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WHO UNICEF Immunization Coverage Estimates 2022 revision (*released 18 July 2023*)

The WHO and UNICEF estimates of national immunization coverage aim to describe the performance of routine childhood immunization programmes. Estimates are based on data and information available to WHO and UNICEF as of 26 June 2023.

The data are available from WHO (https://immunizationdata.who.int/) and UNICEF (https://data.unicef.org/topic/child-health/immunization/) web sites.

An explanation how to interpret the country profiles is also available: https://cdn.who.int/media/docs/default-source/immunization/immunization-coverage/user_ref_country_reports.pdf.

METHODOLOGY

Each year WHO and UNICEF jointly review reports submitted by Member States to both agencies—mainly through the Joint Reporting Form on Immunization (eJRF) for annual data collection—regarding national immunization coverage, finalized survey reports as well as data from the published and grey literature. Based on these data, with due consideration to potential biases and the views of local experts, WHO and UNICEF attempt to distinguish between situations where the available empirical data accurately reflect immunization system performance and those where the data are likely to be compromised and present a misleading view of immunization coverage while jointly estimating the most likely coverage levels for each country for each year since 1980.

WHO and UNICEF estimates are country-specific; that is to say, each country's data are reviewed individually, and data are not borrowed from other countries in the absence of data. Estimates are not based on ad hoc adjustments to reported data; in some instances, empirical data are available from a single source, usually the nationally reported coverage data. In cases where no data are available for a given country/vaccine/year combination, data are considered from earlier and later years and interpolated (or extrapolated) to estimate coverage for the missing year(s). In cases where data sources are mixed and show large variation, an attempt is made to identify the most likely estimate with consideration of the possible biases in available data.

Following disruptions in immunization system performance data collection during 2020–2021 due to the COVID-19 pandemic, response levels from countries improved, with 183 of 195 reports from WHO/UNICEF Member States received as of 26 June 2023. For countries that did not report data by 26 June 2023, estimates for 2022 reflect an extrapolation from the prior year’s coverage data.

WHO and UNICEF estimates are produced for the following vaccine-dose combinations from 1980 through the present revision as shown in the table below. Further details on the addition of new vaccines provided elsewhere in this document.

	Vaccine-dose combinations for which estimates are produced	
Years	**Number**	**Vaccine-dose**
1980–1984	6	BCG, DTP1, DTP3, MCV1, POL3, RCV1
1985–1989	7	… + HEPB3
1990–1996	8	… … + HIB3
1997–1999	9	… … … + YFV
2000–2005	12	… … … … + HEPBB + MCV2
2006–2007	13	… … … … … + ROTAC
2008–2014	15	… … … … … … + PCV3
2015–2022	16	… … … … … … … + IPV1

BCG, BACILLE CALMETTE-GUÉRIN; DTP, DIPHTHERIA-TETANUS-PERTUSSIS CONTAINING VACCINE; MCV, MEASLES CONTAINING VACCINE; POL, POLIO; RCV, RUBELLA CONTAINING VACCINE; HEPB, HEPATITIS B CONTAINING VACCINE; HIB, HAEMOPHILUS INFLUENZAE TYPE B CONTAINING VACCINE; YFV, YELLOW FEVER VACCINE; HEPBB, HEPATITIS B BIRTH DOSE; ROTAC, ROTAVIRUS VACCINE LAST DOSE; PCV, PNEUMOCOCCAL CONJUGATE VACCINE; IPV, INACTIVATED POLIO VACCINE

A detailed explanation of the estimation methods is provided in following three publications:

Burton A, Monasch R, Lautenbach B, Gacic-Dobo M, Neill M, Karimov R, Wolfson L, Jones G, Birmingham M. WHO and UNICEF estimates of national infant immunization coverage: methods and processes. Bull World Health Organ. 2009;87(7):535-41.

Burton A, Kowalski R, Gacic-Dobo M, Karimov R, Brown D. A Formal Representation of the WHO and UNICEF Estimates of National Immunization Coverage: A Computational Logic Approach. PLoS ONE 2012;7(10): e47806. doi:10.1371/journal.pone.0047806

Brown D, Burton A, Gacic-Dobo M, Karimov R An Introduction to the Grade of Confidence in the WHO and UNICEF Estimates of National Immunization Coverage The Open Public Health Journal, 2013, 6, 73-76

Danovaro-Holliday MC, Gacic-Dobo M, Diallo MS, Murphy P, Brown DW. Compliance of WHO and UNICEF estimates of national immunization coverage (WUENIC) with Guidelines for Accurate and Transparent Health Estimates Reporting (GATHER) criteria. Gates Open Res. 2021;5:77. doi: 10.12688/gatesopenres.13258.1. eCollection 2021

Coverage estimates for global, regional and other country groupings

Aggregated estimates by global, regional and other country groupings are weighted WUENIC estimates based on population estimates provided by the United Nations Population Division (UNPD):

- BCG and HepBB: Live births
- MCV2: Estimated number of children aged 2 when the dose is recommended in the second year of life, or on the estimated denominator of the minimum age at which MCV2 is recommended (for example if recommended between 4-6 years of age, the estimated population of children aged 4 is used to weight the MCV2 contribution of that country)
- All other antigens: Surviving infants

The population estimate time-series data are published by the UNPD every two years as part of the World Population Prospects (WPP) with a release date usually taking place during June/July. The current WUENIC release uses the WPP 2022 revision.

All countries are included in global and regional calculations. Countries for which a WUENIC estimate is not produced (usually because the vaccine has not been introduced or reporting has not started) are included in the calculation using a value of zero for the estimate. There are three exceptions to this:

- BCG: Includes countries that recommend BCG universally in the first year of life (usually at birth)
- IPV: Includes countries that have OPV in their schedule
- Yellow Fever (YFV): Includes countries that are in the list of countries at risk of yellow fever for the calendar year in question. The list is annually updated and can be found here: https://www.who.int/publications/m/item/countries-with-risk-of-yellow-fever-transmission-and-countries-requiring-yellow-fever-vaccination-(november-2022)

Calculation of number of un- and under-vaccinated children

The estimated numbers of un- and under-vaccinated children provide a regional and global approximation to call attention to countries with large numbers of unprotected children, including those with high vaccination coverage and large birth cohorts.

The number of infants who are un- and under-vaccinated are estimated by country, region and globally by applying WUENIC coverage to the target population from the latest available release of the UN population estimates.

The term “zero-dose” children refers to those who have not received any dose of DTP-containing vaccine.

For example, the calculation of zero-dose prevalence is as follows:

- 100 - WUENIC for DTP1 = Zero-dose prevalence

This is then applied to the target population to derive the number of zero-dose children:

- (Zero-dose prevalence / 100) x UN estimates of surviving infants = # zero-dose children

The number of zero-dose children are reported rounded to the nearest thousand.

Disclaimer

All reasonable precautions have been taken by the World Health Organization and United Nations Children's Fund to verify the information contained in the WUENIC. However, the WUENIC are distributed without warranty of any kind, either expressed or implied. The responsibility for the interpretation and use of the material lies with the reader. In no event shall the World Health Organization or United Nations Children's Fund be liable for damages arising from its use.

Vaccine-dose estimated coverage values should be interpreted alongside the descriptive text that accompanies each data point.

VACCINES RECENTLY ADDED TO THE ESTIMATION PRODUCTION CYCLE

The number of vaccine-dose combinations added since the first release of the WHO and UNICEF estimates of national immunization coverage is shown below with detailed notes in the following sections.

Summary table of the evolution vaccine-dose combination for which WHO and UNICEF estimates are produced

1999	2005	2010	2014	2016	2017
BCG	BCG	BCG	BCG	BCG	BCG
DTP3	DTP3	DTP3	DTP3	DTP3	DTP3
POLIO3	POLIO3	POLIO3	POLIO3	POLIO3	POLIO3
MCV1	MCV1	MCV1	MCV1	MCV1	MCV1
HEPB3	HEPB3	HEPB3	HEPB3	HEPB3	HEPB3
	DTP1	DTP1	DTP1	DTP1	DTP1
	HIB3	HIB3	HIB3	HIB3	HIB3
		PCV3	PCV3	PCV3	PCV3
		ROTA (LAST)	ROTA (LAST)	ROTA (LAST)	ROTA (LAST)
		YFV	YFV	YFV	YFV
			MCV2	MCV2	MCV2
			HEPBB	HEPBB	HEPBB
				RCV	RCV
					IPV
(5)	(7)	(10)	(12)	(13)	(14)

Second dose of measles containing vaccine

Beginning with the 2013 revision (completed in July 2014), WHO and UNICEF produce coverage estimates for the **second dose of measles containing vaccine** (MCV2) from 2000 onwards for countries where a second dose is recommended in the

national immunization schedule for universal use and where empirical data are available for at least one year since introduction in the schedule. In the 2022 Revision, MCV2 estimates are produced for 187 Member States.

Coverage estimates for MCV2 are produced for the age cohort according to the administration recommended in national immunization schedule of each country. Global and regional coverage estimates are produced for vaccinations by 2 years of age and by the nationally recommended age. Currently, much of the information available is nationally reported coverage, as relatively few countries have included MCV2 in nationally representative coverage surveys.

Hepatitis B birth dose

Beginning with the 2013 revision (completed in July 2014), WHO and UNICEF produce coverage estimates for the **hepatitis B birth dose** from 2000 onwards for countries where the vaccine dose is recommended in the national immunization schedule for universal use and where empirical data are available for at least one year since introduction in the schedule.

Hepatitis B birth dose (HepBB) estimates are produced for doses given within 24 hours after birth. WHO and UNICEF started to separate out reported coverage given in 24 hours and HepB birth dose total (doses given within and after 24 hours of birth) for performance year 2016 onwards. An assumption is made that countries who were able to distinguish birth doses from late doses as of 2016 were able to do so prior to this performance year. Currently, survey results for HepBB are scant and in many instances the surveys either do not appropriately collect or report on the strict timing for administration. Estimates are made only for countries able to distinguish doses administered within first 24 hours of life. WHO and UNICEF estimates for HepBB may well be overestimated, especially for countries with low rates of institutionalized births.

In the 2022 Revision, HepBB estimates are produced for 104 Member States.

Inactivated polio vaccine

WHO and UNICEF began producing estimates of vaccination coverage for **inactivated polio vaccine** (IPV) in 2015 following the Global Polio Eradication Initiative (GPEI) strategic plan recommendation that at least one full dose, or two fractional doses, of IPV be included in routine immunization schedules as a strategy to mitigate the potential consequences should any re-emergence of type 2 poliovirus occur following the withdrawal of Sabin type 2 strains from **oral polio vaccine** (OPV). In April 2016 the switch from trivalent OPV (tOPV) to bivalent OPV (bOPV) began, thereby removing the type 2 component from immunization programmes worldwide in order to minimize the risk of continued type 2 circulating vaccine-derived poliovirus (cVDPV)

cases and vaccine associated paralytic polio (VAPP). In 2018-19, ≥1-dose of full IPV or two fractional doses were recommended by the Strategic Advisory Group of Experts on Immunization (SAGE) to induce long-lasting protection against poliomyelitis and since 2022 >=2 IPV doses are recommended for all countries[1].

Beginning with the 2015 revision (completed in July 2016), IPV coverage estimates were produced for countries using both IPV and OPV in their immunization programme. Beginning with the 2016 revision, IPV estimates are produced for all countries using IPV and reporting IPV coverage data regardless of OPV use. Estimated global and regional average coverage levels are produced **only for those countries where both OPV and IPV are included in the national immunization schedule**.

The production of IPV coverage estimates results in no change on the estimated coverage levels for the third dose of polio (Pol3). For countries recommending routine immunization with a primary series of three doses of IPV alone, the WHO and UNICEF estimates of coverage for Pol3 are equivalent to estimated coverage with three doses of IPV. For countries with a sequential schedule, estimated coverage for Pol3 is based on that for the third dose of polio vaccine regardless of vaccine presentation.

During 2015-17 revisions (i.e., estimates for 2015, 2016 and 2017), estimates for IPV reflect coverage with at least one routine full dose, or two fractional doses, of IPV (IPV1) among infants <1 year of age. With the new recommendation for ≥2-doses of IPV, whether full or fractional, the interpretation of WHO and UNICEF estimates for IPV have become more complex as of the 2018 revision with regards to what the estimates reflect.

For IPV1, in the 2016 revision, WHO and UNICEF produced estimates for individual countries, but not regional or global coverage estimates given that countries were still introducing this vaccine and IPV supply was unreliable. **Beginning with the 2017 revision, WHO and UNICEF produced regional and global average coverage estimates for IPV1 for countries using OPV.**

During 2016 and 2017 (mostly), with the occurrence of global IPV supply disruptions, some countries began implementing fractional doses of IPV. The quality of reporting for first and second fractional doses is largely unknown; however, when countries did report coverage for the first and second fractional dose, the WHO and UNICEF estimate for IPV reflects coverage for the second fractional dose. This remained the practice since the 2018 revision (completed during July 2019). However, with the new SAGE recommendations, interpretation of what IPV1 reflects as of the 2018 WUENIC revision is not straightforward. See the table below.

[1] https://www.who.int/teams/immunization-vaccines-and-biologicals/policies/position-papers/polio

IPV	bOPV	Protection
1 fractional dose	≥3 doses	Primed for protection against poliovirus types 2; Protected against poliovirus types 1 and 3
≥2 fractional doses	≥3 doses	Protected against poliovirus types 1, 2 and 3
1 full dose	≥3 doses	Primed for protection against poliovirus types 2; Protected against poliovirus types 1 and 3
≥2 full doses	≥3 doses	Protected against poliovirus types 1, 2 and 3
1 fractional dose	<3 doses	Primed for protection against poliovirus types 1, 2 and 3
≥2 fractional doses	<3 doses	Primed for protection against poliovirus types 1 and 3; Protected against poliovirus type 2
≥2 full doses	<3 doses	Primed for protection against poliovirus types 1 and 3; Protected against poliovirus type 2
1 full dose	<3 doses	Primed for protection against poliovirus types 1, 2 and 3

In some instances, estimated IPV1 coverage may reflect the percentage of infants in a country who received two fractional IPV doses, in which case these children are protected against strains 1, 2 and 3 if the child has received bOPV3. In other instances, estimated IPV1 coverage may reflect the percentage of infants in a country who received one full dose of IPV, in many instances through a combination penta- or hexa-valent vaccine. Further discussions around the best measure(s) for polio vaccination coverage are planned during 2023–24.

CAUTIOUS INTERPRETATION OF IPV1 COVERAGE ESTIMATES IS RECOMMENDED AT THIS TIME.

Rubella containing vaccine

Also beginning with the 2015 revision, WHO and UNICEF produce coverage estimates for **rubella containing vaccine** for those countries where the vaccine is included in the national immunization schedule. Estimates are made for the entire time series from 1980. The approach taken to estimate coverage for rubella containing vaccine is as follows:

- If rubella-containing vaccine is recommended in year Y and rubella containing vaccine is administered with the *first* dose of measles-containing vaccine (MCV1), then the estimate for rubella containing vaccine for year Y is equal to the estimated coverage for MCV1 in year Y.
- If rubella-containing vaccine is recommended in year Y and rubella-containing vaccine is administered with the *second* dose of measles-containing vaccine (MCV2), then the estimate for rubella containing vaccine for year Y is equal to the estimated coverage for MCV2 in year Y.
- When a rubella combination vaccine is introduced and reported coverage represents partial year introduction, the estimate is annualized to the entire target population of the year of introduction.

Because no single antigen rubella vaccine is in use and given that estimates for rubella containing vaccine are based on estimates for either MCV1 or MCV2, reported country coverage, though available, are not displayed in the country reports in order to avoid confusion by readers as to how such data are incorporated.

Global and regional average estimates have been produced for rubella-containing vaccine since the 2015 revision. In the 2022 Revision, RCV1 estimates are produced for 174 Member States.

Country response to the Joint Reporting Form on Immunization, 2023 (data for 2022)

Reported immunization service delivery performance data were received through the Joint Reporting Form on Immunization by 26 June 2023 from 183 of 195 WHO/UNICEF Member States.

List of WHO and UNICEF member states with no reported coverage data submitted as of 26 June 2023.

Country (ISO-3)	Country (ISO-3)
Cyprus (cyp)*	Poland (pol)
Germany (deu)	Panama (pan)
Israel (isr)	Sao Tome (stp)
Luxembourg (lux)*	Sudan (sdn)
Morocco (mar)	Saint Vincent and The Grenadines (vct)
Nauru (nru)	Venezuela (ven)

* eJRF reported but no coverage data provided

SUMMARY OF WUENIC VALUES FOR THE THIRD DOSE OF DTP CONTAINING VACCINE

The table below provides a summary of WUENIC for DTP3 for 2022. WUENIC was equal to the reported coverage in 2022 for nearly two-thirds countries, and was equal to the prior year's estimated coverage level due to absent reported data for an additional 8% of countries. WUENIC was less than reported coverage for nearly one-third of countries and was greater than reported coverage for just seven countries.

Summary of WUENIC values for the third dose of DTP containing vaccine, 2022

WUENIC = reported coverage	127 (65%) countries --- 22 countries with reported data that are supported by a survey within the last 5 years (not necessarily supportive of the 2022 coverage level, however) (BFA, BGD, COD, COM, DJI, FJI, GMB, GUY, HND, IND, MEX, MWI, NGA, NPL, PAK, PSE, RWA, SRB, STP, THA, VNM, WSM) --- 54 countries for which there have been no surveys since 2000 and thus no data other than reported data on which to base WUENIC.

	Many if not most of these countries are high or upper middle income countries.
WUENIC < reported coverage	61 (31%) countries; --- 27 countries with ≥10%-point difference, --- 13 with ≥5% and <10% -point difference
WUENIC > reported coverage	7 (3%) countries; --- 2 countries with ≥10%-point difference, --- 3 with ≥5% and <10% -point difference
WUENIC 2022 = WUENIC 2021 due to no reported coverage data for 2022	15 (8%) countries

Rule for survey inclusion / exclusion

Final survey reports that were either publicly reported and available or those received from countries by the WHO and UNICEF working group prior to 26 June 2023 were included in the 2022 revision of the WUENIC, sent to countries for review and comment. If a country replied to the draft WUENIC with information on survey results to consider, then the survey results were included in the final report if the survey report included a methods description in addition to the survey coverage estimates.

As in the past, only surveys with final reports are considered for inclusion. The purpose for this restriction of including survey data between the Draft and Final estimates is to hold true to a general principle not to make changes in underlying input data or working group decisions that the Member States have not seen. Past experiences with coverage survey results that changed between preliminary and final reports dictate the importance of this restriction. In addition, preliminary survey results often present vaccination coverage estimates based on the combination of respondent recall and documented evidence but not by documented evidence alone, making recall bias adjustment for multidose antigens impossible. If preliminary survey results are available, they are noted in the right-side explanatory text in the country reports.

Countries for which new surveys were included for the 2022 WUENIC revision:

Demographic and Health Survey (DHS)

Cambodia: Demographic and Health Survey 2021-2022 [survey results used to inform estimates for 2019, 2020 cohorts]

Madagascar: Enquête Démographique et de Santé, 2021 [survey results used to inform estimates for 2019 cohort]

Multiple Indicator Cluster Survey (MICS)

Bangladesh: Bangladesh Multiple Indicator Cluster Survey, 2019 [only assessed receipt of maternal tetanus toxoid containing vaccine]

Fiji: Fiji Multiple Indicator Cluster Survey, 2021 [survey results used to inform estimates for 2018, 2019 cohorts]

Nigeria: Nigeria Multiple Indicator Cluster Survey, 2021 [survey results used to inform estimate for 2020 cohort]

Uzbekistan: Uzbekistan Multiple Indicator Cluster Survey, 2021 [survey results support reported official coverage data for 2019 cohort]

Other coverage surveys including vaccination coverage

Cabo Verde: Inquérito Demográfico e de Saúde Reprodutiva, IDSR-III, 2018 [survey results support reported official coverage for 2016 cohort]

Central African Republic: Enquete de Couverture Post-Campagne de Vaccination contre la Rougeole, 2021 [survey results not utilized by the working group; <10% documented evidence available]

Chad: Evaluation de la Campagne de Vaccination contre la Rougeole, 2022 [survey results not utilized by the working group; <20% documented evidence available]

Comoros: Rapport de l'enquête de couverture vaccinale de routine, 2022 [survey results support reported official coverage for 2020 cohort]

El Salvador: Encuesta Nacional de Salud (ENS), 2021 [survey results used to inform estimates for 2018 and 2019 cohorts]

Mexico: Encuesta Nacional de Salud y Nutrición (ENSANUT) 2021 sobre COVID-19 [survey results support reported coverage for some antigens for the 2019 birth cohort]

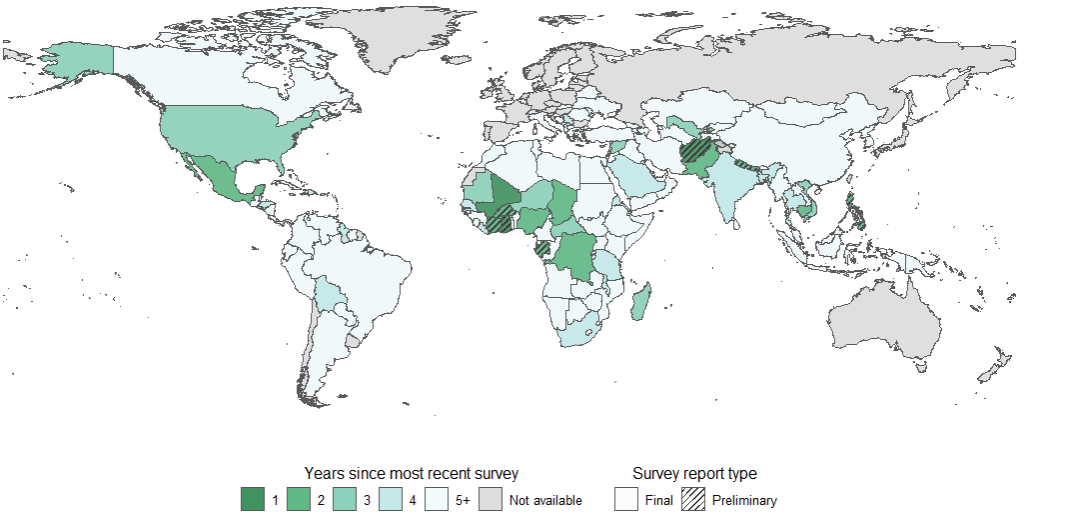
Niger: Enquête Nationale sur la Fécondité et la Mortalité des Enfants de Moins de Cinq Ans, 2021

Pakistan: Third-Party Verification Immunization Coverage Survey Round Two (TPVICS R-II), 2022 [survey results support reported official coverage for 2020 cohort]

Saudi Arabia: The 2019 Kingdom of Saudi Arabia World Health Survey [survey results not utilized by the working group; small sample size and non-standard analysis]

In addition to the surveys reviewed to inform WUENIC, available key indicators reports were available for and were added to the explanatory text that accompany the estimates for Afghanistan (2022-23 DHS), Burkina Faso (2021 DHS), Cote d'Ivoire (2021 DHS), Gabon (2021 DHS), Ghana (2022 DHS), Nepal (2022 DHS). For Tanzania, the publicly released key indicators report did not include immunization results and the 2022 Bangladesh Demographic and Health Survey did not include an immunization module.

Figure 1. Years since most recent survey with vaccination coverage estimates



Source: WHO/UNICEF estimates of national immunization coverage, 2022 revision
Notes: Calculated based on number of years between 12-23m survey cohort year and 2022.
Preliminary results do not directly inform the WUENIC estimates, but are noted in the comments.
This map is stylized and based on an approximate scale. It does not reflect a position by UNICEF on the legal status of any country or territory or the delimitation of any frontiers.

Additional data sources:

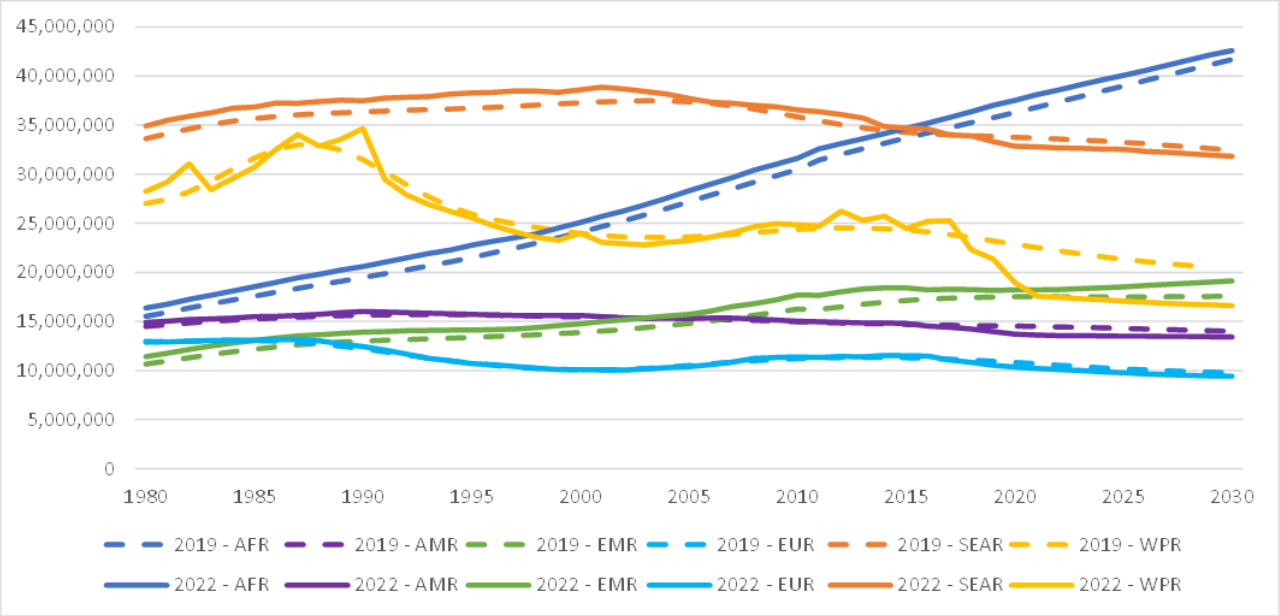
Estimated population data[2] from the UN Population Division are used as one of the inputs utilized in the review of country data and when the working group considers uncertainty in the WHO and UNICEF estimates. The 2022 WUENIC revision (published in July 2023) used the *2022 revision of the* ***World Population Prospect*** *from the United Nations Population Division* for estimating the Grade of Confidence (GoC) in each WUENIC estimate and for calculations of regional and global vaccination coverage figures**.**

The World Population Prospect 2022 was published on 11 July 2022 and replaced the 2019 revision. It considers data from 1,758 censuses. In some countries, population registers based on administrative data systems provide the necessary information. Population data from censuses or registers referring to 2015 or later were available for 152 countries or areas, representing 64 per cent of the 237 countries or areas included in the analysis. For 74 countries or areas, the most recent population count data available were from the period 2005-2014. For the remaining 11 countries or areas, the most recent available census data were from before 2005. In addition, in the present evaluation information on births and deaths from civil registration and vital statistics systems for 169 countries, and demographic indicators from 2,890 surveys. More details can be found here: https://population.un.org/wpp/

[2] United Nations, Department of Economic and Social Affairs, Population Division (2022). *World Population Prospects 2022, Online Edition.*

As with most revisions, estimates of live births and surviving infants changed compared to previous years, and also the projections for the future were updated. Large changes, reflected in a decline compared to population estimates from the 2019 revision, were observed for the WHO Western Pacific Region. A larger increase in surviving infants than previously estimated was observed for the WHO Eastern Mediterranean Region and to a lesser extent for the WHO African Region (Figure 2). The changes in target population estimates result in a 1% lower global DTP3 coverage than if calculations had utilized data from the 2019 revision; the changes in target population estimates result in 2 percentage point lower regional average DTP3 coverage for the Western Pacific Region.

Figure 2. Estimated number of surviving infants by WHO region, 2019 and 2022 revisions, 1980-2030



Direct communications with country teams between WUENIC Draft and Finalization

WHO and UNICEF encourage countries to review and comment on the country reports shared following the Draft production. In past years, regional or sub-regional consultations have been held during May/June to go through select country data and estimates. During the 2022 revision cycle, WHO and UNICEF held a conference call consultation with the country team from South Sudan and Equatorial Guinea.

CHANGES BETWEEN 2021 AND 2022 WUENIC REVISIONS:

Database structure change.
None

Changes in estimates due to updates in empirical data between revisions result from:

- Updated data submitted by Member States and previously reported time series were revised.
- New survey data becoming available after 2021 revision (between 7 July 2022 and 26 June 2023)
- 2021 data reported late, and not included in 2021 revision of coverage estimates (between 7 July 2022 and 26 June 2023)

A list of countries with major changes in the estimated time series is provided in Table 1.

Vaccine introduction and data availability

For vaccine introduction, or the introduction of additional doses into the routine immunization schedule (such as the second dose of measles-containing vaccines or Hepatitis B birth dose), WHO and UNICEF estimates of national immunization coverage are produced beginning in the first year for which data are reported by national authorities. In situations where a vaccine was introduced sub-nationally or the introduction occurred after January, the WHO and UNICEF estimates of coverage are based on computed coverage for the annual national target population.

The following lists of countries reflect those where WHO is aware that the country has introduced the vaccine but for which there is insufficient data for generating WUENIC.

- ***Hepatitis B***

Countries with infant immunization not in national schedule: DNK;FIN;HUN;ISL.

- ***Hepatitis B birth dose:***

Data collection form was modified in 2017 (for 2016 data). Countries were asked to report birth dose given in 24 hours and "all birth doses" (i.e., within and after 24 hours). This permitted revision of historical data and exclusion of countries where data on birth dose given within 24 hours is not available. These include:

Angola: Introduced in 2015; however, data on birth dose given within 24 hours is not reported.
Australia: No data reported on birth dose given within 24 hours or late birth dose.

Bosnia and Herzegovina: No data reported on birth dose given within 24 hours (reported data on all doses from 2004).
Canada: Reports partial HepB birth dose, but no data are reported.
Equatorial Guinea: Introduced in December 2018; reported only very few vaccine doses administered; no coverage reported on birth dose given within 24 hours.
Libya: No birth dose given within 24 hours reported (reported data on all doses from 2001).
Mauritania: Introduced in 2013. No data reported on birth dose given within 24 hours.
Pakistan: Introduced in 2019. No data reported on birth dose given within 24 hours.
Paraguay: Introduced in 2017. No data reported on birth dose given within 24 hours.
Syria: Introduced in 2003. No data reported on birth dose given within 24 hours.
Russian Federation: Does not appear that hepatitis B birth dose is recommended; reported national schedule information notes a recommended dose of hepatitis B at day 1, but not necessarily within the first 24 hours. Data not reported by the country.

- ***Hib***

Only 1 country, China, is missing national introduction.

- ***Pneumococcal conjugate vaccine (PcV):***

Austria: Introduced in 2014. No reported data.
Monaco: Introduced in 2006. No reported data.
Tajikistan: Introduced in 2020. No reported data.

***Iraq:* Following introduction in 2017 and reported coverage data for 2017–19, the country appears to have stopped using the vaccine. Since 2020, the country has reported coverage levels equal to 'zero'. WHO and UNICEF will continue to work to obtain confirmation whether the vaccine has been formally removed from the national schedule.

***Venezuela:* Following introduction in 2014 and reported coverage data for 2015–16, the country appears to have stopped using the vaccine. Since 2017, the country has reported coverage levels equal to 'zero'. WHO and UNICEF will continue to work to obtain confirmation whether the vaccine has been formally removed from the national schedule.

N.B.: Countries may use different PCV schedules, namely 3 basic doses in infants with no booster (3+0), 2 basic doses in infants with a later booster (2+1), or 3 basic doses in

infants with a booster (3+1). Recommended PCV schedules are in flux with countries making changes, most often from a 3+0 to a 2+1 or 3+1 schedule. In most countries, PCV3 represents the third dose whether given before 12 months or at or after 12 months; however, in some cases WUENIC estimates for PCV3 may reflect the percentage of surviving infants who received two doses of PCV prior to the 1st birthday.

Countries that have not yet introduced: Antigua and Barbuda, Bosnia and Herzegovina, Belarus, Belize, Brunei Darussalam, Cabo Verde, Chad, China, Comoros, Cook Islands, Cuba, Czechia, Democratic People's Republic of Korea, Dominica, Egypt, Equatorial Guinea, Estonia, Gabon, Grenada, Guinea, Iran, Jamaica, Jordan, Maldives, Montenegro, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Sri Lanka, Somalia, South Sudan, Suriname, Syria, Thailand, Timor-Leste, Ukraine, Viet Nam.

- ***Second dose measles-containing vaccine:***

Ireland: Introduced since 1982; data are not reported.
DR Congo: Introduced since 2022; data are not reported.

Countries that have not yet introduced as 2022: Benin, Central African Republic, Gabon, Mauritania, South Sudan, Vanuatu.

- ***Rubella-containing vaccine:***

Based on Measles estimates (either first or second dose as appropriate per schedule) but modified if partial introduction.
Democratic People's Republic of Korea: Introduced in 2019. No reported data.

Countries that have not yet introduced: Afghanistan, Central African Republic, Chad, DR Congo, Democratic People's Republic of Korea, Djibouti, Ethiopia, Gabon, Guinea, Guinea-Bissau, Equatorial Guinea, Liberia, Madagascar, Mali, Niger, Nigeria, Pakistan, Somalia, South Africa, South Sudan, Sudan.

- ***Rotavirus vaccine (Rota last dose):***

Andorra: Introduced in 2020. No reported data.
Russian Federation: Introduced sub-nationally in 2016. No reported data.
Tonga: Introduced in 2021 and reported data for Rota1 but not for RotaC.
France: Introduced in 2022. No reported data.
***Venezuela*: Following introduction in 2006 and reported coverage data for 2006–17, the country appears to have stopped using the vaccine. Since 2018, the country has reported coverage levels equal to 'zero'. WHO and UNICEF will continue to work to obtain confirmation whether the vaccine has been formally removed from the national schedule.
****Philippines*: Rotavirus introduction was part of a pilot project during 2012 and 2015 and subsequently discontinued.

74 countries have not yet introduced rotavirus vaccine.

- ***Yellow Fever:***

A listing of at-risk countries can be accessed online at:
https://www.who.int/publications/m/item/countries-with-risk-of-yellow-fever-transmission-and-countries-requiring-yellow-fever-vaccination-(november-2022)

Seychelles: Uses vaccine in routine schedule, but an estimate is not produced because the country is not at risk.
Cabo Verde: Uses vaccine in routine schedule, but an estimate is not produced because the country is not at risk.
São Tome and Principe: Country no longer at risk but has continued using vaccine in routine schedule, and estimates continue to be produced.

Three countries are on the yellow fever transmission risk listing (see above) but have not yet introduced the vaccine. These are: Ethiopia, South Sudan, Sudan.

Figure 3: Countries with important revisions in the WHO and UNICEF estimates of national immunization coverage (WUENIC estimates for DTP3) time series between 2021 and 2022 revisions

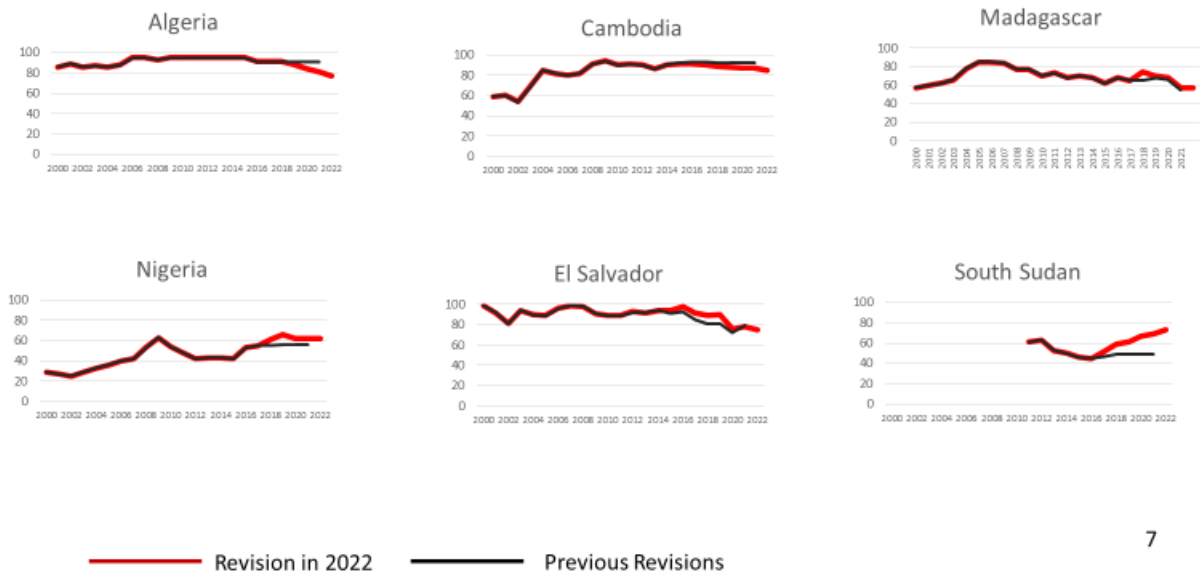


Table 2: List of countries where WHO and UNICEF estimates of national immunization coverage are different (≥5%-pts) from reported data — based on DTP3 coverage in 2022:

Reported data: countries official estimates are treated as reported data unless the working group decides to accept the reported administrative coverage data instead. Administrative coverage data are accepted if the government official data are absent or there is insufficient justification for the government official estimate or the government official estimate represents target coverage instead of achieved coverage. Instances where WUENIC differs from the reported coverage data are shown below.

The comment field in the table below provides an explanation of 2022 coverage estimates; for a more comprehensive explanation, it is important to look at the explanations of the complete time-series for different antigens from the specific country profiles: https://immunizationdata.who.int/listing.html

Gavi Eligible Phase	WHO region	Country	Est	Adm	Gov	Comment	Diff
x	EMR	Afghanistan	69	84	84	Reported data calibrated to 2016 levels. WHO and UNICEF await the final results of the 2022-23 Afghanistan Multiple Indicator Cluster Survey (MICS). Preliminary results from the 2022-23 Afghanistan MICS suggest coverage of 51 percent for children aged 12-23 months at the time of survey. Results will be reflected for the actual cohort upon receiving the final results. Estimate challenged by: D-R-	–15
	AFR	Angola	42	63	63	Reported data calibrated to 2014 levels. Programme reports vaccine supply disruptions for all antigens at subnational levels. WHO and UNICEF recommend assessment of the routine monitoring system. WHO and UNICEF are aware of a 2023 Demographic and Health Survey and await the final results. Estimate challenged by: D-R-	–21
x	SEAR	Bangladesh	98	120	NA	Estimate based on extrapolation from data reported by national government. Reported data excluded. Nationally reported data for official coverage includes only valid doses administered. Reported data excluded because 120 percent greater than 100 percent. Reported data excluded due to sudden change in coverage from 93 level to 120 percent. Estimate challenged by: D-	–22
x	AFR	Benin	76	120	84	Reported data calibrated to 2016 levels. Reported data excluded. Official coverage estimates are unexplained. WHO and UNICEF are aware of a 2021 Multiple Indicator Cluster Survey and await the final results. Estimate challenged by: D-R-	–8
	AFR	Botswana	86	63	NA	Estimate informed by relative change in reported number of doses administered between 2021 and 2022 applied to the prior	23

						year estimate. Reported data excluded. Fluctuation in reported data suggest poor quality administrative recording and reporting. Reported data are incomplete, with two-thirds of expected reports received. The 2022 EPI Review noted increased challenges in data quality and detailed recommendations for data quality improvement were provided. No nationally representative household survey within the last 5 years. WHO and UNICEF recommend a high-quality survey to confirm reported levels of coverage. WUENIC might be overestimating the true coverage in recent years. Programme reports two months vaccine stockout at national and subnational levels. GoC=Assigned by working group. Reported coverage and denominator are inconsistent, and the estimate is confirmed only by survey for 2006 and 2012 birth cohorts.	
x	AFR	Burkina Faso	91	96	96	Estimate based on extrapolation from data reported by national government. Reported data excluded. Reported coverage suggests increase in coverage from 2021 to 2022 while reported number of doses suggests fewer children vaccinated. WHO and UNICEF await the final results of the 2021 Burkina Faso Demographic and Health Survey (DHS). Programme reports less than one month vaccine stockout at national level. Preliminary results of the 2021 Burkina Faso DHS suggest 88 percent coverage for children aged 12-23 months at the time of the survey. Results will be reflected for the actual cohort upon receiving final results. Estimate challenged by: D-	–5
	AFR	Cabo Verde	93	101	101	Estimate based on extrapolation from data reported by national government. Reported data excluded. Estimate informed by prior year estimate. Reported data suggests increasing in coverage while trends in reported doses administered indicate declines. Reported data excluded because 101 percent greater than 100 percent. No nationally representative household survey within the last 5 years. WHO and UNICEF recommend a high-quality survey to confirm reported levels of coverage. GoC=R+ D+	–8
		Cambodia	85	96	NA	Reported data calibrated to 2020 levels. Estimate challenged by: D-R-	–11
x	AFR	Cameroon	68	80	80	Reported data calibrated to 2017 levels. WHO and UNICEF are aware of the 2023 national immunization coverage survey and await the final results. Estimate challenged by: D-R-	–12
x	AFR	Central African Republic	42	91	68	Reported data calibrated to 2017 levels. Reported data excluded. Fluctuations in	–26

						reported data suggest poor quality administrative recording and reporting. Estimated coverage does not reflect increases in reported administrative coverage from 2021 to 2022 for most antigens. Programme notes a planned coverage survey to be conducted in 2023 as well as ongoing data quality improvement activity. Programme reports district level vaccine stockout. Estimate challenged by: D-R-	
x	AFR	Chad	60	91	91	Reported data calibrated to 2017 levels. Programme notes challenges with the availability of data recording tools and training of health centre managers in data verification and analysis. Also, data review and validation meetings are not systematically held at all levels. WHO and UNICEF encourage continued efforts to improve recording and monitoring while also increasing coverage. WHO and UNICEF recommend a high-quality vaccination coverage survey and encourage the conduction of the national immunization coverage survey planned for 2023. Programme reports a one month vaccine stockout at national and subnational levels. Estimate challenged by: D-R-	–31
x	AFR	Côte d'Ivoire	76	91	91	Reported data calibrated to 2020 levels. Preliminary results from the 2021 Demographic and Health Survey suggest 54 percent coverage. Estimate challenged by: D-R-	–15
x	AFR	Djibouti	59	75	75	Estimate based on extrapolation from data reported by national government. Reported data excluded due to sudden change in coverage from 59 level to 75 percent. Increase in reported coverage is in part reflective of a seventeen percent decline in the target population from 2021 to 2022 more so than an increase in the number of children vaccinated. Reported coverage based on incomplete reporting (67 of 72 reports expected). GoC=R+ D+	–16
	AFR	Equatorial Guinea	53	70	70	Reported data calibrated to 2016 levels. Reported data excluded. . No nationally representative household survey within the last 5 years. WHO and UNICEF recommend a high-quality survey as well as a data review to confirm reported levels of coverage. GoC=Assigned by working group. Fluctuation in reported coverage across the time series suggests challenges in routine monitoring system.	–17
x	AFR	Ethiopia	65	93	93	Reported data calibrated to 2017 levels. Estimate challenged by: D-R-	–28
	WPR	Fiji	99	94	85	Reported data calibrated to 2019 levels. WHO and UNICEF recommend a comprehensive review of reporting system and resultant coverage data. Inconsistent	5

						adjustments from reported administrative coverage from 2012. Estimate challenged by: R-	
x	AFR	Guinea	47	87	60	Reported data calibrated to 2016 levels. Reported data excluded. Reported official coverage reflects adjustments that take into account outbreaks and stockouts of vaccine and syringes. However, further documentation is not provided. WHO and UNICEF encourage a data review alongside improvements to the immunization service delivery. No nationally representative household survey within the last 5 years. WHO and UNICEF recommend a high-quality survey to confirm reported levels of coverage. The country conducted several catch-up activities during 2022 to reduce immunity gaps in persons that had been previously missed. The added proportion of infants from the 2021 cohort who were vaccinated in 2022 varied from 1.2 percent for BCG to 3.8 percent for measles. However, reported coverage shown here do not reflect the contribution of these catch-up activities. Programme reports a one month vaccine stockout at national and subnational levels. Estimate challenged by: D-R-	–13
	AMR	Guyana	98	103	103	Estimate based on extrapolation from data reported by national government. Reported data excluded because 103 percent greater than 100 percent. GoC=R+ D+	–5
x	AMR	Haiti	51	73	73	Reported data calibrated to 2018 levels. Reported data excluded. Concerns remain with regards to reported data. See comments for 2021. Estimated coverage levels for the past three years do not reflect patterns in reported number of doses administered for some antigens. As, such estimated coverage levels may overestimate actual coverage. No nationally representative vaccination coverage survey within the last 5 years. WHO and UNICEF recommend a high-quality survey to confirm reported levels of coverage as the country situation permits. Programme reports five month vaccine stockout at national and subnational levels. Estimate challenged by: D-R-	–22
	WPR	Japan	99	104	NA	Estimate based on extrapolation from data reported by national government. Reported data excluded because 104 percent greater than 100 percent. No nationally representative independent assessment within the last 5 years. WHO and UNICEF recommend a high-quality independent empirical assessment to confirm reported levels of coverage. GoC=R+ D+	–5

	EMR	Jordan	77	92	92	Estimate based on extrapolation from data reported by national government. Reported data excluded. Increase in reported coverage for infant vaccination from 2020 levels largely reflects declines in the target population of nearly nine percent points rather than an increase in the number of children vaccinated. Target population for vaccines recommended in the second year of life increases between 2020 and 2022. WHO and UNICEF are aware of an ongoing DHS survey and await the results. GoC=Assigned by working group. Reported data not considered.	–15
x	WPR	Lao People's Democratic Republic	80	92	92	Reported data calibrated to 2016 levels. WHO and UNICEF are aware of an ongoing 2023 Multiple Indicator Cluster Survey and await the final results. Estimate challenged by: R-	–12
	EMR	Lebanon	67	77	NA	Estimate informed by prior year estimated value. Reported data excluded. Unexplained decline of 20 percent in reported target population from 2021 to 2022 accompanied by unexplained declines in reported number of doses administered for most antigens. Rapid year-to-year changes require independent verification. WHO and UNICEF are aware of an ongoing 2023 Multiple Indicator Cluster Survey and await the final results. Programme reports one month vaccine stockout at national and subnational levels. Estimate challenged by: D-R-	–10
x	AFR	Lesotho	87	92	92	Reported data calibrated to 2016 levels. Reported data excluded. Fluctuations in reported data suggest the need for review of the administrative recording and reporting system. Although recent reported coverage levels are more consistent with those of a 2018 survey, WHO and UNICEF encourage another independent coverage assessment to verify coverage levels given fluctuations in reported data for several vaccines that suggest issues with the quality of administrative recording and reporting. Estimate challenged by: D-R-	–5
x	AFR	Liberia	78	95	95	Reported data calibrated to 2018 levels. Estimate informed by trend in reported data. As per 2022 EPI report, programme notes that there is no clear strategy for catch-up on vaccines missed due to prolonged stockouts as well as disruptions due to the COVID-19 pandemic. Estimate challenged by: D-R-	–17
	EMR	Libya	73	96	97	Programme reports three months vaccine stockout at national and subnational levels. As done for previous years, using this information and a strong assumption that immunization services have been severely disrupted during the vaccine stockout, the	–24

						estimate is based on a 25 percentage point reduction in coverage consistent with the duration of the stockout. Despite the ongoing humanitarian crisis, reported coverage levels have been sustained. Government indicates that official estimates are derived from the administrative coverage based on the average of previous years. In 2021, reports indicated that up to 90 percent of primary health care (PHC) were closed in some areas (WHO Appeal for Libya 2023 who.int/emergencies/funding/outbreak-and-crisis-response-appeal/2023/2023-appeals/appeal-libya). No nationally representative household survey within the last 5 years. WHO and UNICEF recommend a high-quality survey to confirm reported levels of coverage, as the situation permits. Estimate challenged by: D-R-	
x	AFR	Madagascar	57	78	78	Reported data calibrated to 2019 levels. Reported data excluded. Unexplained increase in the reported target population of surviving infants of 11 percent between 2021 and 2022. Reported increase in the number of doses for some vaccines of lesser magnitude. Estimate challenged by: D-R-	–21
x	AFR	Mauritania	76	85	85	Reported data calibrated to 2019 levels. Estimate challenged by: D-R-	–9
x	AFR	Mozambique	61	88	NA	Estimate informed by extrapolation from prior year. WHO and UNICEF are aware of an ongoing DHS survey and await the results. WHO and UNICEF encourage a comprehensive review and revision of coverage related time-series data. Programme reports two and one-half months vaccine stockout at national level. Estimate challenged by: D-R-	–27
x	AMR	Nicaragua	92	107	113	Estimate informed by a review of the number of doses administered in 2022 compared to 2020 for a similar target population. Adjustment used for other antigens would imply an implausible year-to-year increase in coverage that would require independent verification. Reported data excluded because 113 percent greater than 100 percent. Reported data excluded due to sudden change in coverage from 101 level to 113 percent. No nationally representative household survey within the last 5 years. WHO and UNICEF recommend a high-quality survey to confirm reported levels of coverage. Estimate challenged by: R-	–21
x	AFR	Nigeria	62	85	57	Estimated coverage informed by prior year estimate. Official reported coverage informed by the survey result for the youngest annual cohort (the 2020 cohort) from the 2021 MICS/NICS survey.	5

						Government has indicated that the 2021 official coverage estimate is also based on survey results. Note that reported official coverage reflects crude survey results for the 3rd dose that do not account for recall bias in the absence of documented evidence of vaccination. For antigens with reported administrative data in 2022, there is the appearance of increases in the number of doses administered from levels reported for 2021; however, it remains unclear whether the transition to DHIS2 has matured sufficiently to monitor trends in coverage. Alongside continued implementation of the national data quality improvement plan activities, WHO and UNICEF encourage continued efforts to independently assess the quality of the administrative recording and reporting system at all levels. Estimate challenged by: D-R-	
x	WPR	Papua New Guinea	36	42	42	Reported data suggest an increase in the number of doses administered during 2022 following a decline from 2020 to 2021. Estimate informed by the absolute difference in reported coverage between 2021 and 2022 applied to the 2021 estimated coverage level. Reported data reflect 94 percent of expected district level reports. No nationally representative household survey within the last 5 years. WHO and UNICEF recommend a high-quality survey to confirm reported levels of coverage. Estimate challenged by: D-R-	–6
	AMR	Paraguay	69	57	57	Reported data calibrated to 2015 levels. No nationally representative household survey within the last 5 years. WHO and UNICEF recommend a high-quality survey to confirm reported levels of coverage. Estimate challenged by: R-	12
x	AFR	Rwanda	98	103	NA	Estimate informed by estimated coverage for 2019 following a review of administrative data which suggests similar number of administered doses in 2022 compared to 2019, though estimated coverage for 2022 may overestimate actual coverage. Reported administrative coverage reflects increases in doses administered as well as a 10 percent decline in the target population compared to 2021 based on updated projections from the 2012 census. Reported data excluded because 103 percent greater than 100 percent. Reported data excluded due to sudden change in coverage from 88 level to 103 percent. Estimate challenged by: R-	–5
x	AFR	Senegal	88	71	93	Reported data calibrated to 2018 levels. Programme notes healthcare worker strikes with resultant impacts on data	–5

						completeness. Estimate challenged by: D- R-	
x	EMR	Somalia	42	90	90	Reported data calibrated to 2010 levels. Reported data excluded. Availability of robust, independent data assessing coverage as well as the quality of recording and reporting system are lacking. WHO and UNICEF are aware of the 2022 Post-campaign coverage survey (PCCS) and EPI Coverage Survey and await the final report. Vaccine stockout reported for all vaccines at the subnational level. Estimate challenged by: D-R-	–48
x	AFR	South Sudan	73	84	84	Estimate informed by relative change in reported doses administered from 2021 to 2022 applied to the prior year estimated coverage. Across the time-series, estimate may overestimate coverage as well as dropout for multi-dose antigens given concerns for quality of administrative recording and reporting system. Reported data excluded. Country reports that due to instability in the country, there is a large population movement in and out of the country which affects the denominator. Country also notes issues related to the accuracy of the numerator such as high turn over of vaccination staff coupled with limited capacity in tallying, recording and reporting of immunization data. WHO and UNICEF encourage continued efforts to improve recording and monitoring, including a high quality survey, while the programme continues efforts to increase vaccination coverage. Estimate challenged by: D-R-	–11
	AMR	Suriname	77	91	91	Reported data calibrated to 2016 levels. Programme reports one month vaccine stockout at national level. Estimate challenged by: R-	–14
x	EMR	Syrian Arab Republic	46	65	65	Reported data calibrated to 2005 levels. Survey results for the 2019 birth cohort suggest estimated coverage levels may be underestimated. Estimate challenged by: D-R-	–19
	SEAR	Thailand	97	88	88	Estimate based on extrapolation from data reported by national government. Reported data excluded. Estimated coverage levels may overestimate actual coverage levels based on patterns signalling declines in the reported number of doses administered. Reported denominator is likely an underestimate. Country reports that denominator is based on count of children residing in the area of responsibility of each health facility. Data for Bangkok are not included in the data reporting system. WHO and UNICEF are aware of an ongoing 2022 Multiple Indicator Cluster Survey and await the final results. Estimate challenged by: D-	9

	SEAR	Timor-Leste	86	98	98	Estimate based on extrapolation from data reported by national government. Reported data excluded. The country notes data quality issues and indicates work is needed to improve recording and reporting. For several antigens, reported number of doses administered decreases while coverage increases relative to prior years. Reported doses administered in 2021-2022 are meaningfully lower than that for the prior five year period. WHO and UNICEF recommend a revision of reported coverage time series. WHO and UNICEF are aware that the country is conducting an EPI coverage survey in 2023 and await the final results. Estimate challenged by: D-	–12
x	AFR	Togo	82	89	89	Reported data calibrated to 2016 levels. Country notes monthly data validation activities that support the recent reported higher coverage levels compared to the last survey which is being used by WHO and UNICEF to adjust the time-series. Country also notes that 2022 census suggests a smaller total population than that from which target population estimates were derived in the past. WHO and UNICEF are aware of a planned EPI programme review and coverage survey during 2023 and await the final results to validate higher reported coverage levels. Estimate challenged by: D-R-	–7
x	AFR	United Republic of Tanzania	88	107	97	Reported data calibrated to 2018 levels. WHO and UNICEF are aware of an ongoing Demographic and Health Survey (DHS) and await the final results. Estimate challenged by: D-R-	–9
x	EMR	Yemen	74	89	89	Reported data calibrated to 2012 levels. Despite the ongoing humanitarian crisis, reported coverage levels have been sustained with an increase in the reported number of children vaccinated in the last four years. Large and disruptive measles and vaccine-derived poliovirus outbreaks are ongoing. WHO and UNICEF are aware of an ongoing MICS survey and await final results. Estimate challenged by: D-R-	–15

Est: WHO UNICEF coverage estimates 2022 revision (completed July 2023)
Adm: reported administrative coverage data
Gov: reported government official estimate of coverage
Diff: difference between reported data and WHO/UNICEF coverage estimates where the reported data reflects the government official estimate if provided, otherwise it reflects the reported administrative coverage data unless government official estimate excluded.
D–: indicates the estimated coverage is challenged by recomputed coverage using reported coverage numerator data and an independent denominator
R–: indicates the estimated coverage is challenged by reported coverage data