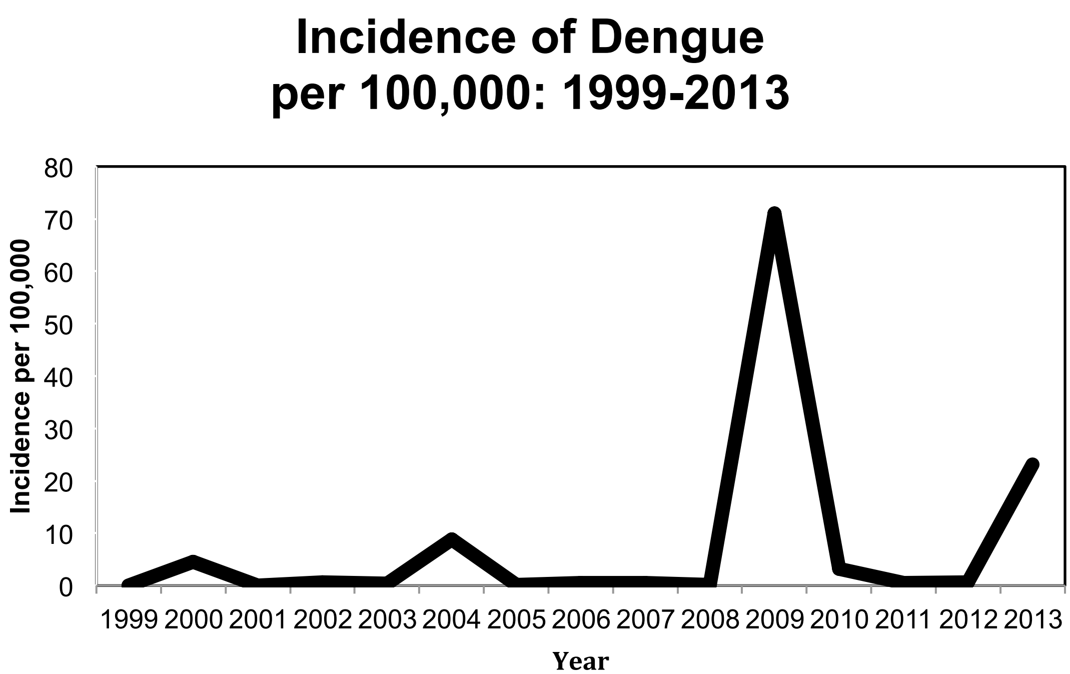

Figure 14: Incidence of Dengue per 100,000 in Argentina from 1999 until 2013.

This graph shows the incidence of dengue per 100,000 in the country of Argentina per year, from 1999 through 2013.

Data: (Pan American Health Organization and World Health Organization 1999-2013).

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