The Royal Society of Medicine

Journal of the Royal Society of Medicine; 2017, Vol. 110(3) 118–120
DOI: 10.1177/0141076817694583

Dramatic effects of control measures on deaths from yellow fever in Havana, Cuba, in the early 1900s

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Background

Yellow fever, named as such due to the jaundice it may cause in an infected person, is a tropical, vector-borne disease, endemic in certain areas of Africa and the Americas.[1] Records suggest that yellow fever in the Americas occurred on the Yucatan peninsula as far back as 1648.[2]

During the early years of yellow fever epidemics in the Americas in the 18th and 19th centuries, European armies suffered greatly from outbreaks. For example, the British army lost 20,000 out of 27,000 men in Cartagena, Colombia in 1741, and the French army lost 8000 men in Santo Domingo in 1803.[3] One of the most significant epidemics occurred in Panama in the late 19th century, when yellow fever and malaria struck French workers constructing the Panama Canal. The project cost thousands of lives lost to yellow fever and malaria, and millions of dollars, contributing with corruption and political scandal, to bankrupting the French company constructing the Canal.[4,5]

Epidemics of yellow fever also plagued cities in the United States. An estimated 10% of the population of Philadelphia was eliminated by the disease in 1793.[6] New Orleans was victim to several outbreaks, causing mass evacuation, with the 1853 epidemic killing an estimated 9000 residents.[7] The 1878 outbreak in the Mississippi Valley resulted in 13,000 cases and 5000 deaths.[3] The disease was dubbed 'yellow jack' because, in addition to causing yellow tinting of the skin, ships displayed a yellow flag when they came into port indicating that persons with the illness were on board.[8]

Initial steps towards yellow fever control

Up until the 19th century, yellow fever was attributed to 'airborne emanations of rotting plant and animal matter, filth, and decay…' otherwise known as *miasmas*, or through objects such as clothing and bedding (*fomites*) spreading infectious diseases through direct contact.[9]

Early accounts of public health efforts to control yellow fever outbreaks before the early 20th century in the southern United States focused on quarantine systems and sanitation ordinances.[6,10] In February 1881, however, at the International Sanitary Conference in Washington DC, the Cuban physician Carlos Finlay hypothesised that an intermediate agent is responsible for spreading yellow fever.[11] In August of the same year, he declared the vector to be the mosquito *Stegomyia fasciata*, which is now known as *Aedes aegypti*.[12]

Finlay's findings were a driving force in the creation of the 4th consecutive United States Army Yellow Fever Commission in Havana, Cuba, which was spearheaded by US Surgeon General Walter Reed and Acting Assistant Surgeons James Carroll, Aristides Agramonte and Jesse Lazear.[13] After running experiments in Havana and a nearby camp site, Los Quemados, the commission confirmed in 1900[14] that yellow fever is indeed caused by the mosquito known today as *Aedes aegypti*.[15]

In 1901, following the Reed Commission's findings, two mosquito elimination campaigns were started in Havana, Cuba, by the US Army, which had occupied the island. Jefferson Randolph Kean and William Crawford Gorgas started parallel elimination campaigns of the mosquito responsible for malaria (*Anopheles*) and that responsible for yellow fever.[16] Around the same time, period, other similar interventions in the Americas included a dual elimination of both *aedes* and *anopheles* run by Oswaldo Cruz in Rio de Janeiro, Brazil,[17] and a campaign focused solely on *Aedes* by Emilio Rivas in Sao Paulo Brazil, a tactic that later proved to be more economically sound.[17]

William Gorgas' campaign to control yellow fever in Havana, Cuba

Following the end of the Spanish-American War at the end of the 19th century, Major William Gorgas was appointed Chief Sanitary Officer in Havana in 1898, with the objective of eradicating yellow fever and malaria.[18] At the same time, the United States began its occupation of Cuba and subsequently began massive public health interventions to reduce the incidence of yellow fever using sanitation policies, quarantine regulations and publication of public health reports in newspapers.[19]

Gorgas implemented an intervention aimed at eliminating *Aedes aegypti*. On 1 March 1901, martial law was declared on all residents of Cuba, and people migrating into Havana. People residing on the island were classified as either *non-immune*, because they had no medical history of yellow fever; or *immune*, because they had a past history of yellow fever (albeit unconfirmed with any serological tests). Throughout the 19th century, it had been assumed that people who had lived for several months in an infected area acquired some protection against yellow fever (and other tropical diseases) and were considered as immune or 'adapted'. The word 'immune' had no immunological meaning.

Gorgas' elimination intervention was divided into vector control, quarantine of active yellow fever cases, and port and city entrance supervision and inspection. The objective of vector control was to prevent reproduction of mosquito larvae and to eliminate both larvae and adult mosquitos. Havana was divided into 20 districts; each district was assigned a sanitation team responsible for house inspections, chemical treatment of drinkable water, and mosquito-proofing of all receptacles containing water. All activities were reported to the central sanitation unit. Teams were also assembled to monitor and treat stagnant water around the city.[20,21]

Every residence in which there was a suspected case of yellow fever was sealed, and pyrethrum powder was burned to eliminate adult mosquitos. After the pyrethrum burning was complete, residences were thoroughly scanned for mosquitoes. All hospitals were made mosquito proof, and guards were placed at every wire door to ensure compliance with the protocol, which required exclusion of non-immune people from yellow fever wards.[20,21]

All arrivals at the port were taken to the immigration station, where they were obliged to report their destinations and register with and attend the nearest hospital for two months. Those whose destinations were outside Havana were sent there directly, without entering the city. The martial law decree required compulsory segregation of non-immune people residing outside Havana in two camps, located in Quemados and Santiago. Inspection posts were placed at all entrances to Havana to document and report the names and addresses of individuals considered to be non-immune. This protocol included visits by inspectors to their residences to look for signs and symptoms of yellow fever on the third and sixth day following visits to Havana.[20,21]

Between 1890 and 1900, there had been an annual average of 462 yellow fever deaths in the city of Havana. In January and February 1901, 12 deaths were recorded due to yellow fever.[20,21] The last death from yellow fever reported during the United States occupation occurred on 28 September 1901. A report sent to the senate by Gorgas, dated 22 January 1903, stated that Cuba remained free of yellow fever, so accomplishing the previously established 18-month benchmark for evidence of eradication.[22,26]

Conclusion

The elimination of yellow fever in Havana proved to be a success for public health, but it was not without controversy. While tackling the disease proved to be a turning point in modern public health, specifically in vector control, it came about as a result of military rule by an occupying power.

The control of the deadly disease was possible through scientific research followed by public health interventions that are, albeit modified, still employed today. A combination of Finlay's postulated mode of transmission of yellow fever, the Reed commission's confirmation that Finlay's hypothesis was correct, and Gorgas' determination to use rigorous control measures to eradicate the mosquito from the island, resulted in a dramatic decrease in incidence of a vector-borne disease.

Similar success in eradicating malaria continues to remain elusive. When there has been success it has depended on populations being either self-disciplined, such as those in trade unions, or disciplined by others, such those in the armed forces and prisons.[23–25]

Declarations

Competing interests: None declared.

Funding: None declared.

Ethics approval: Not applicable.

Guarantor: RIL

Contributorship: RIL did the initial archival research for this article and prepared the first draft. ACC did additional archival research and contributed to the final draft of the article.

Acknowledgements: Rodriguez Abreu provided research assistance at the National Library of Medicine and National Library of Congress. Gabriel Gachelin provided comments on earlier drafts of the manuscript. Luis Gabriel Cuervo provided overall mentorship and facilitated completing this work as part of an internship at PAHO/WHO.

Provenance: Invited article from the James Lind Library

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