HHS Public Access

Author manuscript

Vaccine. Author manuscript; available in PMC 2019 September 05.

Published in final edited form as:

Vaccine. 2019 July 26; 37(32): 4511–4517. doi:10.1016/j.vaccine.2019.06.063.

Differences between coverage of yellow fever vaccine and the first dose of measles-containing vaccine: A desk review of global data sources

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Abstract

Introduction: The strategy to Eliminate Yellow Fever Epidemics (EYE) is a global initiative that includes all countries with risk of yellow fever (YF) virus transmission. Of these, 40 countries (27 in Africa and 13 in the Americas) are considered high-risk and targeted for interventions to increase coverage of YF vaccine. Even though the World Health Organization (WHO) recommends that YF vaccine be given concurrently with the first dose of measles-containing vaccine (MCV1) in YF-endemic settings, estimated coverage for MCV1 and YF vaccine have varied widely. The objective of this study was to review global data sources to assess discrepancies in YF vaccine and MCV1 coverage and identify plausible reasons for these discrepancies.

Methods: We conducted a desk review of data from 34 countries (22 in Africa, 12 in Latin America), from 2006 to 2016, with national introduction of YF vaccine and listed as high-risk by the EYE strategy. Data reviewed included procured and administered doses, immunization schedules, routine coverage estimates and reported vaccine stock-outs. In the 30 countries included in the comparitive analysis, differences greater than 3 percentage points between YF vaccine and MCV1 coverage were considered meaningful.

Results: In America, there were meaningful differences (7–45%) in coverage of the two vaccines in 6 (67%) of the 9 countries. In Africa, there were meaningful differences (4–27%) in coverage of the two vaccines in 9 (43%) of the 21 countries. Nine countries (26%) reported MVC1 stock-outs while sixteen countries (47%) reported YF vaccine stock-outs for three or more years during 2006–2016.

Conclusion: In countries reporting significant differences in coverage of the two vaccines, differences may be driven by different target populations and vaccine availability. However, these were not sufficient to completely explain observed differences. Further follow-up is needed to

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Declaration of Competing Interest

The authors declared that there is no conflict of interest.

identify possible reasons for differences in coverage rates in several countries where these could not fully be explained.

Keywords

Yellow fever vaccine; Stock outs; Routine immunization coverage; Measles vaccine

1. Introduction

Yellow fever (YF) is a vaccine preventable, viral disease transmitted by infected mosquitoes [1]. The clinical spectrum of infection ranges from asymptomatic infection to severe disease including jaundice and death [2]. In the early 1990s, 200,000 cases of YF and 30,000 deaths were expected globally, with 90% occurring in Africa [3]. Of the more than 1900 YF cases and nearly 950 deaths recorded in South America, Peru and Bolivia reported the highest incidence of disease [4]. Recent updates from a 2013 modelling study using African data sources estimated a burden of 84,000–170,000 severe cases, resulting in 29,000–60,000 deaths due to YF [5]. The vast majority of cases (>90%) continue to occur in sub-Saharan Africa, with countries in the Americas, endemic for YF disease, experiencing seasonal cases. Accurately quantifying the burden of disease remains challenging given limitations in epidemiological and laboratory surveillance in the affected regions. As specific treatment for YF is unavailable, an emphasis is placed on prevention of the disease. Insufficient or ineffective control strategies can result in devastating epidemics with high case-fatality rates, especially in populations with low pre-existing levels of immunity [6].

The most important means of preventing YF disease is vaccination using a safe and affordable vaccine [2]. A single dose of YF vaccine confers life-long protection and provides effective immunity to 99% of vaccinated persons within 30 days. Yet, despite an effective, live attenuated vaccine, the virus continues to cause major outbreaks [7]. In 1998, the WHO Technical Consensus Meeting on Yellow Fever examined reasons for the dramatic resurgence of YF outbreaks and concluded that immunization coverage of 80% or more was needed to prevent epidemics [8,9]. Key recommendations from the meeting included improving YF vaccine coverage through routine immunization and preventive mass campaigns, improving detection of cases and laboratory support. The meeting also recommended the creation of an emergency stockpile of 1 million YF vaccine doses in Africa and South America for reactive campaigns [9].

In 2001, the stockpile was established with 2 million doses and from its creation to 2013, more than 65 million doses of vaccine were distributed. By 2014, the emergency stockpile contained around 6 million doses [10]. In 2016, large YF outbreaks in Angola and the Democratic Republic of the Congo (DRC) created an urgent need for more than 28 million doses and repeatedly exhausted the stockpile, hampering efforts to control the epidemics through wide scale reactive vaccination campaigns [11]. The multiple and acute vaccine shortages underlined gaps in existing preparedness and the need for sustained preventive vaccination in at-risk populations [12,13]. In October 2016, WHO’s Strategic Advisory Group of Experts (SAGE) on Immunization reviewed existing control tools and outlined a

long-term and global strategy to “Eliminate Yellow Fever Epidemics” (EYE) globally by 2026 [11].

The EYE strategy includes three primary objectives: protect at-risk populations; prevent international spread of YF virus; and rapidly contain yellow fever outbreaks. The strategy also calls for a new stockpile model: A Revolving Emergency Stockpile. The stockpile will be replenished as soon as vaccine becomes available and improve preparedness response [11]. The strategy classifies 21 (60%) of 35 at-risk countries in Africa and all 13 YF-endemic countries in the Americas as high risk for outbreaks of YF and in need of a 3-pronged vaccination approach (routine childhood immunization, catch-up and preventive mass campaigns) to ensure high coverage with YF vaccine in order to achieve and maintain high levels of population immunity.

Currently, all 13 countries endemic for, or with regions that are endemic for, YF in the Americas have introduced YF vaccine in their routine immunization programs while in Africa, 5 endemic countries have yet to introduce the vaccine [8,14]. WHO recommends that YF vaccine be given to children at age 9–12 months concurrently with the first dose of measles-containing vaccine (MCV1) in YF-endemic settings [3]. While a few countries have adopted their own immunization schedule, similar coverage levels for the two vaccines may be expected in areas adhering to recommendations for concurrent administration. However, discrepancies in estimated routine coverage for YF vaccine and MCV1 have been documented by immunization programs. In the African region, estimated MCV1 coverage increased from 53% in 2000 to 73% in 2010, to 74% in 2015 and decreased to 72% in 2016 [15,16]. In the Americas, from 2000 to 2016, MCV1 coverage has remained stable at 92% [17]. In contrast, from 2000 to 2016, YF vaccine coverage in childhood immunization programs increased from 9% to 45% in Africa and from 24% to 53% in the Americas in yellow fever endemic countries [18]. Overall in 2016, population coverage for YF vaccine in at-risk countries ranged from 0% in parts of Central and East Africa to nearly 100% in at-risk districts in Brazil [18].

The objectives of this study were to review and compare estimated routine coverage of YF vaccine and MCV1 in Africa and Latin America from 2006 to 2016, to identify whether and where discrepancies in coverage occurred, and to explore plausible explanations for the observed discrepancies in vaccine coverage.

2. Methods

2.1. Data extraction and collation

Data on immunization coverage – number of administered doses, immunization schedules, reported vaccination campaigns, administrative and official government estimated coverage – were obtained from official annual reports to the WHO/United Nation Children’s Fund (UNICEF) from national immunization program authorities as part of a program performance data collection exercise (Table 1). The data collection exercise has been previously described [19]. Briefly, using a standardized questionnaire, the Joint Reporting Form on Immunization (JRF), WHO and UNICEF collect information from national immunization programs on planning, performance, financing and quality indicators [14,19].

Data on routine infant vaccination coverage were obtained from the 2017 revision of the WHO and UNICEF estimates of national immunization coverage (WUENIC). WUENIC are derived from a country-by-country review of administrative and survey-based coverage data [20,21] (Table 1). Descriptive and explanatory texts, included in each country's final WUENIC immunization coverage report, were also reviewed for additional contextual factors on program performance as well as actions implemented to address challenges.

Vaccine stock data as well as incidence and duration of reported vaccine stock-outs from 2006 to 2016 were used as a metric of vaccine availability. For information on vaccine stock, country-specific data on shipped doses of YF vaccine for the 11-year review period were requested of the UNICEF Supply Division by the department of Immunization, Vaccines and Biologicals (IVB) of the WHO. In response, the UNICEF Supply Division provided aggregate and country-specific summaries of YF vaccine doses supplied to countries in Africa (Table 1). Additionally, data reported by immunization programs on the number of procured YF vaccine doses were obtained from UNICEF through the UNICEF Vaccine Forecasting Tool [22]. Data on supplied YF vaccine doses were not available for the Americas as UNICEF is not the supplier for those countries. Data on vaccine stock-outs were also obtained from the official annual reports to WHO through the JRF, which includes questions on the frequency and duration of stock-outs at the district and national levels [19] (Table 1). Data from 34 countries (22 in Africa, 12 in Latin America) who have introduced YF vaccine in their Expanded Program for Immunization (EPI) schedules, had available WUENIC data available, and are listed by the EYE strategy as high-risk were reviewed [11].

Reported coverage as well and year-to-year trends in coverage of both vaccines were reviewed to characterize consistency of the available data. Reported estimated coverage and reported vaccine doses administered were also compared. During reported vaccine stock-outs, data on the number of vaccine doses administered during the year of stock-out were compared to the reported vaccine doses administered in both prior and subsequent years. To provide insights into plausible explanations for observed meaningful differences, we reviewed recommendations for administration of the vaccines, reported stock-out events, years of vaccine stock-outs at the national and district levels and WUENIC country summaries. Review efforts focused on vaccine availability and data quality since previous literature has noted that immunization coverage rates are a function of the supply-side rather than demand[23]. Additionally, previous assessments reports on the implementation of the WHO Global Vaccine Action Plan (GVAP) – which aims to improve national immunization coverage to at least 90% – have identified poor data quality and use, as well as vaccine affordability and supply among the barriers to improving vaccination coverage[24].

2.2. Analytical approach

Multi-year differences in coverage estimates from WUENIC were calculated by averaging the differences in coverage of MCV1 and YF vaccine for each year of available data. A meaningful difference in vaccination coverage of the two vaccines was defined as an average difference greater than 3 percentage points, an arbitrary threshold. Descriptive statistics were used to present the data.

3. Results

3.1. Immunization schedule

Of the countries included in the review, 32 countries (94%) had introduced YF vaccine to at-risk endemic regions or nationwide by 2006. Equatorial Guinea, while listed as high-risk for YF transmission by the EYE strategy, introduced the YF vaccine in 2016 and was omitted from this review. In the remaining countries, Guinea-Bissau introduced the vaccine nationwide in 2008 while Argentina introduced the vaccine to areas near the border of Brazil, Bolivia and Paraguay in 2009 (Tables 2 and 3). During the 2006–2016 review period, two countries changed their recommendations for YF vaccine administration from selected risk areas to all children: Ecuador in 2009 and Suriname in 2011. In the Americas, both measles vaccine and YF vaccine are recommended for administration at 12 months of age to all children in 9 (75%) of 12 countries included in the review. In the remaining three (25%) countries, MCV1 is also recommended for all children at 12 months while YF vaccine is recommended for administration to selected at-risk areas at ages 9 months (Brazil), 15 months (Peru) and 18 months (Argentina) (Table 2). For the 22 countries included in the review from the African region, both MCV1 and YF vaccine are recommended for administration at 9 months of age to all children in the country with the exception of Kenya, where YF vaccine is recommended to children in at-risk areas (Table 3).

3.2. Vaccination coverage

Differences in estimated coverage of the 2 vaccines in countries without nationwide introduction of YF vaccine were omitted given differences in target populations, limiting routine coverage data based on WUENIC to 30 countries (88%). In the remaining 9 countries in the Americas, average coverage of YF vaccine ranged from 42% to 97%, while coverage of MCV1 ranged from 87% to 97%. Overall, there were meaningful average differences (7–45%) in estimated coverage of the two vaccines in 6 (67%) of the 9 countries (Table 4). Two countries changed their recommendations for administration from selected at-risk communities to national immunization. Following the change in recommendation for administration in Ecuador, the average difference between coverage of the two vaccines decreased from 42% to 13%. In Suriname, the average difference between coverage of the two vaccines decreased from 45 to 10%. Over the 11-year review period, differences in estimated coverage for YF vaccine and MCV1 were less than 3 percentage points in Bolivia, Guyana and Trinidad and Tobago. In the 21 African countries included in the analysis, average coverage of YF vaccine ranged 29–94%, while coverage of MCV1 ranged from 44% to 94% across the entire review period. There were meaningful average differences (4–27%) in estimated coverage for YF vaccine and MCV1 in 9 (43%) of the 21 African countries (Table 5).

3.3. Vaccine availability

Across the 34 countries reviewed, none reported stock-outs or vaccine stock data for MCV1 and YF vaccine for all years. Nine countries overall (26%) reported national-level measles vaccine stock-outs and sixteen countries (47%) reported national-level YF vaccine stock-outs for three or more years during 2006–2016 (Table 6). Of the sixteen countries reporting national-level YF vaccine stock-outs, eleven (69%) reported meaningful differences in

estimated coverage of the YF vaccine and MCV1. Overall, reporting of stock-out data was incomplete across the review period. Benin reported no stock-out for MCV1 across the time series and only one stock-out of YFV in 2016. Gambia, Mali and Panama also did not report stock-outs for any year.

4. Discussion

This report reviews available routine immunization data over an 11-year period for YF vaccine and MCV1 and compares average estimated coverage for the 2 vaccines in 30 (88%) of the 34 countries designated as high-risk countries for YF transmission by the global EYE strategy and have introduced YF vaccine in their national Expanded Program for Immunization (EPI) schedules. There were meaningful differences, defined as greater than 3 percentage points, between the estimated coverage rates of the two vaccines in 6 countries in the Americas and 9 countries in Africa. In countries with meaningful observed differences in estimated coverage for YF vaccine and MCV1, plausible explanations for these differences include: different recommendations for administration of the vaccines resulting in different target populations, vaccine stock-outs and possible gaps in program performance reflected by differences in official estimated coverage versus survey results and otherwise unexplained factors.

In the Americas, Argentina, Brazil and Panama recommend YF vaccine to endemic, at-risk areas. In these countries, YF is limited to certain endemic areas but these geographic areas are shifting which may lead to revisions in target populations. Among countries recommending YF vaccine for selected risk areas, WHO and UNICEF annualize coverage to the total national target population. As such, estimated coverage levels for YF vaccine and MCV1 are expected to differ in those countries. In Colombia and Peru, while YF vaccine is recommended nationwide, the vaccines are not administered concurrently and differential attendance at the visits may be driving the observed gaps in coverage. In addition, countries in the Americas also reported 25% more stock-out events of YF vaccine than MCV1. However, differences in target population estimates and vaccine stock-outs were not sufficient to completely explain observed differences in other countries.

In Africa, Kenya is the only country to recommend YF vaccine sub-nationally thus coverage of YF vaccine and MCV1 are expected to differ. Previous reports describe availability of YF vaccine as a chronic problem in the region and in this review, African countries reported more than twice as many years of YF vaccine stock-outs than measles vaccine stock-outs [8]. Furthermore, countries reporting differences in estimated coverage of the two vaccines reported 45% more stock-outs of YF vaccine than MCV1 which may contribute to the observed differences. Yet, reported stock-outs as a plausible explanatory factor is also complex, in part due to poor administrative recording and reporting systems in many countries [25]. Reporting of vaccine stock-outs was incomplete, thus, it is unclear whether there in fact were no stock-outs in these countries or whether there were stock-outs that went unreported to WHO and UNICEF. It is also unclear whether challenges in the recording and reporting systems would differentially impact MCV1 and YF vaccine coverage. Additionally, while some countries reported declines in administered doses during reported vaccine stock-outs, others did not. Given that declines in reported administered doses would

be expected during stock-outs, this could be indicative of the availability of buffer stocks or gaps in the data quality on availability of immunization program resources (vaccine availability and funding).

Further follow up is needed to better understand the causes for stock-outs, challenges in reporting and recording systems and to identify possible reasons for differences in coverage rates in several countries where these could not fully be explained. Comparisons of total procured YF vaccine doses through UNICEF Supply Division with reported target population estimates suggest that some countries continue to have challenges with vaccine forecasting. Additional work with UNICEF Supply Division and the national immunization programs may yield additional valuable information to understand challenges with appropriate forecasting of YF vaccine.

The findings of this report are subject to a few limitations. First, numerator and denominator biases could be present due to outdated census data and gaps in coverage reporting capacities, at district and regional levels, which may result in under or overestimates of administrative vaccination coverage. Survey data may suffer from recall bias for multiple-dose antigens given low levels of home-based vaccination records retention. Second, there were missing data across the time series for multiple countries. Furthermore, vaccine stock-outs and their duration are likely to be under-reported and would underestimate the magnitude of the issue. In 2014, SAGE raised the concern about potential under-reporting of vaccine availability [24]. In the 2014 assessment report of the GVAP of the 5 priority problem areas to address to get GVAP back on track, SAGE noted poor quality data on vaccine supply as hindering understanding and corrective action [24].

In its EYE strategy, WHO recommends YF vaccine coverage of 80% or greater in the at-risk population to prevent and control outbreaks [8]. The EYE strategy is a comprehensive, multi-component partnership and supports high and moderate risk countries in Africa and the Americas by strengthening their surveillance and laboratory capacity to prevent, detect and respond to yellow fever outbreaks [2]. The strategy also supports the implementation and sustainability of large-scale measures (routine immunization, preventive and reactive vaccination campaigns) to ensure high coverage with YF vaccine in order to achieve and maintain high levels of population immunity [8,25].

While YF vaccine coverage has increased since 1970, an estimated 393.7–472.9 million people, or 43–52% of the population within yellow fever risk zones still require vaccination to achieve the WHO recommended threshold of 80% coverage [18]. Yellow fever vaccine remains to be introduced in the national routine immunization schedule of five of the 27 high-risk countries in Africa and an additional 12 countries should complete wide-range preventive campaigns [11,25]. In the Americas, all 13 countries, considered to be at high-risk by the EYE strategy, have introduced the vaccine in their routine immunization programs and 10 countries have conducted mass preventive campaigns, mostly targeting populations living in enzootic areas [11]. However, 11 of the 13 countries should plan catch-up campaigns targeting unprotected sections of the population [8].

Reactive campaigns and diversion of global vaccine stocks from preventive use to campaigns and routine EPI use contribute to reported YF vaccine stock-outs. The limited supply of YF vaccine has been a major hurdle in increasing coverage. Between 2013 and 2015, 15 of the 34 countries that introduced the YF vaccine in their EPI schedule reported national level vaccine stock-out[11]. In the Americas, countries receive about half of their vaccine requirement, YF vaccine coverage remains around 70% and has been negatively affected by the current global vaccine shortage[11]. To address the increased demand for YF vaccine, the global supply is expected to increase to between 162 and 183 million doses in 2026 [11,25].

In addition, countries across income groups and regions experience regular vaccine stock-outs that in many cases lead to interruptions in immunization services [26]. Other elements that affect all vaccines in use in the routine system such as microplanning, forecasting, demographic barriers (ethnic minority status, low educational attainment, economic status), low community demand may also be contributing to lower immunization coverage, especially when coverage for more than one antigen is noted to be >80% [27]. Other flaws in implementing vaccination practices such as healthcare workers hesitancy to open a 10 or 20 dose vial due to concerns of vaccine wastage or refusal to vaccinate children after 11 months may contribute to poor childhood immunization coverage [11,28].

The EYE strategy notes that differences between YF vaccine and MCV1 coverage need to be monitored and better understood. This review addresses part of that gap by identifying that in contrast to initial assumptions, coverage of YF vaccine is not consistently below coverage of MCV1. In countries reporting significant differences between the coverage, differences may be driven by vaccine stock-outs. This review also highlights that gaps in availability of data on immunization program performance remain an issue, as noted in previous literature.

Effective interventions to mitigate the frequency of stock-outs and their effects should include vaccine forecasting – matching supply and demand of YF vaccine, strengthening reporting and recording systems, reducing procurement delays and addressing program funding gaps. Moreover, while there has been important progress to improve the gaps in yellow fever vaccination coverage in at-risk areas, improved vaccination strategies are needed to provide adequate protection against outbreaks. Rather than reactive campaigns, incorporating YF vaccine in routine immunization, followed by catch-up campaigns for adult populations, is the best strategy to achieve long-term high vaccination coverage [29,30].

Acknowledgements

We would like to acknowledge David Brown, BCGI, LLC (North Carolina, USA) for his work developing the summary report *"A desk review exercise to characterize plausible explanations for observed differences in coverage between the first dose of measles containing vaccine and yellow fever virus vaccine among countries at risk for yellow fever virus transmission*". [Internet]: World Health Organization; [2017]. License: CC BY-NC-SA 3.0 IGO. We also would like to thank Aaron Wallace from U.S. CDC's Global Immunization for the useful comments on the manuscript.

Funding

The development of the desk review was funded by a grant from the World Health Organization's Initiative for Vaccine Research. The authors would like to acknowledge the contributions of the US Centers for Disease Control and Prevention (US CDC), which provides financial support to the World Health Organization Initiative for Vaccine Research.

Marta Gacic-Dobo, Joachim Hombach, and Philipp Lambach work for the World Health Organization. Nedghie Adrien, Akshaya Krishnaswamy, and Terri Hyde work for the U.S. Centers for Disease Control and Prevention (US CDC). The authors alone are responsible for the views expressed in this publication. The findings and conclusions in this report are those of the author(s) and do not necessarily represent the official position, positions or views of the World Health Organization, Centers for Disease Control and Prevention/the Agency for Toxic Substances and Disease Registry.

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Table 1

Data sources for desk review of reported coverage levels for MCV1 and YF vaccine.

Data source	Data	First and last year of data	No. of countries included
WHO/UNICEF Joint Reporting Forms	Vaccination coverage numerator data (i.e. doses administered); immunization schedule, administrative vaccination coverage; official coverage; reported campaigns	2006–2016	34
WHO/UNICEF Joint Reporting Forms	District and national level stock-out by vaccine	2006–2016	34
WHO and UNICEF estimates of immunization coverage (WUENIC): 2017 revision, 15 July 2018	Routine vaccination: YF vaccine and MCV1 coverage estimates	2006–2016	34
UNICEF Supply Division	Supplied YF vaccine doses	2006–2016	22

Abbreviations: MCV1 = first dose of measles-containing vaccine; UNICEF = United Nations Children's Fund; WHO = World Health Organization; YF vaccine = yellow fever vaccine.

Table 2

Introduction of YF vaccine in routine EPI schedule and age at YF vaccine and measles vaccine administration – Americas, (n = 12).

Country/Territory	Year of introduction	Geographical area	Age at YF administration	Age at measles vaccine administration
Argentina	2008	Border with Brazil, Bolivia (Plurinational State of) and Paraguay	18 months; 11 years	12 months
Bolivia	2003	Nationwide	12 months	12 months
Brazil	1994	Endemic/At-risk areas	9 months-49 years	12 months
Colombia	2002	Nationwide	12–18 months	12 months
Ecuador	2009	Nationwide	12 months	12 months
Guyana	2000	Nationwide	12 months	12 months
Panama	1974	Endemic/At-risk areas	12 months	12 months
Paraguay	2006	Nationwide	12 months	12 months
Peru	2001	Nationwide	15 months	12 months
Suriname	2005	Nationwide	12 months	12 months
Trinidad and Tobago	1980	Nationwide	12 months	12 months
Venezuela	2000	Nationwide	12 months	12 months

Abbreviations: YF = Yellow Fever, EPI = Expanded Program for Immunization.

Table 3

Introduction of YF vaccine in routine EPI schedule and age at YF vaccine and measles vaccine administration – Africa, (n = 22).

Country/Territory	Year of YF vaccine introduction	Geographical area	Age at YF administration	Age at measles vaccine administration
Angola	1999	Nationwide	9 months	9 months
Benin	2002	Nationwide	9 months	9 months
Burkina Faso	1987	Nationwide	9 months	9 months
Cameroon	2004	Nationwide	9 months	9 months
Central African Republic	2000	Nationwide	9 months	9 months
Chad	1985	Nationwide	9 months	9 months
Congo (the)[a]	2004	Nationwide	9 months	9 months
Cote D'Ivoire	1987	Nationwide	9 months	9 months
Democratic Republic of Congo (DRC)	2004	Nationwide	9 months	9 months
Gabon	2003	Nationwide	9 months	9 months
Gambia	1979	Nationwide	9 months	9 months
Ghana	1992	Nationwide	9 months	18 months
Guinea	2002	Nationwide	9 months	9 months
Guinea-Bissau	2008	Nationwide	9 months	9 months
Kenya	2001	Endemic/At-risk areas	9 months	9 months
Liberia	2001	Nationwide	9 months	9 months
Mali	1992	Nationwide	9 months	9 months
Niger (the)	2005	Nationwide	9 months	9 months
Nigeria	2004	Nationwide	9 months	9 months
Senegal	1987	Nationwide	9 months	9 months
Sierra Leone	2002	Nationwide	9 months	9 months
Togo	1992	Nationwide	9 months	9 months

Abbreviations: YF = Yellow Fever, EPI = Expanded Program for Immunization.

[a]Recommended age of administration for YF vaccine and first dose of measles vaccine is listed as 36 weeks.

Table 4

Estimated average routine coverage for YF vaccine and MCV1 based on WUENIC, 2006 – 2016, Americas, (n = 9).

Country/Territory	Average YF vaccine coverage (%)	Average MCV1 coverage (%)	Difference (YF vaccine-MCV1) (%)
Bolivia	89	91	−2
Colombia	85	92	−7
Ecuador[a]	51	93	−42
Guyana	97	97	0
Paraguay	89	88	−24
Peru	69	91	−23
Suriname[b]	42	87	−45
Trinidad and Tobago	90	91	0
Venezuela	76	87	−11

Abbreviations: YF = Yellow Fever, MCV1 = first dose of measles-containing vaccine, WUENIC = WHO and UNICEF estimates of national immunization coverage.

[a]Country changed recommendation for administration from select communities to national administration in 2009. For period following change in recommendation, 2010–2016, difference in estimated coverage of YF vaccine and MCV1 was 13 percentage points.

[b]Country changed recommendation for administration from select communities to national administration in 2011. For period following change in recommendation, 2012–2016, difference in estimate coverage of YF vaccine and MCV1 was 10 percentage points.

Table 5

Estimated average routine coverage for YF vaccine and MCV1 based on WUENIC, 2006–2016 – Africa, (n = 21).

Country/Territory	Average YF vaccine Coverage (%)	Average MCV1 coverage (%)	Difference (YF vaccine-MCV1) (%)
Angola	29	56	−27
Benin	71	70	1
Burkina Faso	84	89	−5
Cameroon	77	78	−1
Central African Republic	52	51	1
Chad	39	44	−5
Congo (the)	69	72	−3
Cote D'Ivoire	58	67	−8
Democratic Republic of Congo (DRC)	62	72	−10
Gabon	66	65	1
Gambia	94	94	0
Ghana	89	90	−1
Guinea	46	50	−4
Guinea-Bissau[a]	68	77	−7
Liberia	68	71	−4
Mali	66	67	−1
Niger (the)	61	69	−8
Nigeria	45	47	−3
Senegal	82	82	−1
Sierra Leone	76	78	−2
Togo	73	74	−1

Abbreviations: YF = Yellow Fever, MCV1 = first dose of measles-containing vaccine, WUENIC = WHO and UNICEF estimates of national immunization coverage.

[a]WUENIC data available from 2008 onward.

Table 6

Reported years of national level measles and yellow fever vaccine stock-outs – Africa and the Americas (n = 34), 2006–2016.

	Reported measles stock-out (years)	Reported YF vaccine stock-out (years)
Americas		
Argentina	2	1
Bolivia	0	4
Brazil	3	1
Colombia	0	2
Ecuador	2	1
Guyana	1	4
Panama	0	0
Paraguay	1	0
Peru	4	4
Suriname	5	3
Trinidad and Tobago	2	2
Venezuela	0	3
Africa		
Angola	3	6
Benin	0	1
Burkina Faso	0	3
Cameroon	1	0
Central African Republic (the)	0	1
Chad	0	3
Congo	0	3
Côte d'Ivoire	3	7
Democratic Republic of the Congo (the)	3	6
Gabon	2	1
Gambia	0	0
Ghana	1	2
Guinea	3	1
Guinea-Bissau	3	6
Kenya	0	5
Liberia	0	2
Mali	0	0
Niger (the)	2	4
Nigeria	1	4
Senegal	3	4
Sierra Leone	0	4
Togo	1	0

Abbreviations: YF = Yellow Fever, MCV1 = first dose of measles-containing vaccine.