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PLAGUE AND YELLOW FEVER:

UNLIKELY OUTLAWS BEHIND THE CRISIS AND RESHAPING OF

RIO DE JANEIRO IN THE EARLY 1900's

by

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Abstract

PLAGUE AND YELLOW FEVER: UNLIKELY OUTLAWS BEHIND THE CRISIS AND RESHAPING OF RIO DE JANEIRO IN THE EARLY 1900s

Annette Cameron Blum

In Third Plague Pandemic history, there is a clear pattern of global response. News that plague had arrived was greeted routinely with denial, delay, and appeal to outside experts. But it was not the case in Brazil. Indeed, Brazilians acted so promptly against plague, that one asks why. This thesis takes the position that decisiveness by Brazilian authorities was due to an exhausting experience with yellow fever, a disease endemic to Brazil during the previous fifty years. Experiments to discover the yellow fever microbe had transformed a generation of young microbiologists. When added to political pressure to clean up the capital city and fear of damage to the port's reputation, this new level of medical expertise in Rio de Janeiro created an opening. To Brazilians, plague's timely entrance provided a convenient impetus for change. From these conditions, Rio's success in battling disease, and its simultaneous urban renewal is best explained.

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Mudam-se os tempos, mudam-se as vontades

Mudam-se os tempos, mudam-se as vontades,
Muda-se o ser, muda-se a confiança;
Todo o mundo é composto de mudança,
Tomando sempre novas qualidades.

Continuamente vemos novidades,
Diferentes em tudo da esperança;
Do mal ficam as mágoas na lembrança,
E do bem, se algum houve, as saudades.

O tempo cobre o chão de verde manto,
Que já coberto foi de neve fria,
E em mim converte em choro o doce canto.

E, afora este mudar-se cada dia,
Outra mudança faz de mor espanto:
Que não se muda já como soía.

(Time changes, and our desires change. What we
believe - even what we are - is ever-
changing. The world is change, which forever
takes on new qualities. And constantly,
we see the new and the novel overturning
the past, unexpectedly, while we retain
from evil, nothing but its terrible pain,
from good (if there's been any), only the yearning.
Time covers the ground with her cloak of green
where, once, there was freezing snow - and rearranges
my sweetest songs to sad laments. Yet even more
astonishing is yet another unseen
change within all these endless changes:
that for me, nothing ever changes anymore.)

by Luís Vaz de Camões

(translated by William Baer)

"Diseases are not neutral," wrote Mary Elizabeth Wilson in a forum in the journal *Epidemiology* in 1995. She continued, "Plague wields a power that is disproportionate to the deaths that it causes. Plague has taken on meanings: Black Death, moral decay, social destruction, and pestilence" (Wilson 1995, 459). Listing major infectious diseases of the twentieth century, including influenza, which had far worse mortality than plague, Wilson explained, "Plague means more than plague, whereas influenza means less than influenza" (Wilson 1995, 459). Traditionally, people felt powerless in the face of plague, and the terror, as well as the disease itself, caused people to flee, to deny, and to suffer. Crops were neglected and dead bodies were thrown into pits, as social breakdown followed plague, its effects lingering for years. Such has been the power and reputation of plague. Suppose for a moment that a society could harness the power of plague and not be defeated by it, that authorities armed with knowledge and expertise could channel fear into useful action rather than paralysis in the face of this disease. This thesis will ponder how medical and government authorities in Brazil responded to the entry of plague into their country in 1899, what tools they used, and what previous experience they brought to the fight.

I. Third Pandemic of Plague Rounds the World, 1894-1899

The Third Plague Pandemic erupted in 1894, a time when medical scientists had made considerable progress in tackling smallpox and cholera, but were unsuccessful in understanding yellow fever, a terrible disease of the tropics. As it would turn out,

breakthroughs in understanding both plague and yellow fever were imminent. Even so, over the next five years, until 1899, yellow fever-weary Brazilians would now watch as a new epidemic, the plague, moved closer to their country.

Scholar Myron Echenberg, writing in 2002, describes the Brazilian government's response to the arrival of plague in its capital, Rio de Janeiro, in January 1900, as "energetic and swift" (Echenberg 2002, "Pestis Redux" 446). Yet the typical response to plague in countries with contemporaneous outbreaks in 1899-1900, Portugal, Paraguay, Argentina, and the United States, was to deny, to waste time, to blame others, and to require outside experts to diagnose the disease and try to save face. In Brazil, government, whether on the local or national level, responded quickly, used highly trained, native expertise, determined and put in place effective anti-plague procedures, and manufactured serum and vaccine in country. An immediate result was the creation of public health institutions. A deeper effect was the plague crisis' impact on an already ongoing discussion in official and medical circles about yellow fever, which had been entrenched for half a century. Plague came ashore in Brazil at a critical paradigm shift in thinking about disease, from a problem of contagion to a problem of insect vectors.

In this paper, I will argue that what caused Brazilians to act so promptly against plague was their exhausting prior experience with yellow fever. In the fall of 1899, when plague cases first turned up in the Brazilian port of Santos, in São Paulo state, and in the beginning of 1900, when the disease arrived in Rio de Janeiro, authorities were on the cusp of a new concept of vectored disease (Appendix A). Within three years, effective anti-rat and anti-mosquito campaigns were being carried out, and the national and local governments in Rio de Janeiro had begun a radical reform of the city itself. By 1907, a

large, chronically diseased area of the city had been cleared and totally rebuilt, and its previous inhabitants had been pushed away from the port to the hillsides. A new grand avenue, lined with tall buildings, with four lanes and a tree-planted median, had slashed directly through the city, and new infrastructure was now in place. All this happened concurrently with efforts to fight yellow fever and plague. The change was so dramatic that in 1908, an Exposition was held on the outskirts of Rio de Janeiro, showcasing Brazilian progress.

The story begins with the spread of plague to South America, follows with diagnosis of the plague in Santos, and then considers the struggles over yellow fever during the previous twenty years, which prepared the ground for the idea of mosquito vectors. The plague crisis of 1900 in Rio de Janeiro and concurrent breakthroughs in the science of yellow fever will be examined next. The uniqueness of the Brazilian response in turning what might have been a disaster into an opportunity is heightened as government actors in Rio de Janeiro seized the opening to put in place large urban renewal projects, with a celebration to top it off. Authorities in Brazil were able to mount an effective attack on plague, to root out diseases in their capital city, to modernize it, and to create new public health institutions all in a period of eight years. There are lessons to be learned in this success.

Yersin, Haffkine, and Simond: 1894-1898

The First Pandemic, known as "Justinian's Plague," erupted in 542 C.E. in the Byzantine Empire and continued in the eastern Mediterranean region through the eighth century (Echenberg 2007, 4, 92). First noticed in Central Asia, the Second Pandemic,

nicknamed "Black Death," was brought to the Mediterranean from the region around the Black Sea via maritime routes in 1347, and from there it spread throughout Europe in waves over the next five years, killing up to half of the Europe's population (Echenberg 2007, 4). Subsequent outbreaks continued in Europe until the last one was recorded in Marseilles in 1720. Second Pandemic plague continued to trouble central Asia and the borderlands between the Russian and Ottoman Empires, causing an epidemic in Moscow in 1770, before tapering off in the Ottoman Empire in the mid-nineteenth century.

The Third Plague Pandemic began somewhere in Yunnan province in Western China around 1890 (Harrison 2012, 175) and reached the mouth of the Pearl River in the spring of 1894, breaking out in Canton, and thence to British Hong Kong, causing 2,552 deaths (Echenberg 2007, 314), thus bringing it to the attention of Western governments and medical scientists. The Japanese government, very concerned, sent Shibasuburu Kitasato, who had studied under noted medical pioneer Robert Koch, to examine the disease. At the same time, Swiss-born Alexandre Yersin, having trained in Paris at the Pasteur Institute, came to Hong Kong to investigate the outbreak. Kitasato worked with an ample budget supplied by local Hong Kong authorities while Yersin did his research without funding (Risse 2012, 77). By the summer of 1894, both men had published claims to the identity of the plague bacillus, with Kitasato getting credit for his discovery of the bacillus on July 7, 1894. At the same time, Yersin posited that rats were a necessary link for the germ to spread, after noticing the same bacillus during his research to find the plague germ in lymph glands of dead rats (Risse 2012, 77; Butler 2014, 204). In 1896, in Hong Kong again, Yersin developed an anti-plague serum, which he tried on patients with some success (Butler 2014, 204). Many decades later, after changes to

taxonomy, Yersin was rewarded with credit for having isolated the plague bacterium, previously known as *Pasturella pestis,* (Risse 2012, 77), which has been known as *Yersinia pestis* since 1970 (Butler 2014, 203).

In 1897 Waldemar Haffkine developed a vaccine, beginning by testing a heat-killed plague culture on rabbits. Haffkine's vaccine was subsequently used widely in India (more than twenty million people received the vaccine) and was thought by many at the time to prevent infection (Butler 2014, 207). Though it was actually only moderately effective, it was still considered one of the tools to counter plague by contemporaries.

In 1898, working in India, Paul-Louis Simond proved the rat-flea transmission link in an experiment with rats in cages (Butler 2014, 204). Simond found plague bacilli in flea-bite marks on the skin of patients (Butler 2014, 204). He also found the plague germ in the stomachs of fleas that had bitten infected rats (Butler 2014, 204).

It is important to point out that the theory of mode of transmission of plague between flea vectors and rats, constructed over time, was not completely confirmed until 1906 (Harrison 2012, 184). Pasteurians, such as Yersin, followed the rat-flea connection, but sanitarians thought the bacillus rested in the soil. Still, since rats and fleas inhabited cities with terrible sanitation, cleaning up a city was the second official impulse, often carried out as oppressively as the first response to an actual plague crisis, a sanitary *cordon* or quarantine.

From Hong Kong to Portugal

While Kitasato and Yersin were competing to publish findings on the bacillus, steamships, heading east and west, left the port of Hong Kong, prior to the quarantine,

thus triggering plague's progress from port to port around the world. An epidemic in India in 1896-1897 caused 10,760 deaths in Bombay (Harrison 2012, 180-184, Echenberg 2007, 314). Newspaper accounts in Western papers tracked the progress of the disease from India, through the Persian Gulf, to Alexandria, Egypt, and the Mediterranean, and simultaneously around Africa and across the Pacific Ocean.

From Alexandria, shipments of rice, transshipped in London, also somehow brought plague to Portugal, coming in the spring of 1899. Porto's clean port status had been suspect in the view of the French government since June (Pontes 2012, 32). As Surgeon Fairfax Irwin, of the United States Marine-Hospital Service noted in a letter to the Surgeon General, "The salient point . . . is that the first 2 cases appeared about the 4th of June in the persons of 2 men living in a filthy den on the river front, these two being employed as laborers to unload vessels" (Irwin 1899 "Letter to the Surgeon General," 1655). Ricardo Jorge, Porto's the Chief Medical Officer, identified the first plague cases on July 6, 1899 (Pontes 2012, 14, 22, 31). Yet Portuguese governmental denials, handwringing and financial concerns about damage to commerce should the truth come out meant that news of the epidemic in Porto was kept quiet until mid-August. Coming too late to have prevented plague from spreading, the Lisbon government's announcement to the world on August 15, 1899 of plague in Porto (Pontes 2012, 31) shocked Brazil, considering its traditional connection to Portugal. By August 24 (Almeida 2014, 695), under pressure from France and Spain (Echenberg 2002, 447), the Portuguese government placed a tight military *cordon sanitaire* around Porto. Yet Portuguese denial persisted. Writing from Lisbon, on September 6, 1899, Fairfax Irwin, Surgeon for the United States Marine-Hospital Service remarked,

> In discussing the question of the importation of plague to the city of Oporto [sic], it is singular to find a large number of the educated people denying its importation altogether, and this is in the face of the rather clear history of the *City of Cork* and its cargo of rice (Fereiro and Irwin 1899, 1653).

Meanwhile, rumors, sensationalized in the press, placed the blame on refugees rather than on international commerce. A September 27, 1899 dispatch from London printed in *The Advertiser*, of Adelaide, Australia, led with the headline, "PLAGUE IN PORTUGAL GRADUALLY EXTENDING," adding, "the outbreak of the plague in Porto was traced to the rice brought thither by refugees who surreptitiously entered Spain in order to escape from plague-infested localities (*The Advertiser* 1899, "PLAGUE IN PORTUGAL," 5). In November 1899, back in the United States, Surgeon Fairfax Irwin reported to the Assistant Secretary of State, on the true cause.

> . . . the persons of 2 stevedores . . . which makes it highly probable that they were infected while handling cargoes . . . no cargoes come to Oporto direct from any of the known infected ports, but are all transshipped in English ports; . . . rice is unpacked, cleaned, and repacked in new bags, and placed in other vessels before going to Oporto. . . as to the method of infection, we have the following possibilities: Personal contact, infected cargo, rats, and . . . vermin. Here we may dispense with personal contact and also vermin, as ships to Oporto do not come up to the wharves or docks, but are unloaded onto lighters in the stream. . . . cargo . . . although it had been previously handled, was nevertheless infected, the stevedores in England having been fortunate enough to escape (Irwin 1899 "Plague Conditions at Oporto," 2212).

As this shows, it is important to point out that the rat-flea vector connection was not widely understood in 1899. An article in the *British Medical Journal* in 1900, referring to the risks faced by rat catchers, is still vague. It mentions vermin, but not specifically the flea, and reports "evidence that it is not the rat itself that is the major source of infection when a diseased rat is handled, but that the vermin which inhabit the rat are themselves inoculated with plague, and as vermin quickly leave a dead rat, the impregnated parasites getting on the clothing of the rat-catcher tend to

the diffusion of the disease" (*British Medical Journal* 1900, "Rats," 678). The notion of a vector can be seen forming, as the recommendation is for exterminating rats, but the process is still framed in terms of disinfection.

> It would therefore seem that the only method of killing rats which will do away with dread of their becoming a source of infection is by trapping them. . . . a slow process, and one which does not recommend itself to the ratcatcher, who is paid by "piecework." Even when the rat is trapped the trap should be immersed in a disinfecting fluid if the ratcatcher is being paid according to results, or the rat should be removed from the trap by tongs and burned immediately. The latter process, however, annuls payment by results, as even if the tail is kept as proof of the number caught it will become a possible source of infection by the vermin inhabiting it (*British Medical Journal* 1900, "Rats," 678).

This was cutting-edge knowledge in 1900; even less would have been understood the previous year, in 1899.

Opposed by physicians in the city, the sanitary cordon caused unemployment, food shortages, rioting and great suffering, trapping out-of-work, restless laborers from the countryside inside the city (Fereiro and Irwin 1899, 1654-1656). During the epidemic, plague foci were numerous, and houses identified as infected were being burned (Irwin 1899 "Letter to the Surgeon General," 1655). According to Surgeon Irwin, at first the *cordon* was tight, "The restrictions to travel leaving Oporto, as reported to me, are very severe" (Fereiro and Irwin 1899, 1653), but later he reported its porosity, "owing to the poverty of the soldiers and their inability to withstand the bribes offered them by the country people wishing to pass through" (Irwin 1899 "Plague Conditions at Oporto," 2213). Irwin concluded his final report on a pessimistic note, noting the disease's slow but steady progress westward. "So far, it seems that wherever plague has secured a foothold it has remained for an indefinite period, and often radical measures seem to have little influence upon its progress. In

this disease, of all others, it appears 'prevention' is the watchword" (Irwin 1899 "Plague Conditions at Oporto," 2213). Irwin had neatly encapsulated future strategies to fight the Third Plague Pandemic.

On the ground in Porto, Dr. Ricardo Jorge, using the so-called radical measures, had been leading the daily, often futile, attack for months against the plague, aided by European doctors who had come to study the outbreak and to assist. Irwin observed, "Many foreign physicians are going to Porto to study the plague clinically in almost every case, and not so much from the commercial and quarantine point of view" (Fereiro and Irwin 1899, 1653). During the crisis, one hundred thirty-two people died (Pontes 2012, 9), among them a noted Portuguese microbiologist, Dr. Luis da Câmara Pestana, and Dr. Ricardo Jorge, with threats on his life, had to flee from the chaos in Porto to Lisbon (Echenberg 2002, 447).

Official alarm in Europe and the United States was high at the time, and it could not then be known that the only major plague crisis in Europe would be in Porto. Fairfax Irwin worried on September 11, 1899:

> . . . there is no direct trade between Oporto and ports of India and China. All goods . . . from Eastern ports are transshipped . . . via one of five ports, viz, London, Liverpool, Bremen, Hamburg, and Rotterdam. Some vessels come here occasionally from Black Sea ports with corn . . . That the disease was imported no one . . . will doubt, but the exact manner of its importation will, I fear, never be known (Irwin 1899 "Letter to the Surgeon General," 1655).

These trade linkages made Europe much more vulnerable to plague than has been admitted in Third Pandemic literature. Other small outbreaks noted by experts and officials at the time occurred in 1899-1900 in ports as diverse as Glasgow (*British Medical Journal* 1900 "Plague in Glasgow," 675-676), London (*British Medical Journal* 1900 "Plague Scare," 678), Barcelona (Irwin 1899 "Plague Conditions at Oporto," 2212),

and Naples (Irwin 1899 "Letter to the Surgeon General," 1655), and there was concern over Marseilles and Toulon (Irwin 1899 "Plague Conditions at Oporto", 2211-2212). News of these small outbreaks or incidents, buried deep in the pages of medical journals, were later ignored or forgotten, while Porto was touted as the only port touched by Third Pandemic plague.

Stall tactics, understatements, and official denials by European authorities of the presence of plague, made governments across the Atlantic anxious. Porto's prominence in Portuguese and British trade to and from South America and the Caribbean, bearing goods that had originated from ports in the eastern Mediterranean and the Indian Ocean, goods that had been transshipped before reaching Portugal, put American ports at risk, especially in Brazil. Brazil, with its historic relationship to Portugal, barely had time to react.

News of Plague

When word of plague in Porto reached Brazil in August 1899, the government of Brazil took the immediate step of requiring, from August 1, that all ships departing Portuguese ports and the port of Vigo, Spain be quarantined for twenty days, and be disinfected (Nascimento 2011, 68). The president of São Paulo state, Dr. Fernando Prestes de Albuquerque, concerned for the economically vital city of Santos, increased the number of sanitary inspectors at the port, with orders to strictly enforce the rules (Nascimento 2011, 69). Following confirmation of reports of the existence of plague in Porto, which were received by telegraph in Brazil late on August 14 (Nascimento and Silva 2013 " 'Não é meu intuito estabelecer polêmica'," 1272), and on August 15 in

London, the Brazilian government extended the quarantine requirement on August 16 to ships originating in Spanish ports of La Coruña, Santander and Bilbao (Nascimento 2011, 69). Finally, on September 5, 1899, an official written confirmation from Portugal was received by the Brazilian government, which included the information that plague had been found in Porto since June 4 (Nascimento 2011, 69). The denials by the Portuguese government, then, the delays in notification, infuriated authorities in Brazil. For seventy days, ships from Portugal that were likely infected had been docking in Brazilian ports (Nascimento 2011, 69).

Plague in Paraguay

Rumors of plague in Paraguay were confirmed officially in mid-September 1899 (Nascimento 2011, 69). News of plague in Asunción, following the bad news from Portugal, caused great alarm, potentially threatening Brazil's agricultural wealth in the states of Mato Grosso and Paraná, rivers there forming part of the La Plata River basin along the unprotected border with Paraguay. On September 21, Brazil closed their ports to vessels from Paraguay (Nascimento 2011, 69).

Plague had first entered the La Plata river system on an Argentine coasting steamer, the *Centauro,* via a shipment of Indian rice that had been transferred from a Dutch sailing ship, the *Zeier,* in Montevideo, Uruguay (Appendix A). The *Zeier* had brought the rice from Rotterdam, inside a sealed hold, which when opened in Las Palmas, Canary Islands, had contained dead rats. On the way to Montevideo, two sailors had fallen ill, one dying (Moll and O'Leary 1940, "Introduction," 455). As the *Centauro* carried its cargo of rice up Rio de la Plata, stopping at Buenos Aires and further at

various ports on the way along Rio Paraná, dead rats were seen on board. Four sailors became sick, with three of them dying shortly after arriving at Asunción on April 26, 1899. The fatalities came on April 28 (Moll and O'Leary 1940, "Introduction," 455), prior to the first outbreak in Porto. The symptoms of the sick sailors were consistent with plague, though sometimes called by other names, and there was an effort to rule out yellow fever (Moll and O'Leary 1940, "Introduction," 455). Fifteen days later around May 13, a rat die-off was noticed in the Asunción customs warehouse, "creating a real nuisance" (Moll and O'Leary 1940, "Introduction," 455), and during the summer, cases of a strange illness spread among nearby scattered houses (Moll and O'Leary 1940, "Introduction," 455). It was almost certainly plague.

In August thirty-seven soldiers in Asunción got sick. Authorities burned their quarters, in a run-down area outside of the central city, to disinfect them. For the first time a plague diagnosis was recorded, this coming at the Military Hospital (Moll and O'Leary 1940, "Introduction," 455). The disease spread from Asunción to villages along the railway line leading from the city (Moll and O'Leary 1940, "Introduction," 455-456) as people fled. The Argentine minister in Paraguay sent for two bacteriologists from Buenos Aires to come to Asunción, where they diagnosed cases of bubonic plague on September 14, 1899 (Moll and O'Leary 1940, "Introduction," 456). After some resistance, the government in Paraguay appointed a commission to study the plague outbreak (Moll and O'Leary 1940, "Introduction," 455). By the end of the year, between eighty-nine and ninety-nine people had died just in Asunción, not counting scattered deaths outside the city; by the end of February, 1900, there would be fourteen more (Moll and O'Leary1940, "Introduction," 456).

Boat traffic, meanwhile, had brought plague back downriver to ports in Argentina, spreading to various provinces. Cases appeared, beginning in September 1899 (Moll and O'Leary 1940, "Introduction," 456), around the same time plague was being diagnosed in Asunción. The disease had been traveling in the La Plata River system since April before being identified officially on September 14, 1899. As in the case with the plague in Porto, there was considerable lag between the arrival of the disease and official diagnosis and notification. If this was the pattern with plague, Brazil was the anomaly.

II. Plague Comes to Brazil

As it happened, with steamboat shipping connecting European industrial economies to markets around the world, it was impossible for South America to have escaped the Third Plague Pandemic. Many species of fleas, rodents and other small mammals in the continent were now exposed for the very first time to this disease. One can guess at the damage to the wild, using twenty-first century understandings unknown in 1899 about ecological systems confronted by invasive species. The human mortality in South America, though not in the same numbers as in Asia, nevertheless caused fear and panic in anticipation, which helped the disease to spread.

With plague, the nightmare is not simply the sickness, but the loss of commerce and social disruption that has historically ensued. Brazilian officials were horrified at the probability of plague entering the country, a fear that was understandable. Contact with Europe for centuries had been limited to annual arrival of the Portuguese fleet. In the nineteenth century, periodic vaccination campaigns had countered the risk of smallpox. Asian cholera, first brought to Brazil in 1855, on board the Portuguese ship *Defensor*,

broke out in Belém, then spread south along the Brazilian coast to Bahía and to Rio de Janeiro, and from there into the interior (Cooper 1986, 470-471). The outbreak caused as many as one hundred sixty thousand deaths in the first year (statistics vary), and more in subsequent outbreaks (Cooper 1986, 483). By 1899, its transmission route now understood, cholera was less of a problem than at mid-century. Yellow fever, a most feared infectious disease, had been creeping for decades south along the coast of Brazil from the Caribbean. Arriving by sea in Rio de Janeiro in 1849, it was now endemic. After two decades of unsuccessful efforts to cure or prevent it, yellow fever remained an enigma at the turn of the century. Brazilian ports and coastal cities, repeatedly infected, had earned international reputations as unhealthy, unsanitary places to be avoided. As plague, an even older enemy of shipping than yellow fever, now approached Brazil, authorities feared that this disease would threaten, not only the health of the country, but its trade and prosperity as well.

Anticipating Plague

In September and October 1899, at the request of the governors of Mato Grosso and Paraná, the Brazilian federal government implemented a military *cordon sanitaire* in less well-guarded points along the Brazil-Paraguay border (Nascimento 2011, 69-70). That seemed to be enough, at the moment, since the plague in Paraguay was in the region around Asunción, not spreading widely at that time. The government also tried to stock up on the anti-plague serum invented by Yersin, the only remedy in use at the time, however problematical it was. Due to the epidemic of plague in Porto, only a limited amount of serum was available in Europe, and there was worry that its efficacy would

diminish with the time it took to transport it from Messina, Italy, to Brazil (Nascimento 2011, 70). Another avenue, potentially, was to procure serum from Uruguay, made from stronger cultures from Asunción, but the general director of public health in Montevideo withdrew the offer to send some to Brazil (Nascimento 2011, 70). He wanted to keep it in Montevideo should Uruguay face a plague outbreak. On October 14, frustrated by these efforts, the Brazilian government received news that plague cases were increasing again in the besieged city of Porto, and it closed all Brazilian ports to any ships leaving from its nearby deep water port, Leixões (Nascimento 2011, 70).

Meanwhile, in Santos there had been sightings of dead rats, the classic harbinger of bubonic plague, starting in early September 1899, around docks, warehouses, and nearby streets in the busy, filthy, and economically vital port. Santos was famous for its exports of coffee and other products from São Paulo state (Nascimento 2011, 70-71). Now the quarantines put in place meant delays in ships leaving port. Argument over policy erupted. Letters to the Rio de Janeiro newspaper, *Jornal do Commercio,* began to appear on August 24 and continued past mid-September, 1899 (Nascimento and Silva 2013 " 'Não é meu intuito'," 1272, 1274) with two doctors, each with an administrative role that concerned public health policy, debating. The two doctors ably summed up the thinking of the age, and their words merit looking at closely.

C*ordons Sanitaires* Debated

Jorge Alberto Leite Pinto, the Director of Hygiene and Public Welfare of the State of Rio de Janeiro, was pushing for a reduced delay in shipping, following the rules of the Venice Sanitary Conference. Jorge Pinto had been slugging it out in the papers with

Nuno Ferreira de Andrade, Director-General of Public Health, who favored a longer quarantine requirement of twenty days, supported by science (Nascimento and Silva 2013 " 'Não é meu intuito'," 1274). The Venice Sanitary Conference of 1897, of which Brazil was not a signatory, had stated that a government should promptly give notice if plague was discovered to be present in its borders, and had set a maximum period of ten days of quarantine for ships outbound from infected ports. This required vigilance toward passengers from infected or suspect ports and prohibited the import of certain goods from those ports (Nascimento and Silva 2013 " 'Não é meu intuito'," 1273). Upon learning of plague in Porto, Director-General Nuno de Andrade recommended strict measures to the Brazilian Minister of Justice and Internal Affairs. In view of the close trade relations with Portugal, the measures were applied on August 15, 1899. Besides the twenty-day quarantine requirement, items prohibited from being unloaded in Brazil included postal packages that concealed the contents, leather, used furniture and accessories, clothing not belonging to passengers, skins or animal remains, fruits or dairy products, and patchwork quilts or rags (Nascimento and Silva 2013 " 'Não é meu intuito'," 1273). The ten-day limit to quarantine was based on the work by French scientist Paul-Louis Simond, who had found that the incubation of the plague illness was no more than eight days (Nascimento and Silva 2013 " 'Não é meu intuito'," 1274).

Objecting to twenty days quarantine as excessive, Jorge Pinto also argued that the measure of quarantining all Portuguese and Spanish ports when only one port was infected was overkill (Nascimento and Silva 2013 " 'Não é meu intuito'," 1274). Restricted imports and excessive quarantines would only cause scarcity and high prices in Rio de Janeiro (Nascimento and Silva 2013 " 'Não é meu intuito'," 1275). Pinto, basing

his case on the Venice Sanitary Conference, held two years earlier, was in support of science only as it supported business; to Pinto, commerce came first (Nascimento and Silva 2013 " 'Não é meu intuito'," 1274). Here, Pinto reflected a prevalent free-trade liberalism that stated that government should not hinder or prejudice trade relations, and intervene only to help business, and not to cause tensions.

Nuno de Andrade turned Pinto's argument around by stating that Simond's experiments were on laboratory animals injected directly with plague, with the time extrapolated to humans, and since in real cases of human plague, it is not necessarily clear when the incubation begins, it would be more prudent to use a twenty-day period of quarantine to certify that a ship was clean. If proof were needed that ten days quarantine for plague was insufficient, one only needed to look to Portugal, a signatory of the 1897 Venice Sanitary Convention, which nevertheless had tried to conceal plague (Nascimento and Silva 2013 " 'Não é meu intuito'," 1276-1277). More reasons to favor stricter measures of the Brazilian Sanitary Regulation were to keep passengers from disembarking while plague germs might be incubating, or to prevent bringing the infection into a clean port.

This back-and-forth in the form of letters in the pages of the newspaper continued through September. Pinto, having first supported his argument on the results of Simond's laboratory experiments, and finding it countered, then made a pseudo-scientific claim, to support a shorter quarantine. Pinto claimed that a germ as terrible and frightening as plague could not possibly stay quiet while incubating slowly (Nascimento and Silva 2013 " 'Não é meu intuito'," 1278). For Pinto to use the fear of plague that went back to the Middle Ages to bolster his point for a reduction in the length of quarantine seems

startling, but it was based on the unspoken reality that Brazil had in recent memory indeed experienced terrible epidemics of cholera, smallpox and especially yellow fever. Other letter writers brought this up in the paper, stoking fear, in spite of the fact that the risk of mortality from Third Pandemic plague was vastly less, in 1899, than in the Middle Ages, due to scientific knowledge and observation (Nascimento and Silva 2013 " 'Não é meu intuito'," 1278).

Pinto kept trying to reinforce his basic point of view that the federal government was wrong to impose strict measures because of the damage to commerce, quoting Europeans who agreed with him. Nuno de Andrade wrote a long response, published in two installments on September 11 and September 13, 1899. Summing up Pinto's varied attacks, Andrade first suggested that Pinto, whose role was at the level of the state of Rio de Janeiro, had been shielding interests at the federal level who might not want to fight publicly with Nuno de Andrade, the Director-General of Public Health (Nascimento and Silva 2013 " 'Não é meu intuito'," 1279). Andrade then examined Pinto's quotes from the writings of Paul-Louis Simond, and discovered that Pinto had quoted Simond incorrectly. Instead of eight days being the maximum limit for incubation, Andrade pointed out that Simond had written that eight days was the shortest time needed for plague to incubate, both supporting the government's twenty-day quarantine restriction and other strict measures, and demolishing the opposing argument for ten days' quarantine in one blow (Nascimento and Silva 2013 " 'Não é meu intuito'," 1280-1281). Andrade drew support from a member of the Italian delegation to the Venice Sanitary Conference, who agreed with the position Brazil had originally taken on August 15, that if one port was infected, a country had the right to turn away ships from other ports. The

newspaper debate was over when the letters turned personal. Jorge Pinto accused Andrade of not being up-to-date if he was supporting an old fashioned sanitary regime, to which Andrade, on September 17, defended himself, writing that the value of Pinto's month-long series of letter attacks in the *Jornal do Commercio* amounted to saying that "there is nothing better than spilling human waste in the stream that snakes in the streets" (*não haverá nada melhor do que derramar os dejetos humanos no regato que serpeia em meio das ruas*), referring to raw sewage that frequently flowed in the streets of the capital (Nascimento and Silva 2013 " 'Não é meu intuito'," 1282).

This debate shows how controversially the sanitary measures were viewed. While Brazil's response to the advent of plague was swift, it was not met without resistance. In spite of these measures exercised by the Director-General of Public Health, Nuno de Andrade, plague arrived in the port of Santos on October 15, 1899. The immediate tools at hand, isolation of the sick and their families, and disinfection of premises (Nascimento and Silva 2013 " 'Não é meu intuito'," 1283), would have to be relied upon until new methods of combatting plague could be developed. Competing political positions, of whether government existed for the primacy of commerce or for public health, would continue to be debated, but in October 1899, anticipation yielded to the awful realities brought on by an outbreak in Santos.

For those in the political camp who had foretold of the injury to commerce that a twenty-day quarantine would bring, the delays in shipping, made worse by the arrival of plague in Santos, was not as bad as was feared at the time. In the previous year, the Rio 7's price of coffee on the Coffee Exchange in New York, a commodity exchange, had been battered down to 4.5 cents, due to market glut. The next year records showed the

actual upside of plague, as one economic observer noted later: "1899—The bubonic-plague boom temporarily halts the downward trend of coffee prices" (Ukers 1922, 734). While this was good news for coffee growers in São Paulo state, people living in Santos or in Rio de Janeiro in late 1899 might not have noticed that silver lining.

Plague in Santos

On October 15, 1899, cases of a peculiar illness with strange symptoms were reported in Santos (Nascimento and Silva 2013 "A peste bubônica no Rio de Janeiro'," 113). Local doctors summoned two experts from São Paulo, Adolfo Lutz, Director of the *Instituto Bacteriológico* (Bacteriological Institute) of São Paulo, and his Assistant Director, Vital Brazil, to examine these patients. At this point, one must consider the level of expertise, supported by institutions, which these men brought to the first cases of this mysterious illness.

In the 1890s, São Paulo had seen the emergence of academic and research institutions, which reflected the interests of an elite class of coffee growers in São Paulo state. The state economy at the time was based on agriculture worked by a paid, largely immigrant labor force, and on the expansion of exports, especially coffee, that were routed to the world via the São Paulo Railway and then through the port of Santos, and also on the interests of a growing class of businessmen and factory owners whose prosperity also depended on the health of the port.

Among these new institutions was the *Instituto Bacteriológico*, founded in 1893 after consultation with Louis Pasteur, and opened under the supervision by Felix Le Dantec (Schwartzman 1991, 84). When Le Dantec returned to France in 1893 after an

only four-month stay, which had been partly for the purpose of collecting yellow fever specimens for study. Adolfo Lutz succeeded him (Schwartzman 1991, 84 note 36). Lutz, first as vice-director, and then as director beginning in 1895, is credited with setting up a bacteriological laboratory that used the newest techniques (Schwartzman 1991, 84-85). Another institution was the *Instituto Vacinogênico* (Vaccinogen Institute), formed in 1892 to produce smallpox vaccine (Schwartzman 1991, 83-84). The state of São Paulo was ahead of the rest of the country in having, one, a public health service, two, a vaccination requirement, and three, public health outposts at various locations in this large state (Schwartzman 1991, 83-84). The *Instituto Vacinogênico* was notable for creating the first smallpox vaccines in Brazil that were not imported, even though Jenner's method of producing vaccines were well-known and in the public domain for nearly a century (Schwartzman 1991, 84 note 32).

By the end of 1899, São Paulo was becoming a center of higher learning. Besides being the location of the vaccine and bacteriological institutes, the region boasted the *Instituto Agronômico* (Agronomy Institute) (1887), which conducted research in agriculture, and new teaching institutions, the *Escola Politécnica* (Polytechnic School) (1893), *Escola de Engenharia Mackenzie* (Mackenzie Engineering School) (1896), and *Escola Livre de Farmácia* (Free School of Pharmacy) (1898) (Schwartzman 1991, 76). Representing their institutions, and a standard in bacteriology developed over two decades, but also representing the greater economic interests of an elite class behind the institutions, health officials, led by Adolfo Lutz, were tapped to diagnose the unusual disease outbreak in the city of Santos.

Vital Brazil brought to Santos a background in public health and clinical practice. After graduating from the *Faculdade de Medicina do Rio de Janeiro* (Faculty of Medicine of Rio de Janeiro) in 1891, Dr. Brazil worked as a sanitary inspector in São Paulo State and in campaigns against epidemics (Houssay 1966, 13) before practicing clinical medicine in the center-west of the state where he encountered the widespread problem of workers on coffee farms dying from cobra bites (Academia Nacional de Medicina 2017 "Vital Brazil"). In 1897, Vital Brazil joined the *Instituto Bacteriológico*, as a technician under the direction of Adolfo Lutz (Houssay 1966, 14), doing research on an anti-venom vaccine at the time of the October 1899 plague outbreak in Santos.

Applying the recent concepts of bacteriology derived from the work of Pasteur for the first time to an unknown disease in Brazil, Adolfo Lutz and Vital Brazil on October 18, 1899 concluded officially, after observing large infected lymph nodes (adenitis) in their patients, that the illness was, indeed, bubonic plague (Cukierman 1998, 15 note 3). Upon being notified, Dr. Epitácio Pessôa (Nascimento 2011 "Quando a peste aportou no Brasil," 7), Minister of Justice and Internal Affairs, decreed that all Brazilian ports be closed to ships originating in Santos, hoping to encircle the epidemic. He also informed the world that plague was now present in Brazil (Nascimento 2011 "Quando a peste aportou no Brasil," 7).

The Brazilian government, weighing the seriousness of the situation, wanted to confirm the diagnosis. Nuno Ferreira de Andrade, minister of the *Directoria Geral de Saúde Publica* (Directorate-General of Public Health) or DGSP, in which position he was also responsible for defense of frontiers from disease invasions, sent a young doctor, Oswaldo Gonçalves Cruz to Santos to investigate the outbreak (Nascimento and Silva

2013 "A peste bubônica no Rio de Janeiro," 113). Wasting no time, on October 22, 1899 Cruz, recently returned to Rio de Janeiro from three years' study and training in microbiology at the Pasteur Institute in Paris, traveled by night train from Rio to Santos, a distance of around 500 kilometers, arriving the next day.

At the same time, Nuno de Andrade also gave Dr. Pereira das Neves the task of discovering what was known about the origin of this plague outbreak in Santos. Pereira das Neves also took stock of the tools and sanitary devices that were available to state authorities (Nascimento 2011 "Quando a peste aportou no Brasil," 7). During his investigations, Pereira das Neves found evidence of there having been two rat die-offs in Santos: the first, coming at the end of July, and more sightings of dead rats during the second half of September (Nascimento 2011 "Quando a peste aportou no Brasil," 8). As there had been no rat extermination campaigns, the die-offs were signs of a contagious illness among the rodent population. Between these two epizootics, more children and adults had needed to consult the city doctor's office, complaining of either benign swollen glands, or of buboes, symptoms having been interpreted as either pernicious lymphatic fever or yellow fever (Nascimento 2011 "Quando a peste aportou no Brasil," 8). Pernicious lymphatic fever was one of a class of severe sudden-onset fevers common in Rio de Janeiro documented by the Brazilian physician João Vincente Torres Homem in his 1877 treatise (Torres Homem 1877, translated 1894). Yellow fever had come to Brazil in 1849 and had been causing urban epidemics for fifty years. As these fevers and were among the most common serious ailments at the time, physicians in Santos would have naturally concluded that patients were presenting with either of these two illnesses,

not a new disease invader from overseas. More suspicious than the human symptoms, however, was the uptick in cases concurrent with the rat epizootics.

Oswaldo Cruz

Arriving in Santos on October 23, 1899, Oswaldo Cruz met Adolfo Lutz, Director of the *Instituto Bacteriológico* in São Paulo, and Vital Brazil, his assistant, and others, including Emílio Ribas, Vitor Godinho, Eduardo Lopes and Luiz Faria. Cruz then proceeded to the *Hospital de Isolamento* (Isolation Hospital), where he set up a lab, using equipment borrowed from Lutz and Vital Brazil, until his own was brought by another train (Cukierman 1998, 6).

After diagnosing and treating plague victims in Santos during the previous week, Vital Brazil had developed early symptoms of the disease, so he was given a high dose of Yersin's anti-plague serum on the night of October 23, 1899 (Cukierman 1998, 12). Dr. Brazil's symptoms at first appeared to lessen, but the next day, he entered the Isolation Hospital. Dr. Brazil would become the first person stricken during the plague outbreak to be released. During this time, news of his illness was downplayed in the São Paulo papers, masking the danger (Cukierman 1998, 46).

In order to confirm the disease using bacteriological experimentation, Cruz conducted examinations of five patients. Most of these patients had been too long convalescing or had already been treated with Yersin's anti-plague serum, and consequently were not good subjects for bacteriological investigation (Nascimento 2011 "Quando a peste aportou no Brasil," 8). One patient, twelve years old, brought to the hospital on the night of the October 24, 1899 had headache, fever, chills, and painful

swelling of the ganglia in the groin and right thigh area (Nascimento 2011 "Quando a peste aportou no Brasil," 8).

With borrowed equipment and guinea pigs, Dr. Cruz began work. Taking a sample of swollen tissue from this patient, investigating it under the microscope, and inoculating a guinea pig with the sample, Cruz noticed that there were a large number of *coccobacilli* present. As the disease progressed, and then killed both the patient and the guinea pig, Cruz stated that the symptoms were consistent with those of septicemic plague (Nascimento 2011 "Quando a peste aportou no Brasil," 8). Cruz summarized his observations. First, from the patient, he had isolated *coccobacilli* with the same shape and characteristics as those described by Yersin as being plague. In doing so, Oswaldo Cruz confirmed from his lab experiments what Lutz and Brazil had determined clinically, that the disease in Santos was bubonic plague (Nascimento 2011 "Quando a peste aportou no Brasil," 9).

Working in the less-than-optimal conditions of the temporary lab in Santos, the researchers cultured and identified plague germs, and created serum, work that carried risks. As noted, Vital Brazil had contracted plague on October 23 (Cukierman 1998, 12), and was able to survive thanks to being immediately treated with anti-plague serum. Brazil left isolation and returned to São Paulo on November 4, 1899. Cruz also injured himself on a pipette at the end of his stay, and injected himself with serum out of caution (Cukierman 1998, 12). After a week in Santos, Cruz took the train to São Paulo, where he rested in a hotel until he had recovered (Cukierman 1998, 15 note 4). He returned to Rio de Janeiro on November 4 to report his findings to Director-General of Public Health, Nuno de Andrade (Cukierman 1998, 12).

Plague in São Paulo

The appearance of plague in Santos caused alarm, especially in the states of São Paulo, Minas Gerais, and Rio de Janeiro, regions connected in a triangle to São Paulo via rail (Appendix B) (Nascimento 2011 "La llegada de la peste al Estado de São Paulo," 81-82). The worry was that plague would follow the 86-mile route (Gelber 2013, 50) of the São Paulo Railway. The route began on a four-section cable railway powered by a stationary steam engine that zigzagged up to the top of a 796 meter (Gelber 2013, 51) escarpment, before continuing the trip on a conventional train across the fertile plateau of São Paulo state with its vast coffee farms and rail network. Like the steamships that carried plague around the world, this railway, inaugurated in 1867 and expanded in 1895 (Gelber 2013, 53), was a vital link to the port of Santos for agricultural exports, especially coffee. Like the steamship, the railway also offered an opportunity for the disease to further its spread.

Up to early November measures taken by São Paulo authorities with respect to the railway to halt plague's spread were the disinfection of baggage cars originating in São Paulo, and isolation of passengers who were suspected of being carriers (Nascimento 2011 "La llegada de la peste al Estado de São Paulo," 78). In Santos, sanitary officials used traditional tools: finding and isolating the sick, disinfection of or burning of houses and belongings, and disinfection of potential plague foci (Nascimento 2011 "La llegada de la peste al Estado de São Paulo," 78). A similar strict regime of disinfection and inspections was carried out for trains with inland destinations in Minas Gerais, trains from stations of origin in Rio de Janeiro and São Paulo, and at checkpoints along the routes. Minas Gerais had no cases of plague in this period (Nascimento 2011 "La llegada

de la peste al Estado de São Paulo," 81-82).

When in early November 1899, a case of plague was found in São Paulo, in a dwelling near the Sorocabana railway station (Nascimento 2011 "La llegada de la peste al Estado de São Paulo," 78), it was clear that even strict sanitary measures were not sufficient. In this case the house was destroyed. Shortly afterward, the São Paulo state government launched the first large-scale urban anti-rat campaign; the link between rats, fleas, and plague had been observed by Simond in India just the year before (Nascimento 2011 "La llegada de la peste al Estado de São Paulo," 78). It would be a two-pronged fight in São Paulo state, involving both the sanitary service and the general population. Poison was put down sewer and rainwater run-off drains, buildings where rats might breed were disinfected, as sanitary workers removed refuse from the streets during their rounds (Nascimento 2011 "La llegada de la peste al Estado de São Paulo," 78). The state government supplied poison and traps to people, encouraging them to kill rats, while newspapers framed the extermination effort in martial terms. The state health service, meanwhile, in a pamphlet it distributed to the population, warned people of the dangers of plague and of the necessity of killing rats and their fleas (Nascimento 2011 "La llegada de la peste al Estado de São Paulo," 79). It even shipped poison to inland towns (Nascimento 2011 "La llegada de la peste al Estado de São Paulo," 78). Topping off the war on rats, starting on November 5, 1899 the government paid people an incentive of 300 *reis* for each dead rat (Nascimento 2011 "La llegada de la peste al Estado de São Paulo," 79). Even in a city where public health had been emphasized for a number of years, the anti-rat effort in São Paulo was a vigorous campaign; by the end of November, 14,000 rats had been captured and incinerated (Nascimento 2011 "La llegada de la peste

al Estado de São Paulo," 80). With the anti-rat campaign in place, only one more case of plague each month was found in November or December, 1899 compared to thirty-two cases in Santos in the same period. Upping the ante, the government raised the incentive for dead rats to 400 *reis* (Nascimento 2011 "La llegada de la peste al Estado de São Paulo," 80). Authorities in the city of São Paulo, population 239, 820 in 1900 (Rider 1917, 191), and led by an elite educated in the newer fields of engineering, took a distinctly practical approach, and never experienced an epidemic of plague, rather only a handful of cases. By the time the first case of plague came to Rio de Janeiro, a city three times larger than São Paulo, in January 1900, population 691, 556 in that year, São Paulo had already used the latest science to successfully fight plague (Rider 1917, 191; Johnston, Akers and Edmundson 1910, 446, notes 2 and 3).

The Economics of Catching Rats in São Paulo in 1899

To put the reward of 300 *reis* per caught rat in perspective, some points about the Brazilian economy in 1899 should be noted. Inflation in Brazil had been increasing throughout the nineteenth century, peaking in 1890-1891 with an event known as the *Encilhamento* (Ónody 1960, 44). On a human level a sampling of salaries gives an idea of what 300 *reis* might have meant to a rat-catcher.

The *Encilhamento,* in the literal sense, refers to the last tug of the cinch of a saddle before a horse enters the racetrack, and to excitement among jockeys competing in the race (Ónody 1960, 44 n. 46, Angelo 2008, 1). In Brazil's Old Republic, then headed by its first president, Marechal Deodoro da Fonseca (1889-1891), *Encilhamento* referred to the provisional government's economic policy that attempted to answer the problem of

a shortage of cash in circulation (Angelo 2008, 1). Since the end of slavery by Princess Isabel's 1888 proclamation *Lei Áurea* ("Golden Law") and the recent abdication of the Emperor, Dom Pedro II, in 1889, and with an increasing influx of southern European immigrants to work in coffee fields, there was an immediate need for more money in the economy to pay laborers (Angelo 2008, 1). In 1890 the government divided Brazil into three monetary regions, in which banks were authorized to issue paper money guaranteed by public debt (Angelo 2008, 1-2). Many people seized the opportunity to found new banks. Three hundred sixteen banks were founded in Rio de Janeiro alone in 1890 (Ónody 1960, 44). With too much cash injected into the economy, the *milreal* fell in value. A spiral followed: inflation, bankrupt investors, expansion of credit, speculation, and bad loans by failed "ghost companies" that were still on the stock exchange (Angelo 2008, 2). Two major consequences emerged. First, expansion of credit helped spur industrialization (Angelo 2008, 2), with a new class of industrialist in the states of Rio de Janeiro and São Paulo exerting influence. Second, the large coffee plantation owners, who led the agricultural sector that underlay the Brazilian economy, demanded to retain their dominant place in the new power structure (Angelo 2008, 2).

Beginning in 1896 and continuing for two decades, the cost of living index in Brazil stabilized at four to five times its 1829 base level (Ónody 1960, 118). Regionally, higher inflation was in the states of Rio de Janeiro and São Paulo with the highest in the *Distrito Federal* (Federal District) of Rio de Janeiro (Ónody 1960, 70-71). According to a trade commissioner reporting from Brazil to the U.S. Embassy in London, "the very low price of coffee, the chief product of this part of Brazil, makes the people poor and reduces demand to a minimum" (*Consular Reports XV* 1999, 224: 2). For a crop so

important to the Brazilian economy, a glut in supply was keeping the price down (Hutchinson 1909, 530-531).

Coffee laborers' pay was calculated closely to the output. Recruited by the Brazilian government, half from southern Italy, whole families of immigrants, including women and children, worked in the coffee fields (Balderas and Greenwood 2010, 1310 note 9, Andrews 1988, 508, 517). Former slaves, having tried to bargain for better conditions, ended up working on farms in the northeast region of São Paulo state, where the soil was poorer and the land more rugged, or hired themselves out as seasonal or day laborers (Andrews 1988, 503).

Beginning in the 1870s, opportunities existed for Brazilian workers on the railroads, which had been first developed using foreign expertise and labor. A laborer rising to the rank of machinist in the 1890s had a monthly salary of as much as 200 *milreis* (Matoon 1977, 291). As the *milreal* was devalued, the salaries rose, and one could retire with a pension of half-pay (Matoon 1977, 291). A day laborer on the railroad in 1899 made 4.3 *milreis* a day and a lineman, two to three *milreis* (Matoon 1977, 291-292). Though some workers might advance from unskilled to skilled positions, wages were still very low. Railroads were an extension of the dominant plantation structure in which labor was not in a position to bargain (Matoon 1977, 292).

The trade commissioner from Brazil also reported on textile manufacturing, cotton textiles being the most mature industry in the country at the time:

> Wages at one of the largest and best managed mills are estimated . . . at 1 *milreis* (17.23 cents) per kilogram . . . or, roughly speaking about 500 *reis* (8.6 cents) per kilogram on coarse cloth and 1.500 *milreis* (25.65 cents) per kilogram on fine" (*Consular Reports XV* 1999, 14).

Immigrants, including women and children, worked in textile mills (Andrews 1988, 518) responsible for meeting a growing proportion of the domestic demand for Brazilian-grown cotton cloth (*Consular Reports XV* 1999, 206, 13).

Former slaves in São Paulo, the informal sector of urban workers, did odd jobs, such as hauling wood or domestic work (Andrews 1988, 505). It is not known who the rat-catchers were exactly, but any low-wage or informal worker would have been eager to make extra money chasing rats. Thus, a rat-catcher in São Paulo would have been paid in the customary manner by the piece, per rat. Earning 300 *reis* per rat, for one rat caught, a rat-catcher could buy a domestically made hat. According to the trade commissioner, "Rough straw hats made in the country of native straw and grass have a very large sale for workmen. A serviceable hat of this kind sometimes costs as little as 300 *reis* (5 cents)" (*Consular Reports XV* 1999, 8). This extra money was valuable. When the bounty for catching rats in São Paulo was raised to 400 *reis* in December 1899, there was an even greater incentive.

The anti-rat campaign in São Paulo in 1899 was organized quickly and authorities paid rat-catchers directly, giving these eager participants an important role in the fight against plague. A few years later, in Rio de Janeiro, this tactic would be more complicated. For now, in November 1899, the doctors gathered during the Santos outbreak had in mind another tool to reduce plague mortality: serum.

Importance of Serum

The three bacteriologists, Adolfo Lutz, Vital Brazil, and Oswaldo Cruz believed that the ability to manufacture anti-plague serum and even vaccine in the country was

critical. First, having easy access to new supplies of Yersin's anti-plague serum would increase preparedness (Nascimento and Silva 2013 "A Peste Bubônica no Rio de Janeiro," 113), since the virulence of the disease was yet unknown and very much feared at the time. During the Santos outbreak, supplies of serum had run short. In response to a telegram from the doctors in Santos requesting new supplies, received by Director Nuno de Andrade in Rio de Janeiro on October 24, 1899, Andrade had reported that he was sending fifty additional vials to Santos by train (Cukierman 1998, 43; note 11). Backed by evidence from the Santos outbreak that serum had saved some lives, Lutz, Brazil and Cruz argued that shortages of serum put the country at risk and that this required immediate remedy (Cukierman 1998, 43-44). Without a doubt, the three scientists also recognized the opportunity at hand to plant and grow the new science of bacteriology in Brazil (Nascimento 2011 "La llegada de la peste al Estado de São Paulo," 77).

Upon his release from the hospital, Vital Brazil, living proof that serum could help, returned immediately to São Paulo to the *Instituto Bacteriológico* to start planning for a laboratory to produce anti-plague serum, at the same moment that Cruz was on the train back to Rio de Janeiro to make the case for a similar laboratory there. Rodrigues Alves, governor of São Paulo State, provided space for the laboratory at the old Fazenda Butantã, located in the countryside nine kilometers west of central São Paulo on the banks of Rio Pinheiros (Academica Nacional de Medicina 2017 "Vital Brazil", Instituto Vital Brazil 2017 "História do Cientista"), which was quickly renovated as a facility for manufacturing anti-plague serum. In mid-November 1899 Vital Brazil was already working at the new temporary lab at Butantã, inoculating horses with plague, the first

step of the process of producing the serum (Nascimento 2011 "La llegada de la peste al Estado de São Paulo," 80), and within four months, the first batch of fresh anti-plague serum was ready (Academia Nacional de Medicina 2017 "Vital Brazil"). In 1901, Brazil was put in charge of a permanent lab, the newly created *Instituto Soroterápico de São Paulo* (Sorotherapy Institute of São Paulo) at Butantã, later known as *Instituto Butantã* (Butantã Institute), which developed vaccines and serums for common epidemic illnesses, as well conducting groundbreaking research on antidotes to the venom of tropical snakes and insects (Instituto Vital Brazil 2017 "História do Cientista"). In 1919, he moved to a lab in Niteroi, a city across Guanabara Bay from Rio de Janeiro, where he founded the *Instituto Vital Brazil* (Vital Brazil Institute) (Schwartzman 1991, 99 note 66) and he continued his scientific work there for many years, until his death in 1950. Concerning the plague in 1899, Vital Brazil is remembered for diagnosing it clinically, surviving it, and for his crucial role in establishing, in São Paulo, the first laboratory in the country to manufacture anti-plague serum. This achievement was followed shortly by Oswaldo Cruz' laboratory, founded near Rio de Janeiro at Manguinhos, about which more will be said.

Why? Quarantines and *Cordons*

By December 1899, after a spring in which plague had come ashore at Santos and had spread up the 796-meter escarpment of the Serra do Mar to the coffee-producing plateau and city of São Paulo, the minds of health authorities were now focused on the threat to the capital, Rio de Janeiro. Before recounting what authorities did to handle the plague crisis in the capital, or how the rapid Brazilian response was atypical, one needs to

ask why. Notwithstanding the risk such a strategy would pose to commerce, why did Director of Public Health Nuno de Andrade immediately impose a twenty-day quarantine period, effective retroactively, on the ports of Rio de Janeiro and Santos, when the international norm was ten days? His reaction being thus swift and strict, why did he then recommend against a *cordon sanitaire,* like one the Portuguese government had put in place around the city of Porto earlier that year?

III. Yellow Fever and Plague in Rio de Janeiro

In answer, it is necessary to appreciate the toll that fifty years of endemic yellow fever, beginning in December 1849, took on Brazil, especially on its principal port and capital, Rio de Janeiro. On July 23, 1898, Eugene Seeger, United States Consul-General in that city, transmitted a report entitled, "The yellow fever season in Rio de Janeiro," to the Hon. Assistant Secretary of State. The report began:

> The first appearance of yellow fever in Rio de Janeiro in December, 1849, undoubtedly constituted an event of graver importance than anything that has happened here before or since. From that time on this terrible scourge has exercised its pernicious influence on the development of the great Brazilian metropolis, which would otherwise be one of the most healthy of the world's great cities, as it certainly is one of the most beautiful (Public Health Reports 1898, 958-959).

The report traced the origin of the first outbreak to the American brig *Brazil*. This ship "from New Orleans, by way of Habana, brought the infectious microbes to Bahia (November 3, 1849), whence the disease was carried into Rio, and there are strong reasons to assume that those records do not state the whole truth" (Public Health Reports 1898, 959).

The report gave the total number of yellow fever deaths in Rio as "up to July 1 of this year, the death of not less than 54,461 of its victims, 939 since January 1" (Public Health Reports 1898, 959). Frustrated at the difficulty of obtaining accurate statistics, U.S. Consul-General Seeger continued,

> . . . the death rate among the yellow fever patients is very different in different years, even if the meteorological conditions are the same; but it is never as great as it appears from the public statistics. The law which makes it obligatory that every case of yellow fever should be reported to the medical authorities is frequently circumvented; the number of cases on record is therefore smaller than the actual number, consequently, the percentage of deaths apparently larger than in reality, although a considerable number of deaths from yellow fever is not reported or is classified under a less alarming caption (Public Health Reports 1898, 959).

That people would go to such lengths to conceal deaths from yellow fever shows the fear this endemic disease had been causing the citizens of Rio de Janeiro.

The report by Seeger continued by mentioning the greater risk to foreigners, stating that during the season, which is from December through May, most foreigners lived in the mountain suburbs, especially in Petropolis, elevation "about 2,500 feet above the level of the sea, in the Serra da Estrella" (Public Health Reports 1898, 959). Not only most of the diplomatic corps, but foreign businessmen made daily trips to the capital. Of the few diplomats who stayed in the city during this yellow fever season, the author mentions four who died: the Chilean minister and chargé d'affaires, the Haitian consul, and the chancellor of the French consulate (Public Health Reports 1898, 959). While this class of people is far from the class of immigrant coffee workers, all that seems to make a difference was being in a higher elevation. U.S. Consul-General Seeger concluded in his report,

> The permanent injury caused to Brazilian commerce, trade, immigration, etc., by the yellow fever is enormous . . . the local authorities are doing a great deal within

> their limited financial means and under the peculiarly difficult ethnological conditions to fight this plague. (Public Health Reports 1898, 959)

As this was written in 1898, months prior to the plague's arrival in Asunción or Porto, the "plague" he referred to in his report was not bubonic plague, but rather the only disease at that moment worthy of such a comparison, yellow fever. Yellow fever's relentless grip on the capital had been already reminding educated people of stories from Boccaccio's *Decameron,* only the mortality was very real.

Researcher and historian Jaime Larry Benchimol, writing in 1999, has analyzed sources on yellow fever mortality in Rio de Janeiro between 1850 and 1912. These numbers, summarized here, are only for the capital city, and do not cover other principal cities or the hinterland. During the thirty years from 1850 through 1879, yellow fever killed 26,191 people (Benchimol 1999, 430). The running total through 1889 was 35,567, through 1894 it was 50,731, and through 1899 it stood at 56,446 (Benchimol 1999, 430-431). At the end of the 1898 yellow fever season, total deaths were only slightly fewer, 55,715 (Benchimol 1999,431), still a higher number than the one given in the report transmitted by the United States Consul-General, Eugene Seeger in that year.

The worst five-year period was from 1890 through 1894, when yellow fever extinguished 15,164 people in Rio de Janeiro (Benchimol 1999, 431). In the same five-year period, smallpox killed 4,814, malaria killed 8,606, and tuberculosis killed 11,016 people in the city, bringing the total for all four epidemic diseases during this five-year period to 39,600 (Benchimol 1999, 431). Public health authorities, charged with protecting the country from disease and defending the port of Rio de Janeiro and hence the economy would be forgiven for feeling discouraged in 1895 when reports of bubonic

plague in Hong Kong began to circle the world in consular reports, telegrams, and medical journals.

Brazil's links with Europe in 1880 were strong, as the Second Industrial Revolution made trans-Atlantic travel by steamship more practical. Doctors who were educated in Brazil and had received medical training at one of Brazil's medical schools and who also wanted to become microbiologists traveled to Europe to study at the Pasteur Institute in Paris or to see the latest medical inventions in Germany. Brazil's emperor Dom Pedro II himself made trips to Paris at regular intervals where he met a number of scientific luminaries of the day. Letters, books, scientific journals and copies of reports, as well as laboratory equipment crossed the Atlantic by steamship.

In the waning days of the empire, as the coffee economy based in São Paulo and its expanding hinterland was becoming more important, immigrants from Europe crossed the Atlantic and disembarked in Rio de Janeiro before continuing to Santos. Part of a larger worldwide pattern of migration at the time, immigrants arrived with their worldly belongings, passing through quarantine stations when required, on ships that were blamed for the introduction of new diseases to Brazil. In addition, there was one tropical disease above the rest that immigrants arriving to work in coffee fields seemed more susceptible to than native-born Brazilians, yellow fever.

Yellow fever outbreaks were an annual event in Brazil, both on the coast and in parts of the interior, though some years stood out for their high mortality. The etiology of the disease, that it is a virus, was not yet known, at a time when microbiologists were identifying other deadly microbes under the best microscopes of the period, and were also focused on preventing death with vaccines. With yellow fever there was much

confusion, disagreement and debate about the cause of the disease, how it was spread, whether in the air or the water or person-to-person and how it could be prevented. The idea of a disease vector was still several years in the future.

The Geography of Rio de Janeiro and Yellow Fever

The local environment of Rio de Janeiro was a large factor in yellow fever's endemicity. Situated on a peninsula edged with hills that jutted east into Guanabara Bay, much of the old city was built nearly at sea level as small lagoons were filled in. At the point where the peninsula jutted out from the rest of the bay's coastline, there was a large mangrove swamp. Rising behind the swamp, abruptly steep mountains formed a backdrop. Frequent rainfall and a high water table meant that city streets would be periodically inundated with water flowing down from the hills. Where once mangrove trees naturally fringed the peninsula, these had long been cut, and in 1899 large waves from the bay often flooded stretches of naked waters-edge or the wharves. Rio de Janeiro's growing human population had been degrading the natural environment for years. Since most streets were not paved, tropical rainfall filled puddles and containers, stagnating, and creating ideal breeding grounds for mosquitos, unhealthy conditions that favored yellow fever outbreaks.

From the early eighteenth century, fresh water from mountain streams had been carried to the city by way of an aqueduct, and the water supplied public fountains, until replaced by other water sources in the late nineteenth century. Visitors and *cariocas* (natives of Rio de Janeiro) alike in the 1880s complained that the city was hot, humid, with overflowing drains and sewers, and narrow airless streets. Older important public

buildings and churches had been built on higher ground. In contrast, the streets close to the wharves were low-lying and narrow, lined with *cortiços* (tenements), where day laborers working at the docks and poor families lived in congested conditions. As the end of the decade approached, the condition of the city, filling up with ever more people, was a source of worry and embarrassment at how it presented Brazil to the world. Political pressure was building to clean it up. Unfortunately, since the transition to the new republic in 1889 and the economic effects of the *Encilhamento* were to postpone action for more than a decade, political will would only grow.

Microbiology

From 1880 to 1900 a new generation of scientists working in Rio de Janeiro, inspired by Robert Koch, Louis Pasteur, and the new germ theory of disease, made a huge effort to isolate the yellow fever microbe and to create a vaccine against it. One doctor, whose research on a vaccine caused two decades of controversy, was Brazilian researcher Dr. Domingos Freire. Freire rose to great prominence before being disgraced near the end of his life and expelled from the *Academia de Medicina* (Academy of Medicine). While Cruz would later use guinea pigs to confirm a clinical plague diagnosis, plague bacteria being quite visible under a microscope, Freire, twenty years earlier, used small animals with no control subjects to develop his theory of yellow fever, germs of which were still invisible through microscopes of the era and would be for decades to come. Freire could not know this, and expecting to see something, he convinced himself that he had seen the yellow fever microbe, which he named *Cryptococcus xanthogenicus* (Benchimol 1999, 32, 40) following a series of experiments

on a rabbit and two guinea pigs (Mississippi Valley Medical Monthly 1883, 366). As his method could only account for what he was able to see, he extrapolated a great deal from this experiment. After injecting blood infected with what he assumed was *Cryptococcus xanthogenicus* into a rabbit, and then the rabbit's blood into the first guinea pig, then that guinea pig's blood into a second one, he observed, "after some hours the animal appeared feverish and oppressed, with cold ears and paws, trembling and blackish vomiting. It died in a short time, and its blood showed an infinity of the characteristic organisms" (Mississippi Valley Medical Monthly 1883, 366). Freire's efforts were hampered, more than he realized, by what he did not know and could not see.

It did not hold him back. Freire first tried to find a yellow fever cure in 1880 by injecting sodium salicylate, an analgesic, into human patients to halt the progress of the disease (Benchimol 1999, 58). In 1883 he thought he had created a vaccine (Benchimol 1999, 77). Between late 1883 and early 1886 he injected the supposed vaccine from his germ into close to five thousand people (Benchimol 1999, 80-81, 105, 108). All told, between 1883 and 1894, he had vaccinated a total of 12,354 people, 8,815 Brazilians and 3,539 foreigners (Benchimol 1899, 40). However, in 1894, three of his previous students brought Freire's prominence to an end by publicly exposing his sloppy lab techniques and dishonesty, when they demanded to view his samples of *Cryptococcus xanthogenicus* and found he had falsified them (Benchimol 1999, 308-310).

Yellow fever deaths totaling 15,164 in the city of Rio de Janeiro, in the five years (1890-1894) since the beginning of the Republic, had tripled, when compared to 4,934 deaths during the preceding five years (1885 to 1889) (Benchimol 1899, 431). Though only covering the capital, and not showing the impact of the disease in other parts of

Brazil, these statistics encapsulate the yellow fever crisis. Perhaps this spike in deaths was related to social and political upheaval during the first years of the new republican government, or there could have been other reasons. What is clear is the mounting pressure and frustration among medical scientists and authorities over yellow fever's death toll.

A Cholera Outbreak and *Cordons Sanitaires*

The year 1894 was significant not only for the beginning of Freire's downfall but also for the growing strength of Brazil's *Academia de Medicina*. Shortly before Freire's disgrace, an outbreak of cholera had erupted in Rio de Janeiro state, in São Paulo state and in towns in Minas Gerais. The disease followed the railroad routes and people fleeing towns in the Paraíba River Valley (Benchimol 1999, 254). Though ineffective, *cordons sanitaires* were placed along roads and trains were halted (Benchimol 1999, 256-257). Passengers on trains were treated to very intrusive searches, and made to bathe, while inspectors sprayed their belongings with strong chemicals or simply burned them (Benchimol 1999, 260-261). During the crisis, a generation of microbiologists who would rise to future prominence, including a young Dr. Oswaldo Cruz, were methodically working to make a bacteriological diagnosis in a small lab with microscopes and cultures (Benchimol 1999, 265-267).

Paradigm Shift

By the end of the decade of the 1890s, frustration with the lack of an answer to the question of yellow fever was growing. Responding to impatience among the public,

the Chamber of Deputies passed a law in 1897 establishing prizes for the person who could identify the germ or find a cure or preventative (Benchimol 1999, 363). Brazilian nationalism was stirring when Dr. Giuseppi Sanarelli, an Italian microbiologist, traveled to Uruguay in 1896 to head a new institute of hygiene at the University of Montevideo (Benchimol 1999, 345). Sanarelli would soon make a claim to have seen the yellow fever germ, which he called *bacillus icteroid*. In January 1897, one young Brazilian doctor visited his lab in Montevideo, which was outfitted with the latest modern equipment. The lab was the envy of microbiologists in Rio de Janeiro (Benchimol 1999, 364-365). Sanarelli had arrived in Rio de Janeiro on June 12, 1896, and had done research there before taking up his post in Uruguay three months later (Benchimol 1999, 345). Writing on March 15, 1898, he offered an interesting perspective of the city and its problems:

> There is perhaps no other [disease] against which it is so easy ... a prophylactic method based on vaccinations. Household infections so typical and constant; the large families that parade slowly, leaving one by one from the same domestic door (...) for the common grave; the infected quarters (...) that you can easily circumscribe and draw in your urban plans, as a small drop of oil that, in the course of days, slowly and resolutely dilates its own diameter; the *cursed houses*, comparable to contaminated pastures, where the cattle are decimated by the anthrax to the last head, demonstrates to you the evidence that in the places where the pathogen of yellow fever has found favorable ecological conditions for its demands and its acclimatization, any other prophylactic means that is not based on the vaccination of the inhabitants will be difficult to achieve, painful and extremely random. (*Não há talvez outra [doença] contra a qual seja tão fácil (...) um método profilático baseado nas vacinações. As infecções domiciliares tão típicas e constantes; as famílias numerosas que desfilam lentamente, saindo uma por uma da mesma porta doméstica (...) para a sepultura comum; os quarteirões infectos (...) que podeis facilmente circunscrever e desenhar em vossas planta urbanas, como pequena gota de óleo que, no correr dos dias, dilata lenta e resolutamente o próprio diâmetro; as 'casa malditas,' comparáveis a pastos contaminados, onde o bestiame é dizimado pelo carbúnculo até a última cabeça, demonstra-vos à evidência que nas localidades onde o agente patogênico da febre amarela encontrou condições mesológicas favoráveis às suas exigências e à sua aclimatação, qualquer outro meio profilático*

> *que não seja baseado na vacinação dos habitantes será de obtenção difícil, penosa e sumamente aleatória.)* (Benchimol 1999, 362)

Again, as in the description by U.S. Consul-General Seeger, yellow fever was compared to another "plague," not bubonic plague this time, but the Old Testament cattle plague and plague of boils, mentioned in *Exodus 9:1-10*. Known in the nineteenth century as anthrax or carbuncle, it played a part in Koch's postulates and Pasteur's animal vaccine. In 1898, even hyperbolic comparisons could not describe yellow fever in Rio de Janeiro well enough.

In competition with Sanarelli and the discovery of *bacillus icteroid,* which he announced from Montevideo on June 10, 1897 (Benchimol 1999, 358), different Brazilian doctors also proposed cures that were unconvincing on technical grounds. Still there was hope of finding a vaccine, even if seeing the germ microscopically seemed elusive. Being, in fact, a virus, the causative agent was not visible to anyone at the time.

By the end of the decade, the medical community was exhausted from their efforts to decipher yellow fever, and yet people kept on dying. When the disgraced Domingos Freire passed from the scene in August of 1899, receiving a dignified funeral with all the trappings due a national hero of science and attended by his peers and former disciples (Benchimol 1999, 374-376) Brazil's health authorities were on the eve of a new paradigm in the Pasteurian Revolution. Then plague arrived.

Plague Comes to Rio de Janeiro

When one factors in the frustration over yellow fever, it becomes understandable on one hand why the authorities imposed a twenty-day quarantine period as a weapon when plague threatened Brazil's ports. If there was a chance to keep plague out of the

country or simply to buy time, a severe quarantine was a useful tool. Once plague was present, it was more important to prevent widespread panic of the kind historically connected with *cordons sanitaires* that tended to spread the illness. The very recent bad experience with *cordons sanitaires* during the cholera outbreak in the Paraíba River Valley had revealed this severe method's impracticality, expense, and potential to do damage. The wise course was to stay calm, and find another strategy to deal with plague.

Interpreting it differently, it could be said that plague played an important role as the last straw in the despair of the public health and medical community in Brazil. When it turned out that the death toll from plague was not as frightening as first feared, and when methods of handling the disease with anti-rat campaigns produced results in São Paulo, minds started to open.

When the first plague case came to light on January 7, 1900, in a home near the waterfront at Ladeira do Valongo, no. 3 (Nascimento and Silva 2013 "A Peste Bubônica no Rio de Janeiro," 115), Rio de Janeiro was a messy, rapidly growing, bustling city (Appendix C). Its population of 690,000 in 1900, growing to 811,000 in 1906 (Nascimento and Silva 2013 "A Peste Bubônica no Rio de Janeiro," 114), had been rising swiftly from 274,049 at the time of the 1872 census (Klein 1969, 36). The city population included immigrants from Europe and migrants from the interior who worked in manual jobs at the port, or in one of Rio de Janeiro's early industries: tobacco factories, breweries or textiles (Nascimento and Silva 2013 "A Peste Bubônica no Rio de Janeiro," 114). Many poorer immigrants and Brazilians lived precariously a few streets in from the docks in blocks of overcrowded *cortiços* ("beehives" tenements), *estalagens* (inns), *casas de cômodos* (rooming houses) or shacks on the sides of nearby hills

(Nascimento and Silva 2013 "A Peste Bubônica no Rio de Janeiro," 115; Echenberg 2007, 158-159) where sanitation was lacking. Low lying streets, littered with refuse, flooded when it rained or became inundated when over-washed by waves from Guanabara Bay during storms (Echenberg 2007, 157). Congested streets led to the docks that were equipped with inadequate cargo storage and old, inefficient machinery. One of the fifteen busiest ports in the world, Rio de Janeiro was in dire need of modernization (Nascimento and Silva 2013 "A Peste Bubônica no Rio de Janeiro," 114). Besides leading in coffee exports, the port also handled imports of freight that was divided up and distributed to smaller cities. The antiquated condition of the capital's infrastructure and its vulnerability to disease was a concern to a middle class with rising expectations and consumer clout, and to government officials alike.

The capital's main economic driver, the port's health, was threatened on January 8, 1900, when a very ill little boy was transferred from his home at Ladeira do Valongo in a water ambulance across Guanabara Bay to the Paula Cândido isolation hospital in Jurujuba cove. He was unable to be treated and died (Nascimento and Silva 2013 "A Peste Bubônica no Rio de Janeiro," 115). Before the child was removed from his home, doctors had begun microbiological research into his illness (Nascimento and Silva 2013 "A Peste Bubônica no Rio de Janeiro," 115). Suspicious-looking plague-shaped bacteria were found, leading to the decision to isolate the patient. On January 13, when the diagnosis had been confirmed, the government announced the first plague case in Rio de Janeiro (Nascimento and Silva 2013 "A Peste Bubônica no Rio de Janeiro," 115).

A strategy to fight plague was instituted right way. Based on a model used previously to combat yellow fever, the plan depended on isolation and sanitation

measures. According to his March 1900 report to President Campos Salles, Dr. Epitácio Pessôa, Minister for Justice and Business, explained that people who became ill with plague or who were suspected of having been in contact with a plague victim would spend ten days in isolation at the Paula Cândido isolation hospital at Jurujuba (Nascimento and Silva 2013 "A Peste Bubônica no Rio de Janeiro," 116, note 31). The principle of isolation was imposed on the entire neighborhood of Santa Rita, where the little boy who fell ill in January had lived, reported Pessôa. In Santa Rita, the strategy was very thorough, according to Pessôa. Houses were to be disinfected completely and inspected, and each inhabitant in the neighborhood was to have a medical examination (Nascimento and Silva 2013 "A Peste Bubônica no Rio de Janeiro," 116, note 31). To prove that plague was not going to stop commerce, the government ordered disinfection of ships leaving the port of Rio de Janeiro and baggage cars leaving the Central station on the *Estrada de Ferro Central* (Central Railway) (Nascimento and Silva 2013 "A Peste Bubônica no Rio de Janeiro," 116).

Serum

With such thoroughness, and no new plague victims after a couple of weeks, authorities began to make plans to set up a laboratory for the manufacture of anti-plague serum, in the event of future cases. The Santos outbreak of the prior year had shown the need for fresh serum that, when administered early enough, could save lives. Dr. Vital Brazil's brush with plague seemed to offer an example of the serum's efficacy (Echenberg 2007, 162). A shortage of anti-plague serum from Europe due to the plague epidemic in Porto pointed to a need for serum manufactured in the country. Founded in

1900 at Manguinhos in some unused buildings at an old farm at the edge of the city, this facility, the *Instituto Soroterápico Federal* (Federal Sorotherapy Institute), represented a microbiological approach based on a breakthrough in 1898 by Alexandre Yersin who had developed the plague serum (Echenberg 2007, 166). It was the most modern tool in the toolkit.

A few months went by. At the end of May 1900 President Campos Sales (1898-1902) reported to the national Congress that the port of Rio de Janeiro had been clean from January 27 forward (Nascimento and Silva 2013 "A Peste Bubônica no Rio de Janeiro," 116). Actually, on April 18, two new cases of plague were found at Praça da Harmonia no. 94, a different neighborhood from the January case (Nascimento and Silva 2013 "A Peste Bubônica no Rio de Janeiro," 117). On May 16, 1900 two more cases were discovered in hospitals: one in Lagoa, in *São João Batista* hospital and the other in the *Santa Casa de Misericórdia* hospital (Nascimento and Silva 2013 "A Peste Bubônica no Rio de Janeiro," 117). Rat die-offs were reported in neighborhoods where people had died, and plague cases were being found in areas where there were quantities of food storage (Echenberg 2007, 163).

These four cases in April and May 1900 had been properly confirmed in the lab and reported to the government by Dr. Epitácio Pessôa, Minister of Justice and the Interior (Nascimento and Silva 2013 "A Peste Bubônica no Rio de Janeiro," 117). President Campos Salles knew about this handful of plague cases but he glossed over it in addressing Congress. While in January, the origin of the outbreak had been unclear, Dr. Pessôa now felt safe pinning the blame for the April outbreak on the ship *Clyde*, which had taken on passengers from Porto during a stopover in Lisbon. The *Clyde* had been

allowed to enter Rio de Janeiro after Porto had been declared clean (Nascimento and Silva 2013 "A Peste Bubônica no Rio de Janeiro," 117). Three of its passengers had been staying in the same room at the crowded rooming house on Praça da Harmonia where two cases of plague were found (Echenberg 2007, 163). At the least it was very convenient to connect the plague to an outside source, and it showed how nervous federal and public health authorities were about protecting their actions, the reputations of the federal government and the port of Rio de Janeiro, which were at stake. These four latest of a handful of cases were disturbing signs that the disease was spreading.

Between 1900 and 1903, efforts to fight plague in Rio were based on the combination of isolation, disinfection and serum. Compared to other ongoing outbreaks of yellow fever and smallpox, mortality was low (Fig. 1).

Fig. 1 Plague, Yellow Fever, and Smallpox Mortality
in Rio de Janeiro, 1900-1903

Year	Deaths from Plague	Deaths from Yellow Fever	Deaths from Smallpox
1900	295	344	590
1901	199	299	1414
1902	215	984	590
1903	360	584	805

(Nascimento and Silva 2013 "A Peste
Bubônica no Rio de Janeiro," 117; Benchimol 1999, 431)

Oswaldo Cruz thought that the use of serum reduced mortality by half (Moll 1940 "Brazil," 1095). In spite of application of serum in cases that were not too far advanced, and some observed benefit from it, there was worry that bubonic plague was becoming endemic in Rio de Janeiro, just as yellow fever had previously. The jump in deaths in 1903 was sobering. It is worth remembering that Oswaldo Cruz and others were dealing with a disease that none of them had previously seen prior to 1899, that they were relying on written texts and experience, judgment and microbiological methods. Besides manufacturing serum, scientists at the Sorotherapy Institute at Manguinhos also made an anti-plague vaccine according to Haffkine's formula. Still Cruz found it difficult to manufacture the vaccine with consistency (Echenberg 2007, 166). Consequently, he thought that for the time being, serum was the only safe tool.

A Breakthrough

While authorities in Rio de Janeiro were worried about plague and commerce, doctors in Brazil who had their eyes on yellow fever were very interested in events as they unfolded in Cuba. In June 1900 the Reed Commission of U.S. Army physicians and medical scientists, led by Dr. Walter Reed and assisted by doctors Jesse Lazear, James Carroll, and Aristides Agramonte, first came to Cuba. Reed still subscribed to a traditional microbiological approach favored by U. S. Army Surgeon-General George Sternberg (Benchimol 1999, 400-401). The team was responding to a crisis in which the United States Army was finding Cuba difficult to govern when so many soldiers were being stricken with yellow fever. Typical sanitation measures, disinfections, quarantines, and isolation of the sick were being carried out as well as vaccinations against smallpox,

but yellow fever was continuing unabated (Benchimol 1999, 401). When the port of Havana reopened midway through 1900, immigration increased to as many as 40,000 by the end of that year, bringing a proportionate increase in yellow fever deaths (Benchimol 1999, 401). The Reed Commission first attacked the problem by efforts to disprove Sanarelli's theory of the yellow fever germ, to which members of the Marine Hospital Service had previously subscribed (Benchimol 1999, 401).

At the same time, two representatives of the Liverpool School of Tropical Medicine, British doctors Walter Myers and Herbert E. Durham, visited Cuba in June, on their way to study yellow fever in the Amazon region (Benchimol 1999, 403). They were investigating a new basic idea, that an insect host was responsible for transmitting yellow fever, and they were interested in meeting members of the Reed Commission. While in Cuba they not only conferred with doctors Reed, Carroll and Lazear, but also met with Major William Gorgas, who was leading the fight against infectious diseases in Havana and Henry R. Carter, of the U. S. Marine Hospital Service (Benchimol 1999, 403; Durham and Myers 1900, 656). Myers and Durham also were able to meet with a group of Cuban experts in tropical diseases and doctors, including Carlos Finlay (Benchimol 1999, 403). Later in January 1901 after they had arrived in Belém, both men got yellow fever. Myers succumbed to the disease (Durham and Myers 1901, 451).

In their preliminary notes in the *British Medical Journal* in September 1900, Durham and Myers described their stay in Havana. They were quite aware of Carlos Finlay's theory.

> . . . the suggestion propounded by Dr. C. Finlay, of Havana, some twenty years ago hardly appears so fanciful in the light of recent discoveries in ague convection as appeared in the days when the idea was first broached. Dr. Finlay's hypothesis is able to account for several curious points which

> obtain with yellow fever. Thus the limitation of the disease to the "yellow fever zone," where frost is unknown, the coincidence of yellow fever and rainy seasons, the cessation of the disease when the temperature falls below a certain point, and its non-recrudescence in an infected locality after a frost, are all compatible with an agency, such as a gnat, which becomes too sluggish to bite, or indeed which dies out in unfavourable climatic conditions . . . some means of transmission by the aid of an intermediate host—a town-loving host for this town-loving disease—is to some extent more plausible than might be anticipated. (Durham and Myers 1900, 656)

Durham and Myers were not taken in by the assertion by Cuban doctors that race made a difference as to immunity.

> "We were lucky enough to see one negro during the course of a typical attack. . . they are not unknown to suffer from a disease called "borras." Clinically "borras" is like yellow fever—sometimes with black vomit and death with suppression of urine." (Durham and Myers 1900, 656)

This comment seems to be more a reaction to the certainty expressed by Cuban doctors, which may have been accompanied by an uncomfortable tone of racism that made the Liverpool researchers skeptical. Though many historians have supported the controversial idea that some people of African descent are more refractory to yellow fever, evidence from epidemics concurs with Durham and Myers' observations (Espinosa 2014, 449). As observers, Durham and Myers were recognizing that yellow fever carries a cultural component.

Following the visit by the researchers from Liverpool, the Reed Commission, which was at an impasse in its research, changed tack and decided to test Carlos Finlay's theory in spite of objections from Sternberg, Gorgas and Reed. On August 11, 1900, Jesse Lazear began experiments on the mosquito theory, using volunteers as human test subjects. In the camp, he was not able to establish strict enough controls over his volunteers to scientifically rule out other kinds of infections. Lazear died on September

25 in the middle of his experiments, after allowing an infected mosquito bite him (Altman 1987, 149-150). Reed, who had been absent from the work in Cuba, returned from a visit to Washington and decided to finish Lazear's experiments, completing them between November 1900 and February 1901 (Benchimol 1999, 406). These experiments showed that an isolated well subject could get yellow fever from an infected mosquito, and that the disease was not transmissible from exposure to contaminated belongings (Benchimol 1999, 406). A second group of experiments led to the confirmation in September and October 1901 that blood injected into a well person from an infected person could transmit the infection (Benchimol 1999, 407). Yellow fever's elusiveness was due to the microbe being so tiny that it could not be seen with the most powerful microscopes, and it was found to have crossed the smallest filters (Benchimol 1999, 407).

When, within two months, it was clear from the results of the early experiments that the mosquito was the culprit that transmitted the disease, Gorgas, although reluctant at first, adopted the new strategy to break its life-cycle in Havana. Isolating the sick under mosquito nets, and eradicating mosquito larvae in standing water was successful in suppressing the disease within six months (Benchimol 1999, 407).

São Paulo

Director of the Sanitary Service, Emílio Ribas, who had been keeping abreast of events in Havana through letters, decided to replicate the Cuban experiments in São Paulo. The tendency among bacteriologists working in São Paulo to think independently was not new. In 1898 Vital Brazil had first doubted Sanarelli's theory, and Adolfo Lutz had already begun studies on the mosquito *Stegomyia fasciata* to determine its extent and

distribution (Benchimol 1999, 410). Interest in a vector was not the reigning view at the time in Brazil; most still focused on finding a yellow fever germ. Starting in January 1901, before Reed would present results to the Third Pan American Congress in February 1901, Ribas, as Director of the Sanitary Service in São Paulo, quietly directed the local sanitary commissions in Santos, Sorocaba, and Campinas to eliminate any stagnant water containing larvae (Benchimol 1999, 410). This practice continued over the next two years, as Ribas added measures to combat contagion and yellow fever infections in the towns of Sorocaba (1901) and São Simão (1902), and discontinued disinfections in Ribeirão Preto (1903) (Benchimol 1999, 410).

At the end of 1901, Rodrigues Alves, president of the state of São Paulo, gave permission for human subjects to be used in experiments to replicate the findings of the Reed commission. Under controlled conditions in the Isolation Hospital of São Paulo (Benchimol 1999, 410), mosquitos for the experiments, collected in Rio de Janeiro, were bred with care to eliminate any other infections that they might carry (Benchimol 1999, 410). The first test got underway on December 15, 1902, lasting until January 20, 1903. Mosquitos were infected by contact with a person diagnosed as being in the second or third day of infection, and were then fed on honey and dates in the lab for twelve days until they were just becoming infectious (Benchimol 1999, 410). Controlling the timing of the experiment was planned in the interest of safety. To further reassure their volunteers, Lutz and Ribas exposed themselves to infected mosquitos to set an example. The Brazilian volunteers stung by infected mosquitos were expected to develop light cases of yellow fever and survive (Benchimol 1999, 410). Such careful preparations were intended to win public acceptance over moral objections to human experimentation.

From April 20 through May 10, 1903, the researchers ran a second batch of experiments, testing contagion, by putting four Italian men in rooms with contaminated objects to prove there would be no adverse effects (Benchimol 1999, 411). Again, a conclusion of the Reed Commission, that yellow fever is not transmissible through casual contact, was tested in a hospital setting.

These successful investigations to prove Finlay's mosquito vector theory brought prestige to São Paulo's medical community. To add gravitas, a medical commission headed by Dr. Luiz Pereira Barreto, a man with impeccable political (president of the state Senate) and academic authority, certified the results (Benchimol 1999, 411). In a monitored setting under controlled conditions to rule out other possible causes of infection, three out of the four volunteers pricked by mosquitos had developed mild infections, and none of the four who lived with contaminated articles had become ill (Benchimol 1999, 411). From the final report of the commission:

> Whatever the germ of this disease, this germ loses its germinative faculty every time it does not find the favorable conditions of its natural environment. The experiments of the Americans in Havana and ours here in the Isolation Hospital show that only in the mosquito organism does the yellow fever germ find the conditions necessary for its evolution.
> *(Qualquer que seja o germe dessa moléstia, esse germe perde a faculdade germinativa todas as vezes que não encontra as condições favoráveis do seu meio natural. As experiências dos norte-americanos em Havana e as nossas aqui feitas no Hospital de Isolamento demonstram que só no organismo do mosquito encontra o germe amarílico as condições necessárias para a sua evolução.)*
> (Benchimol 1999, 411)

Having put its stamp of approval on the results of the experiments, which had demonstrated that yellow fever could be only transmissible through the bite of an infected mosquito, the medical commission then recommended that public health authorities immediately attack the disease.

In Rio de Janeiro there was still official skepticism on the part of Director-General of Public Health Nuno de Andrade, a man who was characteristically conservative and cautious. Also cautious were the English scientists from Liverpool on hand in Brazil (Benchimol 1999, 412). Meanwhile the American navy sent researchers to Veracruz, Mexico to try to replicate the findings realized in Cuba and now in Brazil (Benchimol 1999, 413). In a report in 1902, Gorgas compared the death rate (deaths per thousand) in Havana from the period, 1870 to 1900 (29.30 deaths per thousand) to the same measurement in 1901 after the anti-mosquito campaign and urban clean-up (22.11 deaths per thousand) (Benchimol 1999, 412), a promising improvement, owing at least in part to efforts to eradicate mosquitos. Most prestigious were three scientists from the Pasteur Institute in Paris, Émile Roux, Paul-Louis Simond and A. Tourelli Salimbeni, who came to Rio de Janeiro under a grant from French authorities to conduct research on yellow fever for four years. It was a chance for the scientists to study social aspects of yellow fever and efforts to eradicate it in an urban setting that was not, as Cuba had been, under military occupation (Benchimol 1999, 413). With tools becoming available, the battles against yellow fever and plague were about to converge.

Reorganizing Public Health

In 1902, Francisco de Paula Rodrigues Alves, a coffee baron, lawyer and politician from São Paulo, was elected President of the Republic of Brazil, serving from 1902 to 1906 (Nascimento and Silva 2013 "A Peste Bubônica no Rio de Janeiro," 118). With his election, Rodrigues Alves, with an eye toward the future, recognized the opportunity to modernize Rio de Janeiro. Above all, the public health structure needed to

be reorganized. Public health came under two authorities: the *Diretoria Geral de Saúde Pública* or DGSP (General Directorate of Public Health) on the federal level, and the *Diretoria de Higiene e Assistência Pública* (Directorate of Hygiene and Public Assistance) on the municipal level (Nascimento and Silva 2013"A Peste Bubônica no Rio de Janeiro," 117). Their two charges overlapped too much in some instances, or clashed in others, and left jurisdictional gaps. Under the current federal authority, the DGSP was responsible for maritime defense, including quarantines, isolation and disinfection of ships (Nascimento and Silva 2013 "A Peste Bubônica no Rio de Janeiro," 117). Meanwhile, the municipal authority would fight plague outbreaks in neighborhoods in the capital, focusing on disinfecting houses (Nascimento and Silva 2013 "A Peste Bubônica no Rio de Janeiro," 117). This meant the municipality would locate people who were sick, while the job of isolating them fell to the federal department (Nascimento and Silva 2013 "A Peste Bubônica no Rio de Janeiro," 117-118). The result was people would not report cases of plague or suspected plague for fear of being sent to the isolation hospital or having their houses disinfected or their belongings incinerated (Nascimento and Silva 2013 "A Peste Bubônica no Rio de Janeiro," 117 note 36, 118). The system was breaking down. In July 1902**,** by presidential decree, followed by legislation, the process of reforming the sanitary laws began. By 1904 (Nascimento and Silva 2013 "A Peste Bubônica no Rio de Janeiro," 119) defense of the federal capital had been moved from the municipal level to the DGSP. The municipal law now governed maintenance of sanitation in the city (Nascimento and Silva 2013 "A Peste Bubônica no Rio de Janeiro," 119).

Triple Threat

On March 23, 1903, Oswaldo Gonçalves Cruz was nominated as Director-General of Public Health (DGSP). He was but thirty years old. Cruz came from a medical family. Born August 5, 1872 in São Luís do Paraitinga, a town in the interior of the province of São Paulo (Benchimol 1999, 413), at five, his family had moved to Rio de Janeiro, where his father, a doctor, had a clinic in the neighborhood of Gavéa, on the outskirts of the city (Benchimol 1999, 413). At the age of fourteen, Cruz entered the *Faculdade de Medicina* (Faculty of Medicine) where he studied medicine and microbiology, becoming a doctor in 1892 (Benchimol 1999, 413-414). Between various posts and studies, Cruz would practice clinical medicine or work in labs to support his large family (six children) (Benchimol 1999, 414). By the cholera epidemic in 1894 (Benchimol 1999, 265) Cruz was twenty-two. At this time he became associated with the younger generation of microbiologists in Brazil, with whom he worked in the lab at the *Instituto Sanitário* (Benchimol 1999, 415). In 1896, Cruz, with help from his father-in-law, was able to go to France to attend the Pasteur Institute, where he studied microbiology, biochemistry, histology, hygiene, and sorotherapy (Benchimol 1999, 415-416). He also learned the art of glassblowing in order to be able to supply vessels for laboratory experiments (Benchimol 1999, 417). From France he had stayed abreast of the yellow fever controversies in Brazil (Benchimol 1999, 416). Cruz's time in Paris was important for microbiology, with the identification of a number of important disease pathogens (Benchimol 1999, 416). Following Cruz's return to Rio de Janeiro in 1899, at the age of twenty-seven, plague landed in Santos. Both diseases would come to define his work.

Cruz, succeeding Nuno de Andrade as Director-General of Public Health, had the tools and political and economic support to go after the three worst afflictions facing Rio de Janeiro: yellow fever, smallpox, and plague (Nascimento and Silva 2013, 120). Taking a new approach, Cruz's focus was to go after the illnesses, not people ill from them. To do this, Cruz continued the policy of disinfection, but also started campaigns against the vectors of yellow fever and plague, mosquitos and rats, and promoted vaccination against smallpox**.**

There was varying success (Fig. 2). The vaccine tool against smallpox had been in use for a century since Jenner. In the mid-nineteenth century, the Brazilian Imperial government had once promoted vaccination for a few years in Rio de Janeiro. More recently, vaccinations of a purported vaccine against yellow fever had been carried out somewhat forcefully under the direction of the well-intentioned Dr. Freire. It is not surprising, then, that a mandatory smallpox vaccination campaign in 1904 failed spectacularly, and nearly brought down the government. Resistance to compulsory vaccination ranged from physicians, including former Director-General of Public Health, Nuno de Andrade, who doubted the vaccine's safety (Echenberg 2007, 172). to complaints that the vaccinations would violate women's modesty, to former slaves who preferred variolation. From November 11 to November 18, 1904, there were riots known as the Vaccine Revolt (Echenberg 2007, 175). Director-General Cruz and President Rodrigues Alves decided to halt the campaign on November 17, which ended the rioting. The government of Rodrigues Alves survived. Cruz waited until a recurrence of smallpox in 1908-09 to more quietly vaccinate the population of Rio de Janeiro.

Fig. 2 Plague, Yellow Fever, and Smallpox Mortality in Rio de Janeiro, 1904-1908

Year	Deaths from Plague	Deaths from Yellow Fever	Deaths from Smallpox
1904	275	48	3566
1905	142	289	256
1906	115	42	9
1907	73	39	125
1908	54	4	6545

(Benchimol 1999, 431)

Yellow fever eradication used the newest tool, going after the mosquito vector. The method had been shown to be effective in Havana, Cuba and in São Paulo state. Isolation of the sick in their houses with mosquito netting represented an about-face from an earlier emphasis on quarantine. Cruz sent 2,500 sanitary agents through the city to kill mosquitos and mosquito larvae (Echenberg 2007, 172). The campaign was hugely successful.

Plague was more complicated. It was important to Brazil to demonstrate that it was using the latest science to fight this old disease. The rat-flea vector understanding of the disease that had been proposed by Simond in 1898 was becoming accepted by 1903, which Brazilian health officials well understood. A successful anti-rat program had been carried out by the United States in the Philippines in 1901, providing an example worthy of emulation (Nascimento and Silva 2011, 2). A more immediate and local example was the campaign in São Paulo in 1899. It was especially important to try to catch rats other than during die-offs when fleas would leave the dead rat-host and bite humans.

The anti-rat campaign in Rio de Janeiro had two phases. The first was launched by a decree in September 1903, and it involved paying *ratoeiros* (professional rat-catchers) (Nascimento and Silva 2011, 2). *Ratoeiros* were essentially middlemen--people would sell them dead rats, and *ratoeiros* in turn would bundle them up and sell them to the city (Nascimento and Silva 2011, 2). It did not solve the problem of removing rats before they died of plague, however. To make money, people used creativity to make fake rats from cardboard that were also sold to rat-catchers with a wink (Nascimento and Silva 2011, 2). There was no real proof, as all the dead rats were incinerated.

Ratoeiros needed to catch 150 rats each month to earn a 60 *milreis* monthly salary (Nascimento and Silva 2011, 2). For each additional rat they were paid 300 *reis*, the equivalent of three small cups of coffee (Nascimento and Silva 2011, 2). The *ratoeiros* plied their trade in the port area more than in the streets and neighborhoods, because there were more rats near the docks and the plague problem there was likewise more serious (Nascimento and Silva 2011, 2). They carried a bucket of Creolina to dip the dead rats into, and they also carried a little horn, which they would blow to announce that they were nearby (Nascimento and Silva 2011, 2).

From September through December 1903, 24,000 rats were caught (Fig. 3). In 1904, the total was 296.000 rats (Nascimento and Silva 2011, 3). In spite of this success, plague deaths declined, but slowly.

Fig. 3 Comparison of Number of Human and Rat Deaths from Plague in Rio de Janeiro, 1903-1907

Year	1903	1904	1905	1906	1907
Human Deaths	360	275	142	115	73
Rat Deaths	24,441	295,913	370,012	440,660	471,605

(Nascimento and Silva 2013 "A Peste Bubônica no Rio de Janeiro," 123)

Oswaldo Cruz realized another strategy was necessary. The *ratoeiro* campaign was shut down and instead there was a campaign to pour poison or toxic gas down rat-holes, which reduced the number of rats, and therefore, rat-fleas (Nascimento and Silva 2011, 2). When this was instituted, plague deaths began to decline more rapidly. Plague ceased to be a problem in Rio de Janeiro after 1907 (Nascimento and Silva 2013 "A Peste Bubônica no Rio de Janeiro," 123). Of course, with the extensive destruction and rebuilding of neighborhoods in order to build the new *Avenida Central* (Central Avenue), the habitat of the urban rat in Rio de Janeiro was being altered, which might have been another reason why cases of plague declined in the city. Plague did escape into rural Brazil, with permanent *foci* in the Northeast.

IV. Plague in Brazil, Instrument of Change

As the anti-rat and anti-mosquito campaigns were getting underway, Director-General Cruz, with responsibility for protecting Brazil's ports from disease invaders, had new disinfection equipment installed in the port Rio de Janeiro. Prior to 1903, to disinfect ships had required a lengthy quarantine at the lazaretto on Ilha Grande, a large island in Guanabara Bay north of the city of Rio de Janeiro (Rebelo 2012, 5). Before anyone was allowed to disembark, a worker would board the vessel and spray the shoes of each passenger from a bucket of antiseptic solution (Rebelo 2012, 15). The work was primitive and not supervised by a physician. In the early twentieth century, with recognition of the role of disease vectors, changes were possible (Rebelo 2012, 15). Medical inspectors now inspected vessels either at anchor, or after the ship had docked in a new inspection station at the port (Rebelo 2012, 13, 17). Well passengers were

permitted to go ashore as long as they left contact information so they could be monitored later. In 1903, Director-General of Public Health Cruz had the latest invention, Clayton's gas apparatus installed at the port (Rebelo 2012,16). A barge carrying the apparatus would go out to the ship, pull alongside and carry out the disinfection, under the guidance of a port doctor. Any contaminated objects would be disinfected in a gas chamber or formaldehyde chamber installed on the barge and, without the need to unload cargo, the holds of the vessel would be sprayed with pressurized dry sulfur dioxide to kill insects, rodents, and germs. Passengers who were well could now avoid long quarantine as long as their belongings were sanitized with the Clayton apparatus, and the sick were isolated, in this way limiting the spread of disease.

At the time that the first Clayton apparatus was installed in Rio's port, plague was not yet well controlled. To protect other Brazilian ports from plague, as well as to better comply with sanitary agreements, Cruz had Clayton's gas apparatus sent on outgoing ships to other Brazilian ports (Rebelo 2012, 17). In a May 27, 1904 report, Acting Assistant Surgeon Stewart of the U. S. Public Health and Marine-Hospital Service, stationed at Rio de Janeiro, made note of an interesting experiment being tried in Rio de Janeiro that could hold promise, that Clayton's gas apparatus was then being used to kill rats in the surface drainage sewers, "by closing up all the exits and then filling the sewers with sulfurous acid gas from a Clayton apparatus," ("Brazil: Public Health" 1904, 1057). Plague was becoming a spur to creativity and to action.

Avenida Central

The anti-rat campaign to defeat plague can be seen as an allegory for the removal of poor people who had been living in unhealthy, crowded conditions near the port. It is no accident that *Avenida Central* was built with their displacement in mind, as it was built right through the middle of the yellow fever zone (Appendix D). On September 7, 1904, the axis of *Avenida Central* was inaugurated (Benchimol 1999, 441). The avenue, lined with four and five story tall buildings with façades in the new French style, had two lanes in each direction, a median strip, modern streetlamps, trees and spacious sidewalks. Its construction had resulted in the destruction of thirteen hectares of the city (Echenberg 2007, 179), turning *cortiços* and shops into rubble. The street had also sliced through two hills in order to open access to the water on a north-south axis. Acting Assistant Surgeon Stewart expressed some understandable doubts, in a report on May 27, 1904, though it turned out there was no need:

> The work of demolition for the Avenue (Central), is going rapidly on, and the two extremities of it at Prainha and Adjuda are already in ruins. It is easy enough to pull down and destroy. It is the rebuilding that will be tedious and laborious, and we fear that it will be a long time before, with such ambitious plans, the avenue will be rebuilt ("Brazil: Public Health" 1904, 1056).

People who had been living in the *cortiços* ("beehives") and rooming houses moved west and north of the downtown area, to the hills that had been absorbing the overflow of population. Acting Assistant Surgeon Stewart applauded the improvements:

> . . . with new streets and new avenues, manners, too, are to be reformed and some respect be shown for common decency. The open, offensive sanitary arrangements that disgraced some of the most central parts of the city are disappearing and being replaced by modern, up-to-date constructions that would be a credit anywhere ("Brazil: Public Health" 1904, 1056).

In fact, when *Avenida Central* was completed, by a new city ordinance, men were forbidden to be there without a suit, tie and dress shoes (Gomes, Neves and Velloso 2004, 571), effectively preserving the space to be enjoyed by the middle class and elites. From the viewpoint of an expert foreign observer charged with giving clean bills of health to ships bound for the United States, Acting Assistant Surgeon Stewart's comments are not casual, but summed up how desperately ready many *cariocas* were for change. To a growing Brazilian middle class with aspirations and to elite Republicans who wanted to bring Rio de Janeiro, and the country with it, into a future that was modern and cultured, the geometry and order of *Avenida Central*, built in the style of *fin-de-siècle* Paris, suited the optimism of the time.

The swift, straightforward response of the Brazilian authorities to the arrival of plague came in sharp contrast with how authorities handled the news in Porto, Portugal or in Asunción, Paraguay. There, contemporaneous plague epidemics were greeted by denial, then slow action, followed by help from the outside. In Europe, denial of plague's existence, even as cases were turning up on ships, or the use of traditional measures known for being ineffective and counter-productive, such as the *cordon sanitaire* in Portugal, were common responses. But Brazil's response to plague proved to be so more effective. Certainly, practicalities and strong motivations play a role in this, but above all it was Brazil's tradition of dealing with nasty tropical diseases that played the largest part. It all can be traced to the experience with yellow fever.

From a practical perspective, Brazilian health authorities had fought for and acquired a level of cooperation with the national government and the city of Rio de Janeiro that is unusual. Yet this came about in a context of a republic that had yielded

more power to states following the demise of a more centralized imperial administration. In his work on the sanitation of Brazil, scholar Gilberto Hochman notes:

> . . . the central government's territorial reach remained limited with regard to legislating and taking action without having to negotiate with local powers. The existence of endemic and epidemic diseases in various corners of the country continued to defy the political configuration of the constitution of 1891 and hamper the success of sanitation campaigns restricted to the DF [*Distrito Federal* (Federal District)] and São Paulo. Any modification of the 1891 arrangement would depend on reorganizing intellectual and political forces to push for the expansion of the federal scope of action (Hochman 2011, 58).

Local remedies alone were limited and short lived, as diseases did not observe jurisdictional boundaries. As Director-General of Public Health, having fought for expanded powers, Cruz saw this point clearly.

In a setting where communications via telegram could bridge large distances, local and long-distance transportation, while benefitting from rail networks and steam engines, was still comparatively slow. Photos of Rio de Janeiro at the opening of *Avenida Central* with its Parisian architecture show an eclectic mix of horse-drawn or donkey-drawn vehicles, and early motorcars (Wright 1908, 46). A common sight in central Rio de Janeiro was a team of horses pulling a multi-passenger vehicle down *Rua Uruguayana* along tramway tracks set in the muddy street (Wright 1908, 199). When ideas, people, and goods moved at such varying speeds, a set-up that delegated power to states made sense. Separated from the *Distrito Federal* (Federal District) by a ten-hour train trip, the state of São Paulo, with its growing wealth, took more independent actions. An exception was made on questions of national security. While the country had little to fear from its immediate neighbors, Brazil's commerce was another matter. Motivations to clean up the principal port cities, one of which was the national capital, came about in

the crucible of repeated yellow fever outbreaks. Tropical diseases had always been troublesome and now were perceived in a global trade setting to be a serious threat to the economic life of the nation.

The special history of facing tropical diseases in Brazil grew out of its long experience with long distance trade in the tropics, not the least its dominance for centuries in the Atlantic slave trade, which introduced to Brazil diseases from Africa. At the same time, Portugal's trade in the Indian Ocean and in Asia had inevitably brought new diseases and ideas for cures to the consciousness of physicians of the day. By 1899 Brazilians had become unhappily accustomed to dealing with diseases. Educated Brazilians, their patience tried for half a century, began to see yellow fever as the principal obstacle to modernizing the country. As material progress became the goal in the late nineteenth century, people in Brazil wanted to be rid of endemic yellow fever and other intermittent disease outbreaks once and for all.

Acting Assistant Surgeon Stewart, writing on May 1, 1904, made an important point, praising familiar sanitary precautions against yellow fever, then being taken against plague:

> . . . the number of sanitary inspectors and assistants is already so large, and the inspections and quarantine measures are so many and so well provided for by law and by regulations made thereunder that the advent of a new quarantinable disease does not mean the employment and the general expenditure of money, or greatly increased revenue for the State either, that would be the case did such a disease appear in a country where no quarantinable diseases existed and where such sanitary service had to be organized de novo ("Brazil: History and Treatment" 1904, 1060).

In Stewart's view, the level of efficiency of the sanitary authorities was an unexpected by-product of a half-century of bitter experience with yellow fever. In the letter, Stewart further alluded to why this demonstrated efficiency of Brazil's sanitary department was

unappreciated and not recognized by residents of Rio de Janeiro, who for so long were "victims of sanitary inefficiency" ("Brazil: History and Treatment" 1904, 1059). As a measure of this new efficiency, Stewart pointed out Cruz's sudden unpopularity, "that although the present head of the sanitary department of this country [Cruz] has been in place only eight months he has already made very many bitter and implacable enemies" ("Brazil: History and Treatment" 1904, 1059).

Finally, Acting Assistant Surgeon Stewart made a most profound observation. Coming to the defense of the country's doctors against uninformed opinions of laity with a financial interest in shipping who were claiming to anyone who would listen that there was no plague, Stewart continued:

> When one stops to consider the reputation of the Pasteur Institute in this city, and the fact that a large percentage of the physicians composing the highest health authorities of this country are graduates of the most celebrated universities of Europe, and have therefore been students under world-renowned professors and doctors, as well as the fact that the medical schools of this city stand well up among the best as regards personnel of the faculties and professors and as regards methods of teaching and clinical opportunities for the students themselves, I saw when one stops to consider all these things—facts which need no proof because they are facts well known—it can be nothing but an insult to say that the bacteriologists and clinicians of this city, one of the largest cities of the world, can not diagnose correctly a case of plague. And not one case—perhaps that might be more difficult—but over two thousand, with a mortality exceeding 49 per cent of reported cases ("Brazil: History and Treatment" 1904, 1060).

Here, as an American eyewitness to events in Brazil in 1904, Stewart hit upon what may be the most important reason why Brazilian authorities acted differently, courageously, when faced with plague; there was already in place a high level of native expertise.

When plague arrived, authorities in Rio de Janeiro, unlike in plague cities in other countries, possessed some tools already: the desire to fight, and native medical expertise. New tools, knowledge of vectors and local manufacture of plague serum, came from new

scientific research. An indispensable new tool was political support. In a republic with strong state governments such as São Paulo's, the power of the office of Director-General of Public Health occupied by Oswaldo Cruz within the national government was remarkable. To Brazilians in the early twentieth century, catching rats and eradicating the medieval disease with the worst reputation, plague, and along with it a fearsome disease that had stymied authorities and experts for half a century, yellow fever, symbolized the overthrow of the colonial past and an enthusiastic step into a new possibility.

Dénouement

It is amazing just how much energy people put into cleanup and new construction in Rio de Janeiro, once the secrets of plague and yellow fever vectors were understood. Simultaneously, the city of Rio de Janeiro, under the leadership of its mayor, Francisco Pereira Passos, carried out an extraordinarily ambitious demolition and rebuilding of the essential transportation network of the city (Appendix E). Workers pulling wagons deposited 175,000 square meters of fill dirt into a mangrove marsh to the west of the center of the city, and built the Mangue Canal to drain the water and *Avenida do Mangue,* lined with its signature palm trees, running parallel on either side (Gomes, Neves and Velloso 2004, 570). Over the filled-in area, new port facilities to the north now joined railroad tracks leading out of the city to bring cargo from deep inside the country to ports around the world. At the new docks, workers erected fifty-two electric cranes, built bigger warehouses, and created larger berths for ships (Gomes, Neves and Velloso 2004, 571). Demolition workers with pickaxes impressively removed parts of hills inhabited

since colonial times, Morro São Bento at the north side and Morro do Castelo, at the south side of the peninsula, to open access to the bay for an elegant new street (Gomes, Neves and Velloso 2004, 570). In the center of the city (Appendix F) where the old *cortiços* had stood, 590 buildings were demolished, horse and mule drawn carts hauling away the rubble to make way for this brand new avenue, *Avenida Central,* 1,966 meters long and 33 meters wide, that was completed in eighteen months (Gomes, Neves and Velloso 2004, 570). This then would connect to *Avenida Beira Mar,* a new avenue with a promenade and seawall that that skirted along the shore of Guanabara Bay past the suburb of Botafogo as far as Praia Vermelha, almost to Copacabana (Meade 2010, 87). This grand construction project prepared Rio de Janeiro to become a twentieth-century city, as automobiles were taking the place of horse-drawn vehicles. In speed of execution and splendor, the construction project guided by Pereira Passos and executed under the direction of engineer Lauro Müller was all but un-rivaled.

On August 11, 1908, the Brazilian National Exposition opened, "In Celebration Of The Centenary Of The Opening Of Brazilian Ports To The Commerce Of The World" (Wright 1908, 1). Modeling the exhibition after the Centennial celebration in the United States in 1876, the government of President Afonso Pena (1906-1909) hoped that showcasing national products would spur Brazilian commerce (Wright 1908, 12-14). The Centennial was situated on *Praia Vermelha* (red beach), a strip of sand between the mouth of the Bay and the ocean (Appendix G), with the steep sides of *morros* (hills) *Babylonia* and *Urca* rising as backdrops, while a thirty-foot by fifty-foot Brazilian flag fluttered on the top of the nearby *Pão d'Assucar* (Sugarloaf) (Wright 1908, 28). Elaborate exhibition halls designed by well-regarded architects in a variety of fantastic

styles and tastes contained exhibits from all twenty states and from Portugal (Appendix H). Wealthier states contributed their own pavilions. Bahía's pavilion with its dome and curved stairways evoked sixteenth century Italy, Minas Gerais's compact building sported a tall spire, while São Paulo's exhibition hall with exotic oriental arches and domes held the largest collection (Wright 1908, 136, 130, 123).

Inside the general exhibition halls or state pavilions people enjoyed displays on agriculture, industry, mining, textiles, shipbuilding, native small craft, inventions, history and art. An aviary with tropical birds delighted visitors (Wright 1908, 121-122). Coffee, including new coffee-processing machinery and fibers of all kinds were common themes in the state exhibits (Wright 1908, 107-108). One could send a telegram, make a phone call, or mail a postcard from the Postal and Telegraph building (Wright 1908, 150-151) or visit the pavilion for Rio de Janeiro's fire brigade (Wright 1908, 156). In an emergency, the Red Cross Society, with well-equipped motorcar ambulances, was there to help (Wright 1908, 154). Visitors could admire thoroughbred horses and goats from Minas Gerais and cattle from Goyaz in the livestock section (Wright 1908, 104-106), hear band concerts or listen to an orchestral performance by indigenous Bororós people from Mato Grosso (Wright 1908, 168-169). Tourists could watch equestrian parades, regattas, fireworks, cinematographs or theater (Wright 1908, 166-167), or they could try out a water fountain on a hot day, a meal at a restaurant, sample refreshments from a kiosk, or ride in a circle train around the grounds (Wright 1908, 28). This celebratory burst of optimism was only possible due to recent steps in public health a few years before, a point made clear in a display on the sanitary service showcased among the many exhibits from the state of São Paulo (Wright 1908, 128).

To get to the Exhibition, visitors took a ferry from Rio de Janeiro or rode fashionably in motorcars down the brand new *Avenida Beira Mar*, then boarded a streetcar to reach the entrance (Wright 1908, 22-23). Well-dressed Brazilian couples with their children, little girls with big bows in their hair and boys in sailor suits, then crossed a wide causeway, passing under a grand archway on their way to explore Brazilian accomplishments and consider a national future not possible only a few years before.

In a sense, this all had less to do with freedom of the seas than with Brazilian nationalism and can-do spirit. Purportedly, the celebration commemorated the exit of D. João VI from Lisbon, Portugal, with the entire court and bureaucracy on board British ships to escape Napoleon's army at the end of 1807, arriving in Rio de Janeiro in 1808, a first step in the development of Brazil as a separate entity. Freedom of the seas, announced by royal decree of the Prince Regent D. João VI when he and his court first touched land at Bahia (Wright 1908, 5-6), was part of a deal struck with the British as a price that the Portuguese monarchy had paid for being rescued. In 1908, strangely, people were celebrating something that had also happened under duress. Maybe, instead, the exhibition was really a nationalist triumph looking for a theme, a triumph of modernity based on freedom from disease. One can say that the struggle against disease had been one of comparable duress against an invading army of microbes and disease vectors. Only this time, Brazilians had stood their ground and were winning.

Lessons and Cautions

The efforts in Rio de Janeiro to fight plague had grown out of the city's long and painful experience with yellow fever. As important as understanding disease vectors was

for Rio de Janeiro and its inhabitants, one should not conflate yellow fever with plague. The two diseases are not much alike, except both are sylvatic diseases that have adapted to the human landscape, and epidemics of both are controlled, by persecuting their most visible vectors, mosquitoes, or rats and fleas. Its code cracked, yellow fever in Brazil was the easier disease to fight, because the disease is adapted to a particular kind of mosquito, *Aëdes aegypti.* Plague travels in the guts of more than thirty species of flea, which are in turn transported in the fur of more than 220 species of rodent and can infect a number of different small and medium sized mammals, not simply rats (Wilson 1995, 458). It is only in an urban context where the two diseases have been equated, in the model of their destruction and prevention. Both are candidates for an indirect ecological approach in designing urban space in ways to discourage mosquitos to breed and rats to become ensconced. Even using this approach, with yellow fever there are fewer moving parts than with plague. Both diseases were imported to Brazil during the nineteenth century and remain dangerous. Using science and knowledge gained from experience, both diseases can be kept at bay, if not truly eradicated.

Transferable lessons can be drawn from the fight against yellow fever and plague in Brazil. We can learn better ways to respond to the threat of vectored diseases. People can strengthen public health and medical research institutions in order to insure that the knowledge is available when a disease threat emerges. A strong partnership between public health and government can speed the ability to respond. Taking the fight to the streets by organizing people around something constructive they can do, rather than confining the battle to the laboratory, gets the public to accept a role in combating disease. It comes down to patience and persistence among scientists, the public, and

politicians. Governments can do well to plan, resources need to be provided, and panic must be avoided.

The history of diseases has been compartmentalized as scholars have focused on each disease separately. Scholars of the Third Plague Pandemic have concentrated on the rapid spread of the disease due to advances in transportation in the late nineteenth and early twentieth centuries. Our attention to it then rapidly diminishes as plague returns in our minds to a netherworld of cartoonish skeletons and giant rats, or is encapsulated on a CDC fact sheet. Scientists have known which bacterium causes plague since Yersin's discovery in 1894, and its genome was decoded in 2011. Yet plague, as a concept, is very old. For centuries plague has represented evil, mystery, divine wrath, panic, desolation, fate, economic devastation, and loss. Framing it according to the experience of a distant time, a common mistake born from fear, leads to denial of its existence in the present. When plague is portrayed in culture as a phantom of the past, real outbreaks of plague often catch people off guard. In an era of genomes, the concept that surrounds this highly ignored dangerous disease is long overdue for revision.

Not only is plague understood as if it existed alone, our knowledge of it has become segmented by region and language. A huge amount of information on plague, gathered in the former Soviet Union during the Cold War or in China, is inaccessible to researchers in the West. Considering that plague is a disease that at times has been widespread, it is counterproductive that these rigid barriers of language and politics persist.

Today there is an opportunity to build a new concept of plague in the Americas that crosses disciplinary and disease boundaries. In the Americas, there has always been

some sharing of knowledge concerning Third Pandemic plague. Increasingly, barriers between English and Spanish and Portuguese have been diminishing. One can follow plague's progress in the Americas in near real time, only a generation removed from direct memory. Plague landed here when germ theory was already accepted, when medical journals brought on the same steamships that brought plague disseminated news, and when the understanding of disease vectors was fresh. A good question for students of plague in the Americas today is how it fits into the pattern of the Columbian Exchange, how plague has performed, from the moment it first came ashore in 1899, in a region that had never encountered it. Many species of fleas, rodents and other small mammals in the continents have now been exposed for the first time to this disease, and the mortality and ecosystem damage in the wild will never be completely known. Scholars have new tools to investigate historical, geographical and social patterns of plague outbreaks in the Americas, while scientists can track plague's ecological impacts over more than a century. Plague deserves serious study to see if it behaves differently over time in our New World laboratory.

A corollary to the concept of plague in the Americas is that plague thrives in an ecology that includes other diseases or conditions of disorganization. Using that as the framework for understanding plague is a better way to keep this fearsome disease in check. This is the important innovation that Brazilians conceived of at the turn of the twentieth century. In Rio de Janeiro in the early twentieth century, plague shared center stage with yellow fever and smallpox and general conditions of urban disorder as the city brimmed with immigrants from abroad and internal migrants from the north. Each disease required a specific strategy, whether catching and exterminating rats, dumping

standing water or isolating sick people at home behind nets, or vaccination. There were limits to what the public would accept as the riots in 1904 over obligatory vaccination against smallpox showed.

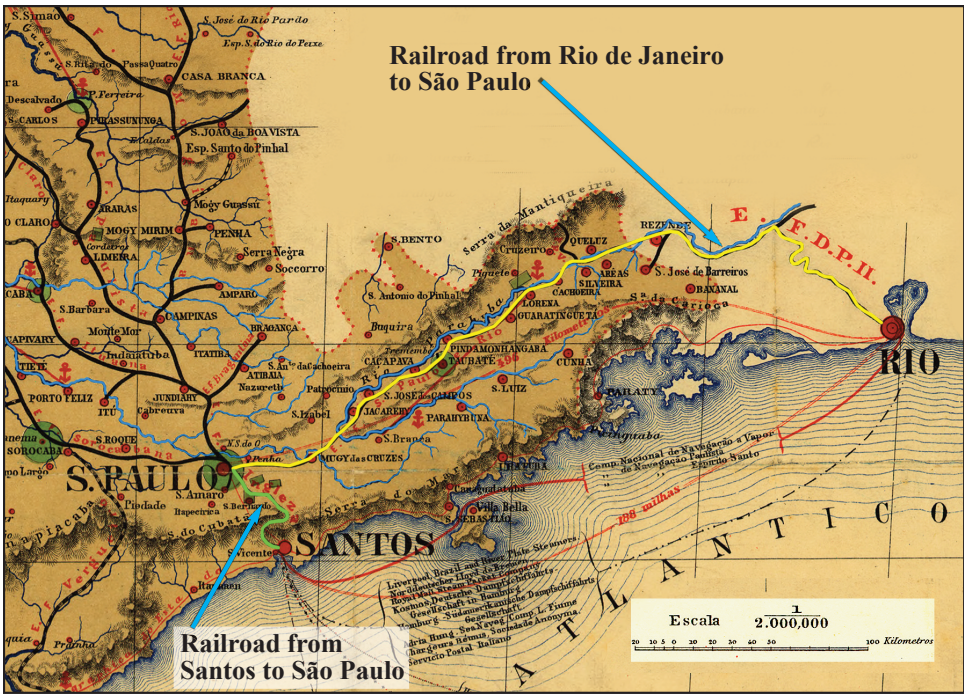
Nevertheless, concerted, prompt and decisive action by Brazilian government and health authorities, against diseases including plague, backed by new medical research and a radical redesign of the urban environment were accomplishments worthy of celebration then and of consideration now. We can learn from a society that considered the health needs of the public and the commercial needs of the country together, recognizing that the country could not move forward if people continued to be victims of epidemic diseases. One must also recognize that Brazil may have responded so dramatically to the reality of plague due to specific pressures and changes in the country in the late nineteenth century, conditions that cannot be replicated, or due to something unique in the larger Brazilian experience. Even so, a comprehensive, ecological approach to disease epidemics in the Americas, taking plague into account, is valuable today as we tackle environmental questions. Here, the coming of plague to Rio de Janeiro, Brazil in 1900 is worth study.

Appendix A.

Plague comes to South America. Source: *South America.* 1892. Map. Chicago: Rand McNally and Co.

Appendix B.

Railroad routes in Southeast Brazil with Rio de Janeiro to São Paulo (yellow) and Santos to São Paulo (green) highlighted. Source: Sociedade Promotora De Immigração De S. Paulo. 1886. *Mappa da provinica de São Paulo*. Library of Congress. Detail.

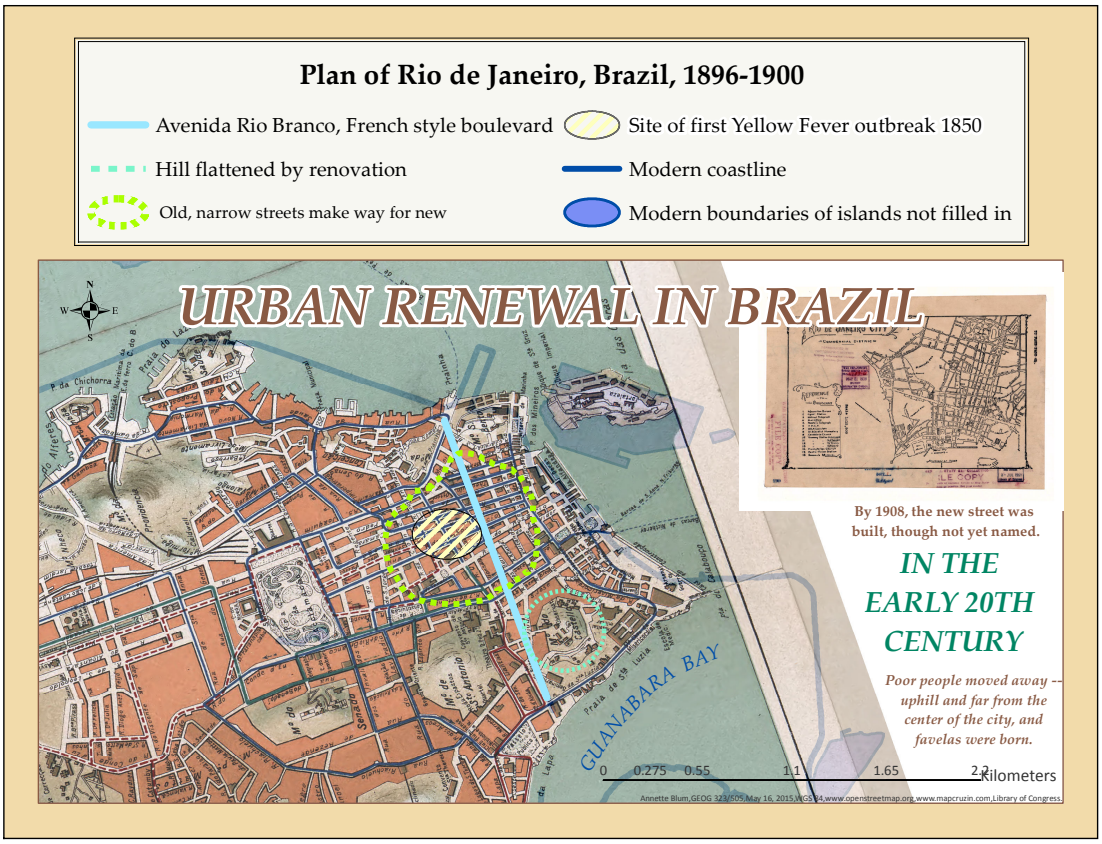


Appendix C.

Plague comes to Rio de Janeiro. First case on Ladeira do Valongo, January 1899. Source: Reis, Manoel Pereira. 1900. *Planta da cidade do Rio de Janeiro*. Rio de Janeiro: Lith. do Archivo Militar. Map. Library of Congress. Detail.

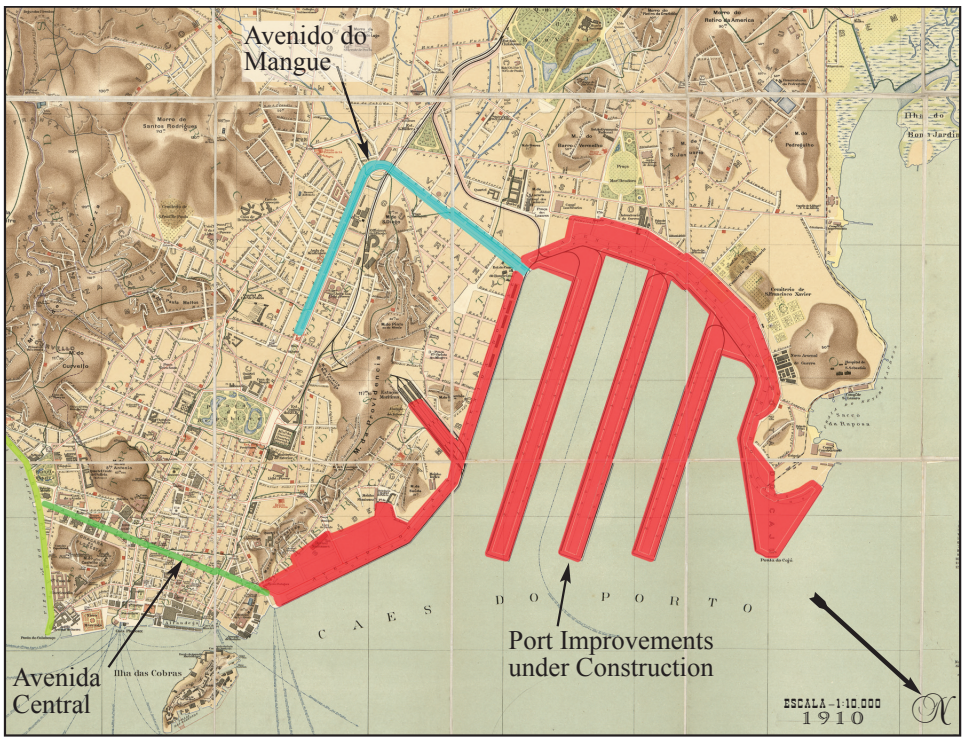
Appendix D.

Avenida Central and the yellow fever zone. Rio de Janeiro in 1900 and 1908 showing yellow fever zone and new *Avenida Central.* Sources: Merian, A. *Planta do Rio de Janeiro com os horarios dos bondes, estradas de ferro, barcas, estradas de rodagem etc*. 1900. Map. Rio de Janeiro: Fauchon & Co. Library of Congress, and *Rio de Janeiro city: Commercial District*. 1908. Map. Library of Congress.



Appendix E.

Avenida do Mangue and Port Improvements in Rio de Janeiro 1903-1910. Source: Mattos, F. Jaguaribe Gomes De. 1910. *Planta da cidade do Rio de Janeiro: obedecendo á divisão da cidade em districtos municipaes*. Rio de Janeiro: Representante depositario Julien Derenne. Map. Library of Congress. Detail.

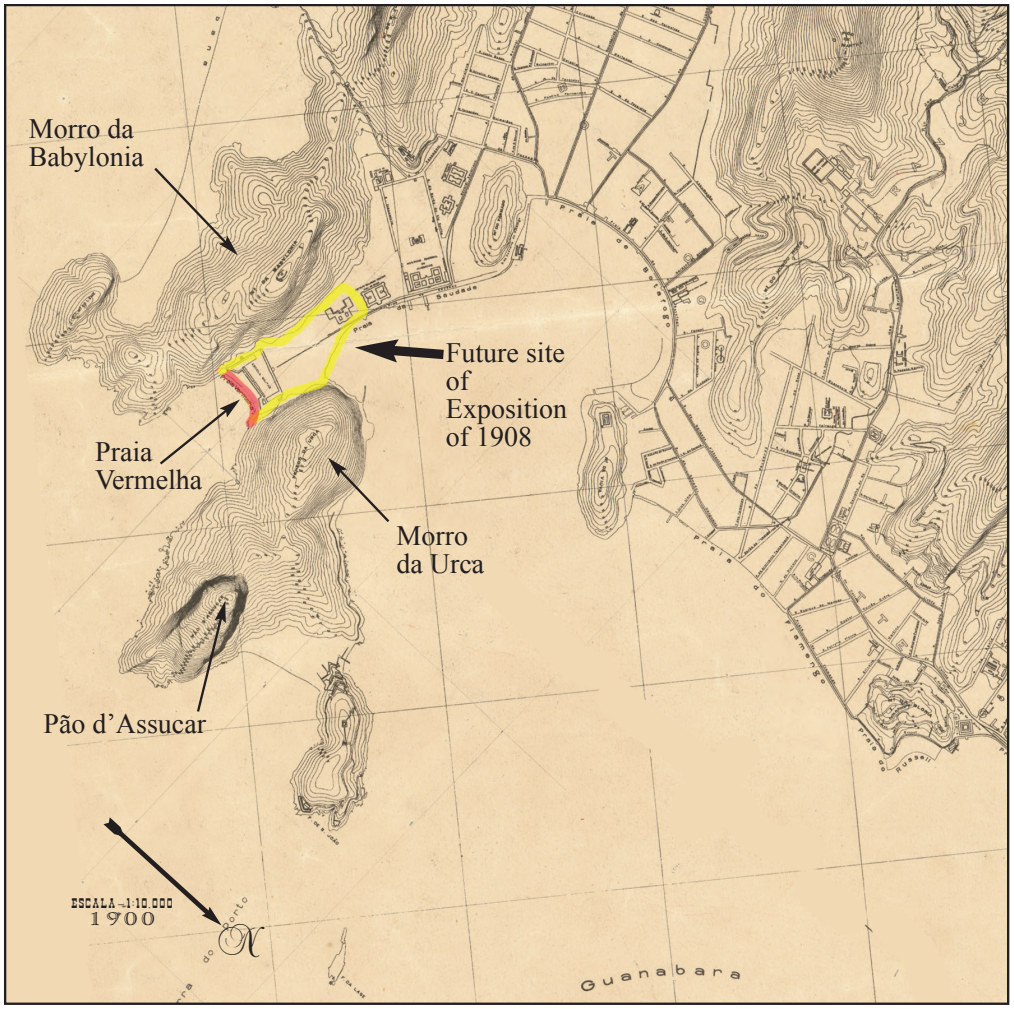


Appendix F.

Avenida Central and *Avenida Beira Mar* to *Praia Vermelha.* Source: Mattos, F. Jaguaribe Gomes De. 1910. *Planta da cidade do Rio de Janeiro: obedecendo á divisão da cidade em districtos municipaes*. Rio de Janeiro: Representante-depositario Julien Derenne. Map. Library of Congress. Detail.

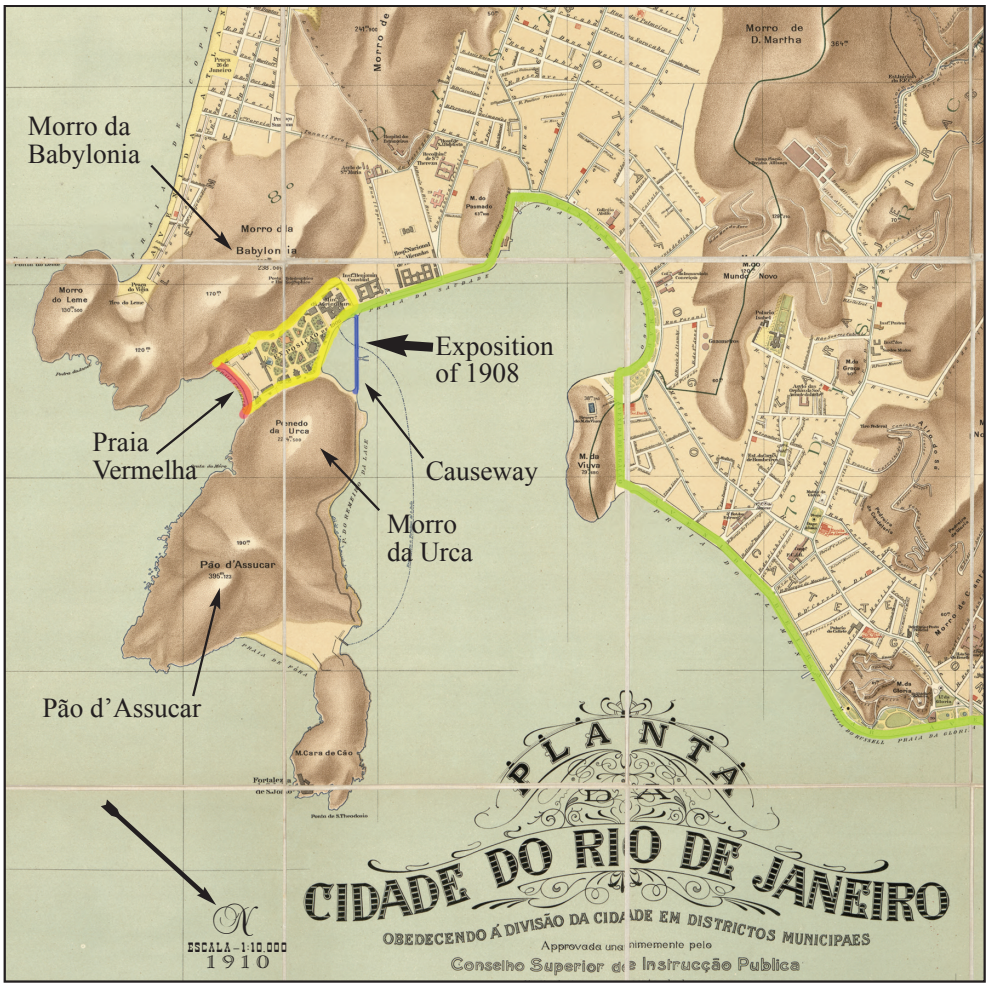
Appendix G.

Praia Vermelha in 1900. Source: Reis, Manoel Pereira. 1900. *Planta da cidade do Rio de Janeiro*. Rio de Janeiro: Lith. do Archivo Militar. Map. Library of Congress. Detail.



Appendix H.

Praia Vermelha in 1900. Source: Mattos, F. Jaguaribe Gomes De. 1910. *Planta da cidade do Rio de Janeiro: obedecendo á divisão da cidade em districtos municipaes*. Rio de Janeiro: Representante-depositario Julien Derenne. Map. Library of Congress. Detail.



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Curriculum Vitae

Annette Blum

[redacted]

Objective:

Continued research into responses to initial outbreaks of Third Pandemic plague.

Education:

Master of Science, Social Science, May 25, 2017, Towson University, Towson, MD
Global Analysis track with thesis, cumulative GPA: 3.6/4.0.

Thesis: Masters of Science in Social Science Thesis, Towson University, Spring 2017, "Plague and Yellow Fever: Unlikely Outlaws Behind the Crisis and Reshaping of Rio de Janeiro in the Early 1900's."

In Third Plague Pandemic history, there is a clear pattern of global response where news that plague had arrived was greeted routinely with denial, delay, and appeal to outside experts. This was not the case when plague came to Brazil in 1899. As part of the response, Brazilian authorities not only employed new tactics against plague, but also seized the political opportunity plague provided to carry out major urban renewal. In this thesis, reasons for such a different response to plague are explored, especially in the context of Brazil's previous history with yellow fever. It is further suggested that Third Pandemic plague be viewed, in the Americas at least, not as a stand-alone disease, but in the ecology of other diseases and conditions of disorder.

Bachelor of Science, May 2013, Towson University, Towson, MD
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