Assessing the Global Distribution and Surveillance of Yaws

by

Zachary Pierre

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This essay was presented

by

Zachary Pierre

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and approved by

Essay Advisor: Mackey R. Friedman, PhD, MPH, Assistant Professor, Infectious Diseases and Microbiology, Graduate School of Public Health, The University of Pittsburgh

Essay Reader: Linda Rose Frank, PhD, MSN, FAAN, Professor, Infectious Diseases and Microbiology, Graduate School of Public Health, The University of Pittsburgh

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Zachary Pierre, MPH

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Abstract

Background: Yaws is a Neglected Tropical Disease spread by skin-to-skin contact. Left untreated, yaws can lead to lifelong pain and disfigurement. Yaws is readily treatable with antibiotics, leading to global efforts to eradicate the disease in the 1950s and 1960s. However, those efforts were not completed, and as time has passed the global distribution and prevalence of yaws is unknown.

Objective: The aim of this systematic literature review is to assess the current standing of yaws surveillance systems to identify gaps in understanding of yaws prevalence in countries with histories of yaws. It will also identify published literature that presents evidence of yaws transmission in countries lacking in surveillance data.

Methods: WHO data was reviewed to establish the current understanding of yaws prevalence and surveillance. Then, following the identification of a previous systematic literature review, keywords were searched in PubMed pertaining to yaws. Finally, regional WHO offices, including reports and programming, were searched for additional information.

Results: A total of 39 articles which fulfilled inclusion criteria were reviewed. In some instances, published journal articles match official WHO data, suggesting that there may be no governmental surveillance for yaws happening in those countries. Additionally, official data was found to be contradictory with official data and reports presenting different information and data. Recommendations on how to prioritize and operationalize yaws eradication programming are available to address the gaps in data and understanding identified in this essay.

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1.0 Background

1.1 Yaws: The Infection

Yaws is an endemic treponemal infection caused by *Treponema pallidum* sub-species *pertenue.* Though closely related to the causative agent of syphilis, yaws is not spread by sexual contact but by direct skin-to-skin contact. Without treatment, yaws is a chronic infection with relapsing disease. In the past, yaws was treated with benzathine benzylpenicillin, but is currently treated with a single dose of oral azithromycin (Marks, 2018).

Yaws disease presents in three distinct phases. In the primary phase, the initial lesion appears at the site of exposure after approximately 21 days (Mitijà and Asiedu, 2016). This lesion usually appears as a localized papule that can develop into a papilloma that turns into an ulcer if untreated. For most, this lesion will heal between 6-9 months without treatment. In the secondary stage, new lesions occur (typically one to two months after the first). They are raised, yellowish lesions and can be accompanied by pain, general malaise, swollen lymph nodes, and swelling of bones.

The third phase, tertiary yaws, is thought to occur in up to 10% of patients not treated for the disease. This phase is hallmarked by more serious and lasting damage to skin and bones. Patients that recover from the symptoms of primary and secondary yaws (with or without lasting damage or scarring) without progression to tertiary yaws but who are not treated are said to have latent yaws. Infectious relapses can occur for untreated patients with latent yaws.

Field tests for yaws are available, but are of limited used as they cannot distinguish between past and current infection (World Health Organization, 2019). Laboratory antibody tests are

available for yaws, but similarly they are unable to differentiate between past and current infection (or even differentiate between yaws and syphilis), requiring polymerase chain reaction (PCR) testing for a definitive result. However, because PCR is not readily available in many areas, diagnosis of yaws can be made clinically given the characteristic symptoms of the disease. The WHO notes that up to 40% of ulcers identified as yaws are actually caused by the unrelated H. ducreyi, so accurate diagnosis requires both testing and a clinical assessment.

1.2 Historical Efforts to Eradicate Yaws

The historical effort to eradicate yaws is best summarized by a 2014 paper by Kingsley Asiedu, Christopher Fitzpatrick, and Jean Jannin. In it, they write that endemic treponematoses, including yaws, were such a major health burden that the World Health Organization (WHO), founded in 1948, resolved in 1949 to support the control of these infectious diseases. WHO held its first international conference on yaws in 1952 in Thailand to establish the global distribution of the disease and discuss lessons learned from nations that had taken up efforts to control yaws. By 1955, in Nigeria at WHO's second international conference on yaws, enough was known about the control of yaws that guidelines for the eradication of the disease were established, noting that, "success would depend on 100% treatment coverage of both active clinical disease and latent infections; anything below 90% was considered inadequate."

Before large-scale control campaigns, endemic treponematoses infected 50-150 million people per year (Hackett, 1953). Other estimates say that in the 1950s, an estimated 50 million people in 85 countries and territories were infected with yaws specifically (World Health Organization, 2018a; Mitijà and Asiedu, 2016). But, as Asiedu et. al. write, mass treatment

campaigns supported by WHO and by the United Children's Fund (UNICEF) running between 1952-1964 screened "about 300 million people… and over 50 million cases and contacts were treated. By the end of the campaign, the global burden of cases of endemic treponematoses was estimated to have reduced by 95%, to just 2.5 million" (Asiedu et. al., 2014; Marks, 2018). At that point, mass campaigns were downscaled and the remaining work of eradication was left to each individual nation to manage.

1.3 Current Status of Yaws

Left to individual nations to manage, the world did not eradicate yaws. The reduced disease burden meant that yaws fell off of the global agenda, leading to a resurgence in the 1970s (Asiedu et. al., 2014). Some countries took efforts to control the disease in response, but yaws was largely deprioritized until 2012 when WHO met in Switzerland to outline an updated plan for eradication. By that point yaws was considered a neglected tropical disease, and WHO committed to it being the third disease eradicated by 2020 after dracunculiasis and poliomyelitis by way of the Morges Strategy (World Health Organization, 2012).

The Morges Strategy is dependent upon two components. The first is mass treatment of communities endemic with yaws with oral azithromycin. This approach is also referred to as total community treatment (TCT). The Morges Strategy also calls for total targeted treatment (TTT), which is the treatment of clinical cases of yaws and treatment of patient contacts (Dyson et al., 2019). For the Morges Strategy to succeed, then, it is imperative to know where yaws cases are and in what number.

A systematic literature review by Mitijà et al. found that in the years 2010-2013, there were approximately 65,000 cases per year in 13 countries endemic for yaws, while incidence was unknown in other countries with a history of the disease. This is compared to what had previously been the most recent systemic literature review up until that point, published in 1992, that showed 85,000 cases per year in 33 endemic countries (Meheus & Antal, 1992).

As 2020 has passed, some are eyeing 2030 as the target for yaws elimination (Holmes et al., 2020). However, this goal will not be possible given the current status of surveillance systems and data on this disease as is. While some areas are well known still be experiencing disease transmission, surveillance efforts for the disease in other areas have been reduced, in some cases to the point of elimination, making it impossible to know the true incidence and prevalence of yaws, and thus, impossible to know exactly which communities would benefit from TCT and TTT.

A 2015 systemic literature review by Mitijà et al. summarizes the situation by saying:

> "Little activity to control the infection has been undertaken since 1990. The scarcity of political will, inadequate funding, and weaknesses in primary health-care systems in affected countries have been the biggest obstacles to the reduction of the burden of yaws in the past two decades" (Mitijà et al.).

There exists then a need to first understand what activities currently take place to surveil and study yaws, and that is what this essay explores. To bridge the gap in understanding of the global distribution of yaws, this essay will look at gaps in surveillance data in countries with histories of yaws and identify literature that can confirm yaws cases in countries where these gaps exist. Ultimately, doing so can help to understand the systems and the scope of effort needed to finally eradicate this disease.

2.0 Methods

The World Health Organization Global Health Observatory was assessed to understand the current status of yaws endemicity, categorized as either “no previous history of yaws,” “previously endemic (current status unknown),” “currently endemic,” or “interrupted transmission” (World Health Organization, 2021). The interactive data repository and visualizer of the Global Health Observatory was then accessed to determine which countries with an endemicity status of previously endemic (current status unknown), currently endemic, or interrupted transmission had data available on reported confirmed and suspected cases of yaws.

Data on both confirmed and suspected cases were available for the years 2017-2020, and so this essay will be limited to those years. This data was first accessed in March 2021 when data was only available for the years 2017 and 2018, but the data was updated in 2021 to include data for 2019-2020. This update is not dated, so it is unknown precisely when it was published, and it resulted in discrepancies that are not explained.

Next, a preliminary search on PubMed of “yaws” returned “Global epidemiology of yaws: a systematic review” by Mitijà et al. published in 2015. A literature search was modeled off of this review using the same keywords (“yaws” OR “treponematosis” AND “prevalence” OR “incidence”) OR (“yaws” AND [each individual previous and current yaws-endemic country]) but limiting results to those published in 2017 or later to provide an updated understanding of the current epidemiological status of yaws in the years since this review was completed. Given the low number of results, a search with just ("yaws" OR "treponematosis") for the same time span was completed. Titles and abstracts were analyzed to see if they contained information on

confirmed cases from countries where the WHO did not have data. Full texts of these results were then read and analyzed.

A search was also conducted in WHO Institutional Repository for Information Sharing (IRIS) records utilizing a search method optimized by Fitzpatrick et al (2018) first identified in the preliminary search that included local names; the terms "yaws OR treponematoses OR "Treponema pertenue" OR frambesia OR framboesia OR pian OR buba OR bouba" were searched, but limited to publications the authors found success in. More information on these searches is below in Figure 1.

On the recommendation of an expert on the history of Neglected Tropical Diseases (Mari Webel, personal communication, Sept 29, 2021), the websites for the regional offices of WHO were accessed and searched for recent information or publications on yaws that would not have been included in the above search of the WHO Institutional Repository for Information Sharing (IRIS) records. Each regional office's "Health Topics" page was checked for either "yaws," "neglected tropical disease," or "tropical disease."

The results in this essay will be presented according to their global region as grouped by WHO. First, countries with a history of yaws will be identified along with what is known about their current yaws status. Then, official WHO data on suspected case (defined as "a person with a history of residence in an endemic area [past or present] who presents with clinically active yaws-like lesions,") and confirmed cases ("a suspected or probable case that is both treponemal and non-treponemal positive on [a rapid test] and/or positive PCR.") will be presented (World Health Organization, 2018b). Finally, findings from the literature search that show evidence of yaws transmission not captured in WHO data will be presented. Gaps and weaknesses in these data will be addressed throughout.

3.0 Results

Publications on yaws in recent years have been limited. Thirty-five articles met the inclusion criteria, with all seven articles included from the first search overlapping with the second. Included results were primarily case studies and cross-sectional studies. Of the 35 included articles, 17 contained no information on yaws in specific countries; these articles addressed either modeling methods for yaws, treatment protocols for yaws, or discussed yaws as broad topic.

Three articles addressed the historic presence of yaws in specific countries, but did not provide any evidence of its current prevalence there. Two articles were further excluded due to their data being from outside the inclusion criteria. The one article identified from the WHO IRIS database reported on the status of yaws surveillance, but not the prevalence of the disease. Twelve articles contained information on yaws in specific countries, both providing evidence of both its presence and its absence in those countries. More details on search results are below in Figure 1 and a more detailed summary of included literature is in Appendix A.

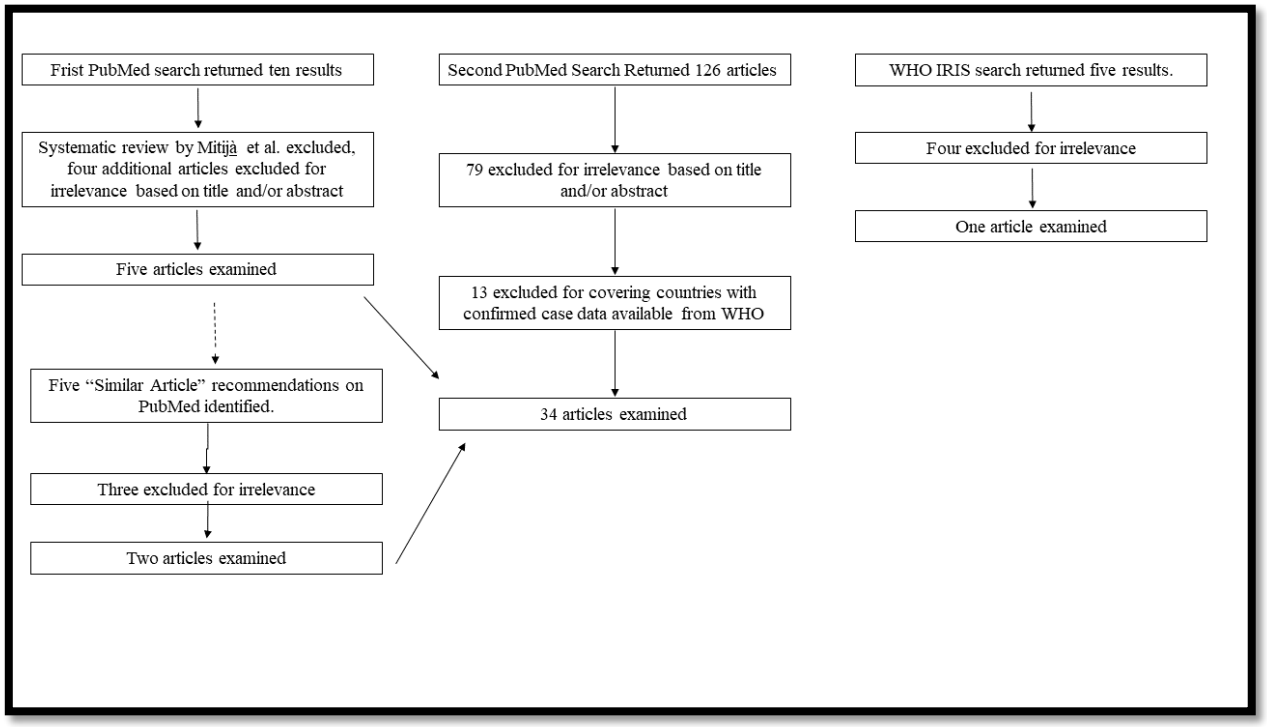

Figure 1- Literature Search Resuls

It is difficult to know the exact status of yaws eradication due to the lack of robust surveillance for the disease; reporting yaws infections to WHO has not been mandatory since 1990, possibly explaining the gaps in surveillance data discovered (Zoni et al., 2019). Of the 99 countries with histories of yaws, one (India) is classified as having achieved "interrupted transmission", 15 countries are classified as "currently endemic," and 83 are classified as "previously endemic (current status unknown)" (World Health Organization, n.D.). A lack of ongoing research into the incidence and prevalence compounds the difficulty in knowing the current status of yaws around the world.

The surveillance systems for yaws that do exist contain significant weaknesses. As will be evident in this section, many of the countries that are known to have a history of yaws do not report data to WHO, while many of the data that is reported suffers shortcomings. The most obvious

example of this is that the most recently updated surveillance data on yaws available from WHO, updated in the summer of 2021, contradicts data previously reported by WHO accessed in March 2021. Additionally, there are a number of countries and territories with known histories of yaws that do not appear in the front-facing "Status of yaws endemicity" data and can only be seen in the "Endemic treponematoses" data visualizer.

3.1.1Americas-WHO Data

In the Americas region, 33 countries are known to have a history of yaws, listed below in Table 1 (World Health Organization, n.D.). Six countries or territories (Aruba, British Virgin Islands, French Guiana, Guadeloupe, Martinique, and Netherlands Antilles) do not appear in the front-facing WHO data on yaws endemicity status and can only be seen in the data visualizer. All 33 countries have their current endemicity status as "previously endemic, current status unknown." Data available after the 2021 update is in Table 2, while the data previously available is in Table 3. Comparing the two, data on suspected cases in Ecuador and Guatemala have disappeared. All other countries, both before and after the 2021 update, had no data available for either confirmed or suspected cases for these years and have been excluded from Tables 2 and 3.

Table 1 Countries with a history of yaws (all "Previously endemic, current status unknown")

Antigua and Barbuda	Dominican Republic	Martinique
Aruba	Ecuador	Netherlands Antilles
Bahamas	El Salvador	Nicaragua
Barbados	French Guiana	Panama
Belize	Grenada	Peru
Brazil	Guadeloupe	Saint Kitts and Nevis
British Virgin Islands	Guatemala	Saint Lucia
Colombia	Guyana	Saint Vincent and the Grenadines
Costa Rica	Haiti	Suriname
Cuba	Honduras	Trinidad and Tobago
Dominica	Jamaica	Venezuela (Bolivarian Republic of)

Table 2 Cases of yaws reported in the Americas region after 2021 updated

	Confirmed Cases				Suspected Cases			
	2020	2019	2018	2017	2020	2019	2018	2017
Cuba	No data	0	0	0	No data	No data	0	0
Ecuador	No data	0	0	0	No data	No data	No data	No data
Guatemala	No data	No data	No data	No data	No data	No data	No data	No data
Suriname	No data	0	0	0	No data	No data	No data	No data

Table 3 Cases of yaws reported in the Americas region before 2021 update

	Confirmed Cases		Suspected Cases	
	2018	2017	2018	2017
Cuba	0	0	0	0
Ecuador	0	0	682	129
Guatemala	No data	No data	92	51
Suriname	0	0	No data	No data

3.1.2 Americas- Literature Findings

A systematic review by Zoni et al (2019) of the epidemiological evidence of yaws in the Americas reveals that data on the current status of yaws in the region has become scarce after it was dropped from the WHO list of mandatory reportable infections. This review states that between 2014 and 2017, two countries in the region, Haiti and Colombia, identified yaws cases, but this data is not cited and so it is not clear when those two countries identified cases or how many cases were identified, though it does state that seven cases were seen in Haiti in 2015.

3.1.3 Pan American Health Organization

No additional information or recent publications on yaws were identified on the website for the regional WHO office for the Americas, the Pan American Health Organization. Yaws is not mentioned as one of the agency's "Infectious Diseases Candidates for Elimination by 2030" (Pan American Health Organization, n.D.). A search for "yaws" as a "topic" returned no results.

3.2.1 Africa: WHO Data

As of 2021, According to the WHO there are 35 countries in this region with a known history of yaws. Of the 35, 26 countries are considered to be “previously endemic (current status unknown)” and nine are listed as “currently endemic” (World Health Organization, n.D.). Those countries, and their current status, are identified below in Table 4. Table 5 displays the most up-to-date data available from WHO; information is available from 13 countries, an increase from 10 from the previously available data. After the most recent update, data from Guinea has for 2018 has been changed; this is shown in Table 6, which reflects data for 2017 and 2018 available from WHO prior to the most recent update.

Table 4 Current status of countries with a history of yaws

Angola	Previously endemic (current status unknown)	Kenya	Previously endemic (current status unknown)
Benin	Currently endemic	Liberia	Currently endemic
Burkina Faso	Previously endemic (current status unknown)	Madagascar	Previously endemic (current status unknown)
Burundi	Previously endemic (current status unknown)	Malawi	Previously endemic (current status unknown)
Cote d'Ivoire	Currently endemic	Mali	Previously endemic (current status unknown)
Cameroon	Currently endemic	Mozambique	Previously endemic (current status unknown)
Central African Republic	Currently endemic	Niger	Previously endemic (current status unknown)
Chad	Previously endemic (current status unknown)	Nigeria	Previously endemic (current status unknown)
Comoros	Previously endemic (current status unknown)	Rwanda	Previously endemic (current status unknown)
Congo	Currently endemic	Senegal	Previously endemic (current status unknown)
Democratic Republic of the Congo	Currently endemic	Sierra Leone	Previously endemic (current status unknown)
Equatorial Guinea	Previously endemic (current status unknown)	South Sudan	Previously endemic (current status unknown)
Ethiopia	Previously endemic (current status unknown)	Togo	Currently endemic
Gabon	Previously endemic (current status unknown)	Uganda	Previously endemic (current status unknown)
Gambia	Previously endemic (current status unknown)	United Republic of Tanzania	Previously endemic (current status unknown)
Ghana	Currently endemic	Zambia	Previously endemic (current status unknown)
Guinea	Previously endemic (current status unknown)	Zimbabwe	Previously endemic (current status unknown)
Guinea-Bissau	Previously endemic (current status unknown)		

Table 5 Cases of yaws reported in the African Region after 2021 update

	Confirmed Cases				Suspected Cases			
	2020	2019	2018	2017	2020	2019	2018	2017
Angola	0	No data	No data	No data	0	No data	No data	No data
Benin	9	No data	4	No data	9	11	4	No data
Burkina Faso	No data	No data	0	0	No data	No data	No data	No data
Cameroon	No data	No data	150	53	No data	1,713	2,591	1,237
Cote d'Ivoire	20	No data	30	15	564	1,749	3,240	1,749
Democratic Republic of the Congo	18	No data	27	No data	45	40	27	No data
Ghana	146	No data	448	26	4,695	1,483	1,833	1,917
Guinea	0	No data	No data	No data	0	No data	3,652	No data
Guinea-Bissau	No data	No data	0	0	No data	No data	0	0
Liberia	No data	No data	24	0	No data	No data	24	0
Senegal	No data	No data	0	0	No data	No data	No data	No data
Sierra Leone	0	No data	No data	No data	0	No data	No data	No data
Togo	24	0	No data	No data	291	No data	No data	No data

Table 6 Cases of yaws reported in the African Region before 2021 update

	Confirmed Cases		Suspected Cases	
	2018	2017	2018	2017
Benin	4	No data	4	No data
Burkina Faso	0	0	No data	No data
Cameroon	150	53	2,591	1,237
Cote d'Ivoire	30	15	3,240	1,749
Democratic Republic of the Congo	27	No data	27	No data
Ghana	448	26	1,833	1,917
Guinea	0	No data	3,652	No data
Guinea-Bissau	0	0	0	0
Liberia	24	0	24	0
Senegal	0	0	No data	No data

3.2.2 World Health Organization: Regional Office for Africa

A search for "yaws" returned 17 results. Only one result had information on yaws cases, pertaining to an outbreak that occurred in Cameroon in 2017 (Regional Office for Africa, 2017). The Regional Office for Africa does have a data tracker for Neglected Tropical Diseases, but the only indicator it tracks is "Number of people requiring interventions against neglected tropical diseases" (Regional Office for Africa, n.D.).

3.2.3 Africa: Literature Findings

An earlier review identified seven countries in the African region as being endemic for yaws in 2012, stating that hot-spots for yaws included Ghana and the indigenous populations in the tropical forest region along the Congo, Cameroon and Central African Republic borders (Kazadi et. al, 2014). According to the abstract, a 2017 survey of one community conducted by the Central African Republic (CAR) Ministry of Health found 137 clinical cases of yaws; 102 cases had positive laboratory tests (Um Book, 2019). This study also claims that 79% of those cases were the "high contagious form." Full text was not available. Another study published in 2019 showed the results of health survey in z; 28 suspected cases were identified over an 8-day period; however, full text was not available so it is unknown where these cases were found (Zeba et al., 2019).

Finally, a study out of London School of Hygiene and Tropical Medicine published in 2021 but conducted in 2018 confirmed 24 cases of yaws in Liberia (Timothy et al., 2021). It is possible that these are the 24 cases that have been reported by Liberia in 2018 shown in the table above.

3.4 Eastern Mediterranean

Two countries, Somalia and South Sudan, are classified as "Previously endemic (current status unknown)." No data on suspected or confirmed cases for 2017-2020 is available in the Global Health Observatory (World Health Organization, n.D.). No information or data regarding these two countries were identified in the literature examined. South Sudan does not appear in the forward-facing data on yaws endemicity and can only be seen in the data visualizer. No additional

information was identified through the WHO Regional Office for the Mediterranean; yaws is neither a health topic to explore or covered under “Neglected Tropical Diseases” page (World Health Organization Regional Office for the Eastern Mediterranean, n.D.).

3.5 Europe

No country in Europe is known to have a previous history of yaws.

3.6.1 South-East Asia: WHO Data

In the South-East Asia region six countries are known to have history of yaws; those countries and their current status are below in Table 7. (World Health Organization, n.D.). Data available from WHO after the 2021 update is in Table 8, while the data previously available is in Table 9. Comparing the two, data for suspected cases in 2017 and 2018 have been changed for Indonesia, while data for both confirmed and suspected cases in Timor-Leste have changed for both years.

Table 7 Current status of countries with a history of yaws

India	Interrupted transmission
Indonesia	Currently endemic
Myanmar	Previously endemic (current status unknown)
Sri Lanka	Previously endemic (current status unknown)
Thailand	Previously endemic (current status unknown)
Timor-Leste	Currently endemic

Table 8 Cases of yaws reported in South-East Asia after 2021 update

	Confirmed Cases				Suspected Cases			
	2020	2019	2018	2017	2020	2019	2018	2017
India	No data	No data	0	0	Interrupted transmission	Interrupted transmission	Interrupted transmission	Interrupted transmission
Indonesia	81	673	353	1,218	81	673	353	1,218
Timor-Leste	No data	No data	0	3	No data	No data	194	3,098

Table 9 Cases of yaws reported in South-East Asia before 2021 update

	Confirmed Cases		Suspected Cases	
	2018	2017	2018	2017
India	0	0	Interrupted transmission	Interrupted transmission
Indonesia	353	1,218	No data	285
Timor-Leste	1	1	1	No data

3.6.2 WHO South-East Asia

No additional information on yaws was identified.

3.6.3 South-East Asia: Literature Findings

No literature was found to contain information on yaws transmission in this region.

3.7.1 Western Pacific: WHO Data

In the Western Pacific region of the world, as of 2018, 19 countries are considered "previously endemic (current status unknown)" and four are considered "endemic" (World Health Organization, n.D.). Those countries are below in Table 10. Five countries or territories (American Samoa, Guam, Norther Mariana Islands, Pitcairn Islands, and Wallis and Futuna) are not available in the WHO front-facing endemicity data and can only be seen in the data visualizer. Data available for the region after the 2021 update is in Table 11, while the previously available data is in Table 12. Comparing the two, suspected cases in 2017 and 2018 has changed for Papua New Guinea, while data on both confirmed and suspected cases in 2017 and 2018 has changed for Vanuatu.

Table 10 Current status of countries with a known history of yaws

American Samoa	Previously endemic (current status unknown)	Northern Mariana Islands	Previously endemic (current status unknown)
Australia	Previously endemic (current status unknown)	Papua New Guinea	Currently endemic
Cambodia	Previously endemic (current status unknown)	Philippines	Currently endemic
Cook Islands	Previously endemic (current status unknown)	Pitcairn Islands	Previously endemic (current status unknown)
Fiji	Previously endemic (current status unknown)	Samoa	Previously endemic (current status unknown)
Guam	Previously endemic (current status unknown)	Solomon Islands	Currently endemic
Kiribati	Previously endemic (current status unknown)	Tonga	Previously endemic (current status unknown)
Lao People's Democratic Republic	Previously endemic (current status unknown)	Tuvalu	Previously endemic (current status unknown)
Malaysia	Previously endemic (current status unknown)	Vanuatu	Currently endemic
Marshall Islands	Previously endemic (current status unknown)	Viet Nam	Previously endemic (current status unknown)
Micronesia (Federated States of)	Previously endemic (current status unknown)	Wallis and Futuna	Previously endemic (current status unknown)
Nauru	Previously endemic (current status unknown)		

Table 11 Cases of yaws reported in the Western Pacific after 2021 update

	Confirmed Cases				Suspected Cases			
	2020	2019	2018	2017	2020	2019	2018	2017
Papua New Guinea	No data	No data	No data	No data	81,369	69,723	54,082	25,444
Philippines	No data	No data	No data	14	No data	No data	No data	150
Solomon Islands	No data	No data	0	0	No data	13,694	13,047	13,415
Vanuatu	48	99	205	169	823	374	728	504

Table 12 Cases of yaws reported in the Western Pacific before 2021 update

	Confirmed Cases		Suspected Cases	
	2018	2017	2018	2017
Papua New Guinea	No data	No data	53,809	25,384
Philippines	No data	14	No data	150
Solomon Islands	0	0	13,047	13,415
Vanuatu	140	104	1,245	681

3.7.2 WHO Regional Office for the Western Pacific

Yaws is listed as a Health Topic for this regional office. The page for yaws contains links to the WHO Global Health Observatory for more data on yaws, but it does state that four countries in the region are endemic for yaws: Cambodia, China, Philippines, and Lao People's Democratic Republic (World Health Organization Western Pacific, 2018). This contradicts the broader WHO

data that states that while Philippines are currently endemic, Cambodia and Lao People's Democratic Republic are considered "previously endemic (current status unknown) and China is considered "No previous history of yaws."

3.7.3 Western Pacific: Literature Findings

According to Marks and Mitijà, "close to 100%" of the population of Papua New Guinea, the Solomon Islands, and Vanuatu are "assumed" to be at risk for yaws (2019, p 144). These same authors also note that bone involvement in yaws infections seem to be more prominent in this region than in others as is documented in a 2017 case review of a boy in Papua New Guinea with yaws osteoperiostitis (González-Beiras et al., 2017). Papua New Guinea only reports suspected cases, but in a 2018 *Science* article that follows Dr. Oriol Mitijà, he treats yaws cases in Papua New Guinea, confirming that yaws transmission was still occurring in the country (Enserink, 2018).

A study of children in the nation of Kiribati by Handley at al. (2019) aged 1-9 found two children who tested positive for exposure to yaws. Clinical examinations were not conducted and there are limitations with the test that the researchers used, but while such low levels indicate that there is not wide-spread transmission of yaws in Kiribati, it is possible that low-levels of transmission are occurring.

4.0 Discussion

As is shown in this essay, the surveillance systems for yaws that currently exist are not ready to support meaningful eradication efforts. Official data is scare, and sometimes even contradictory, while many countries struggle to confirm cases due to low access to PCR testing. A 2017 survey can partially explain the situation: of 164 countries contacted to respond to a WHO global survey on yaws, only 56 responded (World Health Organization, 2018a). Of the 56 countries that responded, only 13 countries indicated that yaws is included in their national disease surveillance system. This includes two countries that WHO considers to be "currently endemic" (CAR and Congo), but has no data available from in the Global Health Observatory. However, that does not explain why data on cases changed after the 2021 update; the reason for those discrepancies was not discovered during the course of researching and writing this essay.

For the eradication of yaws to be realized, it is imperative that the WHO recommit to that goal. The WHO criteria for eradication are of yaws are: absence of new serologically confirmed indigenous cases for three consecutive years, absence of any case proven by PCR, and absence of evidence of transmission for three continuous years measured with serology among children aged 1-5 years old (World Health Organization, 2019).

For a country to meet these criteria, active case finding must be utilized, and countries known to have histories of yaws transmission must be given the support needed to complete active surveillance. Looking at the stark difference in numbers between suspected and confirmed cases for many of the countries above, this support must also increase the availability of PCR and serology testing where it is currently sparse. Without expanded access, these countries will not be able to meet the eradication criteria.

There is reason to believe that the Morges strategy for eradication can be successful. A 2015 paper by Mitjà et al. describes a longitudinal study conducted from April 2013 through May 2014. On Lihir Island of Papua New Guinea, 13,302 of the island's 16,092 (82.7%) residents participated in a TCT initiative and received one dose of azithromycin. After the initial treatment, targeted treatment occurred every six months that included clinical examinations and treatment of all active cases and their contacts, while a local health facility treated any cases (and their contacts) identified between the follow up targeted treatments. At 12 months, prevalence of active yaws fell from 2.4% to 0.3%.

Other challenges face surveillance efforts in any yaws eradication effort, with Ecuador providing an interesting example of the state of yaws surveillance in recent history. Though the most recent update indicates no data for suspected cases in 2017 and 2018, the previously available data showed 129 suspected cases in 2017 and 682 in 2018 (Tables 2 and 3). This comes years after Ecuador proclaimed it had eliminated yaws from the country in 2003 (Anselmi et al., 2003); indeed, claims that Ecuador may have eliminated yaws continue to circulate in more recent publications and writings (Fitzpatrick et al., 2018) despite this reported increase in suspected cases. Without more information on what is happening with this data, the real status of yaws endemicity in Ecuador is unknown.

Philippines is another illustration of the difficulties facing any efforts to eradicate yaws. Philippines was thought to have eliminated yaws as a public health threat during its own national campaign in the 1950, but after suspected cases were reported to the Department of Health, a clinical-seroprevalence survey was conducted in 2017, primarily taking place in randomly selected schools (Dofitas et al., 2020). While full results are pending publication, case reports of four active, confirmed cases of yaws identified in the schools have been published, the first official report of

yaws infections in the Philippines since 1973. It is possible that this study alone accounts for the reported suspected and confirmed cases reported by Philippines to the WHO seen in Tables 11 and 12. If it does, it would mean that there is no other surveillance system in place in the country for yaws.

Now is the time to recommit to the eradication of yaws for another reason. By 2050, the number of people having to migrate as a result of climate change is estimated to be between 25 million and 1 billion people, with much of that migration happening in the Western Pacific (Campbell and Warrick, 2014). The same region accounts for the majority of suspected yaws cases as reflected in the data above. While there is work being done in this region to mitigate the effects if climate change and prevent the need for mass-migration, the possibility remains that individuals afflicted with yaws will migrate to new areas and either introduce or re-introduce the disease to their new location. If this happens, the world may forever lose the opportunity to eradicate yaws once and for all.

5.0 Recommendations

The 2015 paper by Mitjà et al. on the Lihir Island TCT trial was published with an accompanying article entitled "Yaws Eradication- A Goal Finally Within Reach" that laid out the challenges facing any eradication including:

First, mass treatment and targeted treatment programs with high-quality, regular monitoring for both active and latent yaws need to be maintained for a minimum of 3 years.

Second, yaws elimination efforts will be conducted by local health systems that must place high priority on other infectious-disease control programs, such as deworming in children and malaria and filariasis elimination efforts. Many yaws control programs will be executed in areas where the public health infrastructure is weak and constrained by limited human and financial resources.

Third, since yaws is highly focal and heterogeneous in its geographic distribution, better mapping will be needed in order to prioritize areas for the initiation of elimination programs…

Finally, as with mass drug-administration programs for controlling and eliminating other infectious diseases, maintaining high levels of community participation in treatment and monitoring will be essential. (Kazura, 2015)

To address those challenges, and others presented in this essay, the following recommendations should be enacted:

1. Make yaws eradication a WHO priority.

For yaws to be eradicated, the world must first care about yaws. Over the past decades yaws has failed to capture attention and resources against other public health problems. Eradication will require high level and visible dedication to the goal from WHO leaders.

2. Make yaws a learning moment.

After a 95% decrease in yaws cases, the global community moved on without finishing the job. That has led to decades of suffering for an unknown number of people from an easily-treatable infection. In a world where public health problems only continue to get more and more complicated, the story of yaws can serve as a cautionary tale against incomplete work and ignoring basic public health systems or maintenance of those systems.

3. Make yaws a winnable moment.

Global confidence in public health has suffered due to the COVID-19 pandemic. Humanity has only eradicated one human disease before. Eradication of a second would boost public confidence in and support for other public health initiatives.

4. Make yaws reporting to WHO mandatory.

As this essay has shown, surveillance of yaws is weak. Mandatory reporting would instantly improve the quality of data while setting the stage for continued improvement. That data then would guide eradication efforts.

5. Make yaws eradication a lasting investment.

Couple yaws eradication efforts with other public health services by investing in basic public health infrastructures like nationwide surveillance programs, public health workforces, and medical clinics that can be sustained and utilized after yaws is eradicated. This must specifically include increasing the availability of PCR testing; without PCR yaws cases cannot be confirmed and eradication criteria cannot be met.

Appendix A -Literature Review Summary

Author	Published	Title	Publication Info	Main Takeaway
Ackley, C., Elsheikh, M., & Zaman, S.	2021	Scoping review of Neglected Tropical Disease Interventions and Health Promotion: A framework for successful NTD interventions as evidenced by the literature.	*PLoS Negl Trop Dis, 15*(7), e0009278. doi:10.1371/journal.pntd.0009278	No country specific data pertaining to yaws
Baker, B. J., Crane-Kramer, G., Dee, M. W., Gregoricka, L. A., Henneberg, M., Lee, C., . . . Winingear, S.	2020	Advancing the understanding of treponemal disease in the past and present.	*Am J Phys Anthropol, 171 Suppl 70*, 5-41. doi:10.1002/ajpa.23988	No country specific data pertaining to yaws
Bodimeade, C., Marks, M., & Mabey, D.	2019	Neglected tropical diseases: elimination and eradication.	*Clin Med (Lond), 19*(2), 157-160. doi:10.7861/clinmedicine.19-2-157	No country specific data pertaining to yaws
C, G. B., Ubals, M., Corbacho-Monné, M., Vall-Mayans, M., & Mitjà, O.	2021	Yaws, Haemophilus ducreyi, and Other Bacterial Causes of Cutaneous Ulcer Disease in the South Pacific Islands.	*Dermatol Clin, 39*(1), 15-22. doi:10.1016/j.det.2020.08.002	No country specific data pertaining to yaws
Caicedo, C., Anselmi, M., Prandi, R., Márquez, M., Buonfrate, B. D., Gobbi, F., . . . Tognoni, G.	2020	Community participation eliminates yaws in Ecuador	*Assist Inferm Ric, 39*(1), 47-56. doi:10.1702/3371.33476	No data pertaining to yaws incidence or prevalence in Ecuador
Cooley, G. M., Feldstein, L. R., Bennett, S. D., Estivariz, C. F., Weil, L., Bohara, R., . . . Martin, D. L.	2021	No Serological Evidence of Trachoma or Yaws Among Residents of Registered Camps and Makeshift Settlements in Cox's Bazar,	*Am J Trop Med Hyg, 104*(6), 2031-2037. doi:10.4269/ajtmh.21-0124	Found no evidence of yaws in Bangladesh

		Bangladesh.		
Dofitas, B. L., Kalim, S. P., Toledo, C. B., & Richardus, J. H.	2020	Yaws in the Philippines: first reported cases since the 1970s.	*Infect Dis Poverty, 9*(1), 1. doi:10.1186/s40249-019-0617-6	Found cases of yaws in Philippines
Dyson, L., Mooring, E. Q., Holmes, A., Tildesley, M. J., & Marks, M.	2019	Insights from quantitative and mathematical modelling on the proposed 2030 goals for Yaws.	*Gates Open Res, 3*, 1576. doi:10.12688/gatesopenres.13078.1	No country specific data pertaining to yaws
Enserink, M.	2018	A second chance.	*Science, 361*(6399), 216-221. doi:10.1126/science.361.6399.216	Evidence of yaws in Papua New Guinea
Fitzpatrick, C., Asiedu, K., Sands, A., Gonzalez Pena, T., Marks, M., Mitja, O., . . . Van der Stuyft, P.	2017	The cost and cost-effectiveness of rapid testing strategies for yaws diagnosis and surveillance.	*PLoS Negl Trop Dis, 11*(10), e0005985. doi:10.1371/journal.pntd.0005985	No country specific data pertaining to yaws
Fitzpatrick, C., Asiedu, K., Solomon, A. W., Mitja, O., Marks, M., Van der Stuyft, P., & Meheus, F.	2018	Prioritizing surveillance activities for certification of yaws eradication based on a review and model of historical case reporting.	*PLoS Negl Trop Dis, 12*(12), e0006953. doi:10.1371/journal.pntd.0006953	No country specific data pertaining to yaws
Fitzpatrick, C., Sankara, D. P., Agua, J. F., Jonnalagedda, L., Rumi, F., Weiss, A., . . . Biswas, G.	2017	The cost-effectiveness of an eradication programme in the end game: Evidence from guinea worm disease.	*PLoS Negl Trop Dis, 11*(10), e0005922. doi:10.1371/journal.pntd.0005922	No country specific data pertaining to yaws
Friedrich, M. J.	2018	Yaws Eradication Requires Improved Approach.	*Jama, 319*(15), 1539. doi:10.1001/jama.2018.4126	No country specific data pertaining to yaws
Gebre, T.	2021	Rethinking disease eradication: putting countries first.	*Int Health, 13*(3), 215-221. doi:10.1093/inthealth/ihab011	No country specific data pertaining to yaws
González-Beiras, C., Vall-Mayans, M., González-Escalante, Á., McClymont, K., Ma, L., & Mitjà, O.	2017	Yaws Osteoperiostitis Treated with Single-Dose Azithromycin.	*Am J Trop Med Hyg, 96*(5), 1039-1041. doi:10.4269/ajtmh.16-0943	Evidence of yaws in Papua New Guinea

Handley, B. L., Butcher, R., Taoaba, R., Roberts, C. H., Cama, A., Müeller, A., . . . Marks, M.	2019	Absence of Serological Evidence of Exposure to Treponema pallidum among Children Suggests Yaws Is No Longer Endemic in Kiribati.	*Am J Trop Med Hyg, 100*(4), 940-942. doi:10.4269/ajtmh.18-0799	Found evidence of yaws exposure but not transmission in Kiribati
Holmes, A., Tildesley, M. J., Solomon, A. W., Mabey, D. C. W., Sokana, O., Marks, M., & Dyson, L.	2020	Modeling Treatment Strategies to Inform Yaws Eradication.	*Emerg Infect Dis, 26*(11), 2685-2693. doi:10.3201/eid2611.191491	No country specific data pertaining to yaws
Kirkham, E. N., & Paul, S. P.	2017	A challenging skin lesion.	*Br J Hosp Med (Lond), 78*(12), 726. doi:10.12968/hmed.2017.78.12.726	No country specific data pertaining to yaws
Lifigao, M., Nasi, T., Titiulu, C., Lumasa, S., & Duke, T.	2020	Congenital Syphilis in Honiara, Solomon Islands.	*J Trop Pediatr, 66*(6), 583-588. doi:10.1093/tropej/fmaa017	No specific data pertaining to yaws prevalence
Lubinza, C. K. C., Lueert, S., Hallmaier-Wacker, L. K., Ngadaya, E., Chuma, I. S., Kazwala, R. R., . . . Knauf, S.	2020	Serosurvey of Treponema pallidum infection among children with skin ulcers in the Tarangire-Manyara ecosystem, northern Tanzania.	*BMC Infect Dis, 20*(1), 392. doi:10.1186/s12879-020-05105-4	Found no evidence of yaws transmission in Tanzania
Marks, M.	2018	Correction: Prevalence of Active and Latent Yaws in the Solomon Islands 18 Months after Azithromycin Mass Drug Administration for Trachoma.	*PLoS Negl Trop Dis, 12*(3), e0006308. doi:10.1371/journal.pntd.0006308	Excluded upon review; correction to article published previously with data outside of inclusion timeframe
Marks, M., Fookes, M., Wagner, J., Butcher, R., Ghinai, R., Sokana, O., . . . Thomson, N.	2018	Diagnostics for Yaws Eradication: Insights From Direct Next-Generation Sequencing of Cutaneous Strains	*Clin Infect Dis, 66*(6), 818-824. doi:10.1093/cid/cix892	No country specific data pertaining to yaws

		of Treponema pallidum.		
Maxfield, L., Corley, J. E., & Crane, J. S.	2021	Yaws.	In *StatPearls*. Treasure Island (FL): StatPearls Publishing	No country specific data pertaining to yaws
Mitjà, O., Godornes, C., Houinei, W., Kapa, A., Paru, R., Abel, H., . . . Lukehart, S. A.	2018	Re-emergence of yaws after single mass azithromycin treatment followed by targeted treatment: a longitudinal study.	*Lancet, 391*(10130), 1599-1607. doi:10.1016/s0140-6736(18)30204-6	Found evidence of yaws transmission in Papua New Guinea, but unclear when those cases occurred
Mitjà, O., González-Beiras, C., Godornes, C., Kolmau, R., Houinei, W., Abel, H., . . . Bassat, Q.	2017	Effectiveness of single-dose azithromycin to treat latent yaws: a longitudinal comparative cohort study.	*Lancet Glob Health, 5*(12), e1268-e1274. doi:10.1016/s2214-109x(17)30388-1	Confirmed yaws transmission in Papua New Guinea
Mitjà, O., Marks, M., Bertran, L., Kollie, K., Argaw, D., Fahal, A. H., . . . Asiedu, K.	2017	Integrated Control and Management of Neglected Tropical Skin Diseases.	*PLoS Negl Trop Dis, 11*(1), e0005136. doi:10.1371/journal.pntd.0005136	No country specific data pertaining to yaws
Mooring, E. Q., Mitjà, O., & Murray, M. B.	2018	Spatial-temporal clustering analysis of yaws on Lihir Island, Papua New Guinea to enhance planning and implementation of eradication programs.	*PLoS Negl Trop Dis, 12*(10), e0006840. doi:10.1371/journal.pntd.0006840	Data on cases outside of inclusion years
Stewart, A. D. M.	2017	An imperial laboratory: the investigation and treatment of treponematoses in occupied Haiti, 1915-1934.	*Hist Cienc Saude Manguinhos, 24*(4), 1089-1106. doi:10.1590/s0104-59702017000500013	Did not contain recent data on yaws in Haiti
Tabah, E. N., Johnson, C. R., Degnonvi, H., Pluschke, G., & Röltgen, K.	2019	Buruli Ulcer in Africa.	In G. Pluschke & K. Röltgen (Eds.), *Buruli Ulcer: Mycobacterium Ulcerans Disease* (pp. 43-60). Cham (CH): Springer	No country specific data pertaining to yaws
Timothy, J. W. S.,	2021	Epidemiologic	*Emerg Infect Dis, 27*(4), 1123-1132.	Evidence of

Beale, M. A., Rogers, E., Zaizay, Z., Halliday, K. E., Mulbah, T., . . . Marks, M.		and Genomic Reidentification of Yaws, Liberia.	doi:10.3201/eid2704.204442	yaws in Liberia
Um Boock, A., Ntozo'o, J. P., Boua, B., & Vander Plaetse, B.	2019	Evidence of high endemicity of leprosy and yaws in the municipality of Balé-Loko in the Central African Republic.	*Med Sante Trop, 29*(2), 155-158. doi:10.1684/mst.2019.0876	Evidence of yaws in CAR
World Health Organization	2018	Weekly Epidemiological Record	World Health Organization (2018). Weekly Epidemiological Record, 2018, vol. 93, 33 [full issue]. Weekly Epidemiological Record (33), 417 - 428.	Reported status of yaws surveillance systems, but not prevalence
Yotsu, R. R.	2018	Integrated Management of Skin NTDs-Lessons Learned from Existing Practice and Field Research.	*Trop Med Infect Dis, 3*(4). doi:10.3390/tropicalmed3040120	No country specific data pertaining to yaws
Zeba Lompo, S., Barogui, Y., Compaore, J., Ouedraogo, Y., Kafando, C., & Kambire-Diarra, M. C.	2019	An integrated assessment of leprosy, Buruli ulcer, and yaws around the irrigated perimeters of Bagré and Kompienga in Burkina Faso.	*Med Sante Trop, 29*(3), 327-332. doi:10.1684/mst.2019.0912	Evidence of yaws in three countries
Zoni, A. C., Saboyá-Díaz, M. I., Castellanos, L. G., Nicholls, R. S., & Blaya-Novakova, V.	2019	Epidemiological situation of yaws in the Americas: A systematic review in the context of a regional elimination goal.	*PLoS Negl Trop Dis, 13*(2), e0007125. doi:10.1371/journal.pntd.0007125	Possible evidence of yaws in two countries

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