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Childhood Immunization Coverage in Libya: Trends, DTP Dropout and a Zero-Dose Proxy Based on WHO/UNICEF Estimates, 2000–2025

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Keywords:
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ABSTRACT

Background: Monitoring childhood immunization coverage requires attention to both estimated coverage and the quality of the underlying data. In Libya, prolonged conflict, vaccine stockouts and differences between reported and estimated coverage complicate the interpretation of national trends. This study assessed childhood immunization coverage in Libya from 2000 to 2025, compared WHO/UNICEF estimates with administrative and government-reported data, examined confidence grades and country-specific estimation notes, and assessed DTP dropout and a coverage-based zero-dose proxy.

Methods: A descriptive secondary analysis was conducted using the 2025 revision of the WHO/UNICEF Estimates of National Immunization Coverage (WUENIC) for 12 vaccine indicators, together with administrative coverage, government estimates, target populations and grades of confidence. DTP1–DTP3 and MCV1–MCV2 coverage gaps were calculated. The zero-dose proxy was calculated as 100% minus DTP1 coverage, and approximate numbers of children not receiving DTP1 or DTP3 were derived from United Nations Population Division estimates of surviving infants.

Results: WUENIC estimates of DTP1, DTP3, MCV1 and MCV2 coverage fell from 99%, 97%, 95% and 94% in 2017 to 74%, 73%, 73% and 72% in 2018, whereas administrative and government-reported DTP1 coverage for 2018 remained at 99% and 98%, respectively. The estimates were unchanged through 2023, reflecting assumptions about service disruption and vaccine stockouts rather than verified stability. In 2025, WUENIC estimated DTP1, DTP3, MCV1 and MCV2 coverage at 97%, 90%, 93% and 85%, respectively; relative DTP1–DTP3 dropout was 7.2% and the zero-dose proxy 3%. Preliminary survey findings for the 2023 birth cohort were lower (DTP3, 81%; MCV2, 65%). Every estimate from 2009 onward carried the lowest grade of confidence.

Conclusions: Recent increases in WUENIC estimates should be interpreted cautiously because of discrepancies between data sources, catch-up vaccination and low confidence grades. Strengthening routine reporting, recording routine and catch-up doses separately, and validating national estimates against independent surveys are needed to identify unvaccinated children in Libya.

التغطية بالتطعيمات الروتينية لدى الأطفال في ليبيا: الاتجاهات، ومعدل التسرب بين جرعات اللقاح الثلاثي، ومؤشر تقريبي للأطفال غير الحاصلين على أي جرعة استناداً إلى تقديرات منظمة الصحة العالمية واليونيسف، 2000–2025

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الملخص

الخلفية: تتطلب متابعة التغطية بالتطعيمات الروتينية لدى الأطفال مراعاة مستوى التغطية المقدَّر وجودة البيانات معاً. وفي ليبيا، تُصعِّب النزاعات ونفاد اللقاحات والفروق بين التغطية المُبلَّغ عنها والمقدَّرة تفسيرَ الاتجاهات الوطنية. هدفت الدراسة إلى تقييم التغطية بالتطعيمات لدى الأطفال في ليبيا خلال الفترة 2000–2025، ومقارنة مصادر البيانات، وتقييم التسرب بين جرعات اللقاح الثلاثي (DTP) ومؤشر تقريبي للأطفال غير الحاصلين على أي جرعة.

الطرائق: أُجري تحليل ثانوي وصفي لمراجعة عام 2025 لتقديرات منظمة الصحة العالمية واليونيسف للتغطية الوطنية بالتطعيم (WUENIC) لاثني عشر مؤشراً، إلى جانب التغطية الإدارية والتقديرات الحكومية ودرجات الثقة. وحُسبت الفجوة بين الجرعتين الأولى والثالثة من اللقاح الثلاثي والفجوة بين جرعتي لقاح الحصبة، وحُسب المؤشر التقريبي للأطفال غير الحاصلين على أي جرعة بطرح التغطية بالجرعة الأولى من اللقاح الثلاثي من 100%.

النتائج: انخفضت تقديرات WUENIC للجرعتين الأولى والثالثة من اللقاح الثلاثي والجرعتين الأولى والثانية من لقاح الحصبة من 99% و97% و95% و94% عام 2017 إلى 74% و73% و73% و72% عام 2018، بينما بقيت التغطية الإدارية والحكومية بالجرعة الأولى من اللقاح الثلاثي عند 99% و98% على التوالي. وظلت التقديرات ثابتة حتى عام 2023 بناءً على افتراضات بشأن انقطاع الخدمات ونفاد اللقاحات. وفي عام 2025 بلغت التغطية 97% و90% و93% و 85%، والتسرب النسبي 7.2%، والمؤشر التقريبي 3%. وجاءت النتائج الأولية للمسح العنقودي متعدد المؤشرات لمواليد عام 2023 أدنى (81% للجرعة الثالثة من اللقاح الثلاثي و65% للجرعة الثانية من لقاح الحصبة). وحملت جميع التقديرات منذ عام 2009 أدنى درجات الثقة.

الاستنتاجات: ينبغي تفسير الارتفاع الأخير في تقديرات WUENIC بحذر، ويتطلب تحديد الأطفال غير المطعَّمين في ليبيا تعزيز الإبلاغ الروتيني، وتسجيل الجرعات الروتينية والاستدراكية كلٌّ على حدة، والتحقق من التقديرات الوطنية في ضوء المسوح المستقلة.

الكلمات المفتاحية:
التغطية بالتطعيم
تقديرات WUENIC
التسرب من اللقاح الثلاثي
الأطفال غير الحاصلين على أي جرعة
جودة البيانات
ليبيا

1. Introduction

Routine childhood immunization is among the most effective public health interventions for preventing infectious diseases, reducing childhood mortality and limiting the risk of vaccine-preventable disease outbreaks. Sustained coverage protects individual children and maintains population-level immunity, and monitoring coverage over time allows public health authorities to identify gaps in service delivery, evaluate program performance and prioritize interventions for under-vaccinated populations [1,2].

The World Health Organization (WHO) and the United Nations Children's Fund (UNICEF) produce annual Estimates of National Immunization Coverage (WUENIC) to provide standardized national estimates of vaccination coverage. These estimates integrate officially reported vaccination data, survey findings and relevant contextual information, and are widely used to monitor immunization trends and to identify countries and periods in which coverage has stagnated or declined [1,2].

The first and third doses of diphtheria–tetanus–pertussis-containing vaccine (DTP1 and DTP3) are particularly useful indicators of program performance. DTP1 coverage indicates initial access to vaccination, whereas DTP3 coverage reflects completion of the three-dose primary series, so the difference between them helps identify gaps between starting and completing vaccination. Similarly, coverage with the first and second doses of measles-containing vaccine (MCV1 and MCV2) describes uptake of measles vaccination and potential gaps in protection against measles [2,3].

In the WHO/UNICEF framework, zero-dose children are generally defined as children who have not received any dose of a DTP-containing vaccine. Because DTP1 coverage is commonly used as an indicator of access to routine immunization, it can be used to derive a coverage-based proxy for the proportion of the target population that has not received the first DTP-containing dose, calculated as 100% minus DTP1 coverage [4].

The Immunization Agenda 2030 (IA2030) identifies the number of zero-dose children as a key indicator of immunization equity. Under indicator IG 2.1, progress is monitored using the absolute number of zero-dose children, with a global target of a 50% reduction by 2030 relative to the 2019 baseline [4,5]. The number of zero-dose children can therefore be estimated by multiplying the number of surviving infants by the proportion not receiving DTP1. Reporting both the percentage-based proxy and the estimated absolute number is important, because even a small percentage may represent a substantial number of children.

The interpretation of childhood immunization trends in Libya also requires consideration of the country's political, health-system and humanitarian context. The 2011 revolution and subsequent periods of armed conflict, including those of 2014 and 2019–2020, may have affected the organization of health services and access to routine vaccination. Internal displacement, population movement and the presence of migrant and refugee communities may create further challenges for vaccine delivery and for accurate population denominators. Additional disruptions may have occurred during the COVID-19 pandemic and after Storm Daniel and the September 2023 floods in eastern Libya [6]. However, the contribution of each event to changes in national immunization estimates cannot be established from aggregate WUENIC data alone.

Although WUENIC provides annual national estimates for Libya, the published estimates do not, by themselves, explain the sources of

variation in coverage or the reliability of the underlying data. Differences between estimated, administrative and government-reported coverage may complicate the assessment of program performance, and the availability of preliminary survey findings offers an opportunity to examine whether recent improvements in national estimates are consistent with independent population-based evidence. Evaluating these differences is essential for identifying data-quality limitations and avoiding overinterpretation of apparent improvements.

This study aimed to assess childhood immunization coverage trends in Libya from 2000 to 2025 using the 2025 revision of WUENIC. Specifically, it examined trends across all available vaccine indicators; compared WUENIC estimates with administrative and government-reported coverage; assessed the available grades of confidence and country-specific estimation comments; calculated DTP1–DTP3 and MCV1–MCV2 coverage gaps; and estimated the coverage-based proportion and approximate number of zero-dose children. Preliminary findings of the Multiple Indicator Cluster Survey (MICS) were also considered where reported in the WUENIC country comments.

2. Methods

2.1. Study design and data source

A descriptive secondary analysis of national immunization coverage data was conducted for Libya for the period 2000–2025. The primary dataset, the 2025 revision of WUENIC released on 15 July 2026, was obtained from the official WHO/UNICEF Immunization Data Portal and downloaded as an Excel workbook [2]. The data for Libya were extracted from the original file, reviewed, and used to construct the annual coverage tables and calculate the derived indicators presented in this study.

The dataset provides annual national-level estimates for the available vaccine indicators, together with administrative coverage, official government estimates, estimates from the previous WUENIC revision, grades of confidence, numbers of vaccinated children, target populations, United Nations Population Division (UNPD) estimates of surviving infants, and country-specific comments [3]. The 2025 revision was used consistently throughout to ensure comparability across the study period. The country-specific comments were examined to identify documented vaccine stockouts, interruptions in immunization services, catch-up vaccination activities, available survey findings, and methodological assumptions that could affect the interpretation of annual estimates.

Preliminary findings of the Libya MICS 2024–2025 were extracted from the country-specific comments accompanying the 2025 revision. The reported coverage values for the 2022 and 2023 birth cohorts were treated as supplementary contextual evidence and compared descriptively with the corresponding WUENIC estimates. They were not treated as equivalent to annual national estimates because of differences in reference population, measurement methods and reporting periods, and, as the final MICS report was not available, they were interpreted cautiously [2,3].

2.2. Study population and variables

The analysis focused on national-level childhood immunization coverage in Libya, and all vaccine indicators available in the WUENIC dataset were considered: bacille Calmette–Guérin vaccine (BCG); the first and third doses of DTP-containing vaccine (DTP1 and DTP3); the third dose of hepatitis B vaccine (HepB3); the third dose of *Haemophilus influenzae* type b vaccine (Hib3); the first dose and the complete primary series of inactivated poliovirus vaccine (IPV1 and IPVC); the first and second doses of measles-containing vaccine (MCV1 and MCV2); the first dose of rubella-containing vaccine (RCV1); the complete rotavirus vaccine series (RotaC); and the complete pneumococcal conjugate vaccine series (PCVC).

Because the availability of each indicator varied by year, analyses were restricted to years in which the corresponding estimate was available. Hepatitis B birth-dose and oral poliovirus vaccine indicators were not included because they were not available as separate indicators in the Libya dataset. DTP1 was used as an indicator of initial access to vaccination, DTP3 to assess completion of the primary series, and MCV1 and MCV2 to examine measles vaccine uptake and the difference between the first and second doses. The study period extended from 2000 to 2025 for DTP1, DTP3 and MCV1; MCV2 estimates were available from 2001 onward and were analyzed over 2001–2025.

2.3. Outcome measures

The following derived indicators were calculated from the annual national WUENIC estimates:

Absolute DTP1–DTP3 gap (percentage points) = DTP1 coverage (%) − DTP3 coverage (%)

Relative DTP1–DTP3 dropout (%) = [(DTP1 − DTP3) / DTP1] × 100

Zero-dose proxy (%) = 100 − DTP1 coverage (%)

Estimated zero-dose children = surviving infants × (1 − DTP1 coverage / 100)

Estimated children not receiving DTP3 = surviving infants × (1 − DTP3 coverage / 100)

MCV1–MCV2 gap (percentage points) = MCV1 coverage (%) − MCV2 coverage (%)

The zero-dose proxy represents the estimated proportion of the target population not receiving the first DTP-containing dose, and the corresponding absolute number was approximated using the UNPD estimate of surviving infants. The number of children not receiving

DTP3 was estimated in the same way from the complement of DTP3 coverage. These are derived population estimates and should not be interpreted as independently enumerated children or linked individual vaccination histories.

2.4. Data analysis

Annual WUENIC estimates were summarized descriptively as percentages. Administrative coverage and official government estimates were compared with WUENIC estimates for the same vaccine and year to identify discrepancies between data sources, and the grade of confidence was extracted for each available estimate. Absolute and relative DTP1–DTP3 dropout, the MCV1–MCV2 coverage gap and the DTP3–MCV1 difference were calculated for years with available data, and the estimated numbers of zero-dose children and children not receiving DTP3 were derived using UNPD surviving-infant estimates.

For descriptive interpretation, the study period was divided into three periods: 2000–2017, 2018–2023 and 2024–2025. These periods were selected according to the observed estimates and the contextual information in the WUENIC country comments and were not treated as statistically validated change points. Preliminary MICS findings were presented separately from WUENIC estimates. No inferential statistical tests were performed because the analysis used aggregate national-level data, and no individual-level associations or causal relationships were assessed.

2.5. Reporting guideline

Reporting followed the relevant items of the Guidelines for Accurate and Transparent Health Estimates Reporting (GATHER) [7], which were used to improve transparency in reporting data sources, indicators, data processing, derived measures and limitations. The completed GATHER checklist is provided as Supplementary File S1.

2.6. Ethical approval

Ethical approval was not required because this study used publicly available, aggregated national immunization data and did not involve human participants, identifiable personal information or individual-level records.

3. Results

3.1. Trends in childhood immunization coverage

National childhood immunization coverage estimates in Libya showed three broad phases between 2000 and 2025: relatively high coverage during 2000–2017, lower estimated coverage during 2018–2023, and an increase in estimated coverage during 2024–2025 (Table 1; Figs. 1 and 2).

Table 1. Annual WHO/UNICEF national immunization coverage estimates (%) for all available vaccine indicators, Libya, 2000–2025

Year	BCG	DTP1	DTP3	HepB3	Hib3	IPV1	IPVC	MCV1	MCV2	PCVC	RCV1	RotaC
2000	98	97	94	92	—	—	—	93	—	—	93	—
2001	99	96	94	93	—	—	—	93	81	—	93	—
2002	99	97	93	91	—	—	—	91	86	—	91	—
2003	99	99	95	96	—	—	—	96	90	—	96	—
2004	99	99	97	99	—	—	—	99	95	—	99	—
2005	99	98	98	97	—	—	—	97	95	—	97	—
2006	99	98	98	98	—	—	—	98	96	—	98	—
2007	99	98	98	98	56	—	—	98	97	—	98	—
2008	99	98	98	98	98	—	—	98	97	—	98	—
2009	99	98	98	98	98	—	—	98	97	—	98	—
2010	99	98	98	98	98	—	—	98	97	—	98	—
2011	99	99	98	98	98	—	—	98	97	—	98	—
2012	99	99	98	98	98	—	—	98	97	—	98	—
2013	99	98	96	96	96	—	—	96	95	—	96	—
2014	99	96	94	94	94	—	—	93	92	39	93	86
2015	99	98	97	97	97	98	—	98	97	71	98	93
2016	99	98	97	97	97	98	—	97	96	96	97	97
2017	99	99	97	97	97	99	—	95	94	95	95	97
2018	74	74	73	73	73	74	—	73	72	72	73	73
2019	74	74	73	73	73	74	—	73	72	73	73	73
2020	74	74	73	73	73	74	—	73	72	73	73	73
2021	74	74	73	73	73	74	73	73	72	73	73	73
2022	74	74	73	73	73	74	73	73	72	73	73	73
2023	74	74	73	73	73	74	73	73	72	73	73	73
2024	85	90	86	86	86	90	86	89	80	89	89	82
2025	97	97	90	90	90	90	90	93	85	92	93	86

Values are WUENIC coverage estimates (%); — indicates that the indicator was not available for that year. BCG, bacille Calmette–Guérin vaccine; DTP1/DTP3, first/third dose of diphtheria–tetanus–pertussis-containing vaccine; HepB3, third dose of hepatitis B vaccine; Hib3, third dose of *Haemophilus influenzae* type b vaccine; IPV1, first dose of inactivated poliovirus vaccine; IPVC, inactivated poliovirus vaccine completion; MCV1/MCV2, first/second dose of measles-containing vaccine; PCVC, pneumococcal conjugate vaccine completion; RCV1, first dose of rubella-containing vaccine; RotaC, rotavirus vaccine completion. Source: WUENIC, 2025 revision [2].

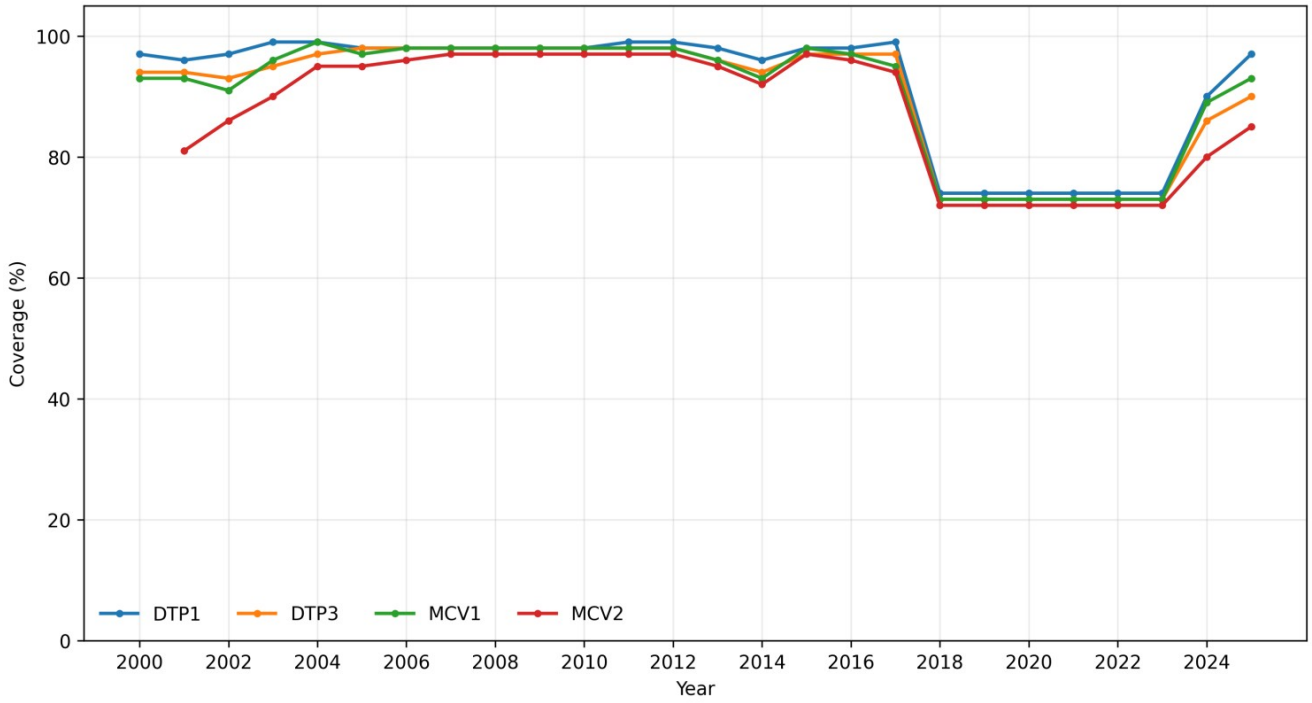

Fig. 1. Trends in WUENIC coverage estimates for DTP1, DTP3, MCV1 and MCV2 in Libya, 2000–2025.

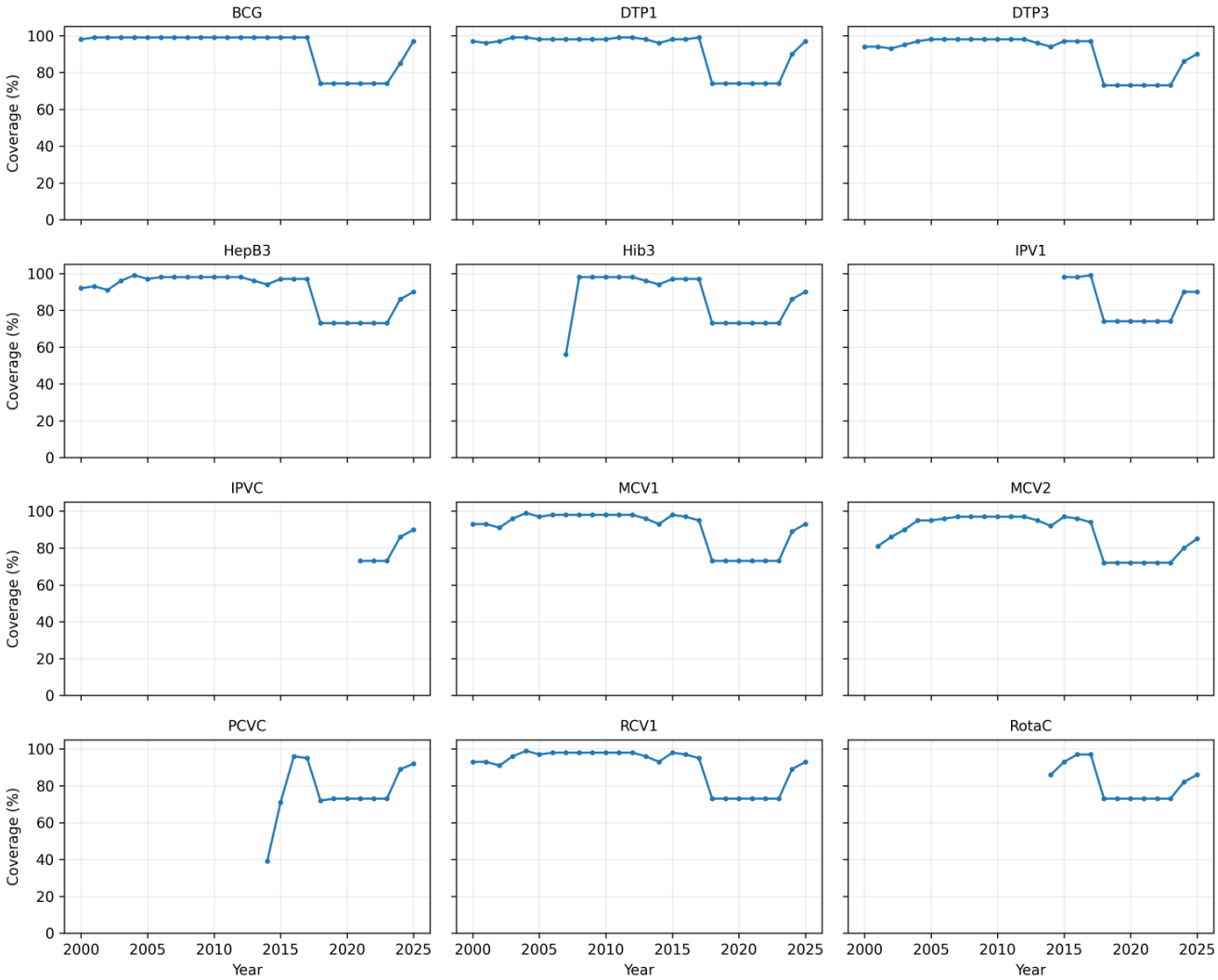

Fig. 2. Trends in WUENIC coverage estimates for all vaccine indicators available in the Libya dataset, 2000–2025.

Between 2000 and 2017, DTP1 coverage ranged from 96% to 99% and DTP3 coverage from 93% to 98%. MCV1 coverage ranged from

91% to 99%. MCV2 coverage, available from 2001 onward, increased from 81% in 2001 to 97% during 2007–2012 before declining to 94% in 2017.

A marked decline was observed in 2018. DTP1 coverage decreased from 99% in 2017 to 74% in 2018 and DTP3 coverage from 97% to 73%, while MCV1 coverage decreased from 95% to 73% and MCV2 coverage from 94% to 72%.

The WUENIC estimates for DTP1, DTP3, MCV1 and MCV2 were identical throughout 2018–2023, at 74%, 73%, 73% and 72%, respectively. According to the accompanying country comments, these repeated values reflected the absence of new reliable data and should not be interpreted as evidence of stable annual vaccination coverage.

Coverage improved in 2024, when DTP1 and DTP3 coverage increased to 90% and 86%, respectively, and MCV1 and MCV2 coverage reached 89% and 80%. In 2025, DTP1 coverage increased further to 97%, DTP3 coverage reached 90%, MCV1 coverage 93% and MCV2 coverage 85%.

3.2. Comparison of WUENIC estimates with other data sources

The 2025 WUENIC estimates were compared with the preliminary MICS findings to assess the consistency of national estimates with independent survey-based evidence. The preliminary MICS findings for the 2022 and 2023 birth cohorts are presented in Table 2. These findings should be interpreted cautiously, because cohort-specific survey estimates are not directly equivalent to annual national WUENIC estimates.

Table 2. Comparison of 2025 WUENIC estimates, reported coverage and preliminary MICS cohort findings by vaccine indicator, Libya

Vaccine indicator	WUENIC 2025 (%)	Administrative coverage 2025 (%)	Government estimate 2025 (%)	Preliminary MICS, 2022 birth cohort (%)	Preliminary MICS, 2023 birth cohort (%)	Confidence grade (code)
BCG	97	100	97	83	90	1
DTP1	97	98	97	82	89	1
DTP3	90	90	90	74	81	1
HepB3	90	90	90	74	81	1
Hib3	90	90	90	74	81	1
IPV1	90	98	90	82	89	1
IPVC	90	90	90	74	81	1
MCV1	93	94	93	—	79	1
MCV2	85	87	85	—	65	1
PCVC	92	94	92	—	70	1
RCV1	93	94	93	—	79	1
RotaC	86	86	86	70	77	1

MICS values are preliminary findings for the specified birth cohorts as recorded in the WUENIC country comments and are not directly equivalent to annual WUENIC estimates; — indicates that a cohort-specific value was not stated. Administrative and government values are reproduced from the WUENIC dataset. Grade 1 is the lowest WUENIC grade of confidence. MICS, Multiple Indicator Cluster Survey.

Differences were also observed between WUENIC estimates, administrative coverage and official government estimates for selected years. These data sources are compared for DTP1, DTP3, MCV1 and MCV2 in Table 3 and Fig. 3.

Table 3. Comparison of WUENIC estimates, administrative coverage and government estimates for selected years and core vaccine indicators, Libya

Year	Vaccine indicator	WUENIC (%)	Administrative coverage (%)	Government estimate (%)	Confidence grade (code)
2011	DTP1	99	—	—	1
2011	DTP3	98	—	—	1
2011	MCV1	98	—	—	1
2011	MCV2	97	—	—	1
2014	DTP1	96	96	98	1
2014	DTP3	94	94	97	1
2014	MCV1	93	93	98	1
2014	MCV2	92	92	97	1
2017	DTP1	99	99	—	1
2017	DTP3	97	97	—	1
2017	MCV1	95	95	—	1
2017	MCV2	94	94	—	1
2018	DTP1	74	99	98	1
2018	DTP3	73	97	97	1
2018	MCV1	73	96	97	1
2018	MCV2	72	95	96	1
2019	DTP1	74	98	98	1
2019	DTP3	73	96	97	1
2019	MCV1	73	95	97	1

Year	Vaccine indicator	WUENIC (%)	Administrative coverage (%)	Government estimate (%)	Confidence grade (code)
2019	MCV2	72	94	96	1
2020	DTP1	74	97	98	1
2020	DTP3	73	95	97	1
2020	MCV1	73	93	97	1
2020	MCV2	72	92	96	1
2021	DTP1	74	98	98	1
2021	DTP3	73	97	97	1
2021	MCV1	73	95	97	1
2021	MCV2	72	95	96	1
2022	DTP1	74	98	98	1
2022	DTP3	73	96	97	1
2022	MCV1	73	95	97	1
2022	MCV2	72	94	96	1
2023	DTP1	74	95	95	1
2023	DTP3	73	93	93	1
2023	MCV1	73	92	92	1
2023	MCV2	72	91	91	1
2024	DTP1	90	92	90	1
2024	DTP3	86	87	86	1
2024	MCV1	89	90	89	1
2024	MCV2	80	81	80	1
2025	DTP1	97	98	97	1
2025	DTP3	90	90	90	1
2025	MCV1	93	94	93	1
2025	MCV2	85	87	85	1

— indicates that the value was not reported in the WUENIC dataset. Confidence-grade codes are reproduced as reported; grade 1 is the lowest WUENIC grade of confidence.

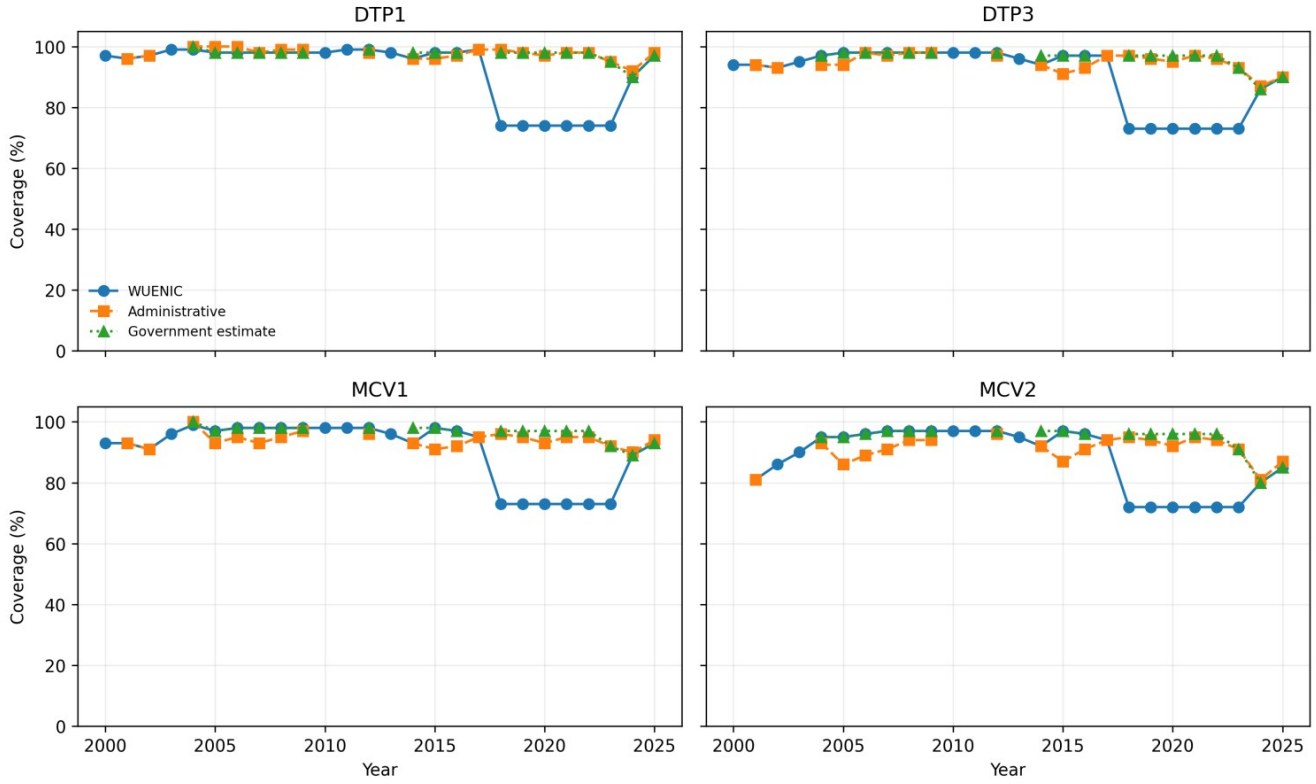

Fig. 3. Comparison of WUENIC estimates with administrative coverage and government estimates for DTP1, DTP3, MCV1 and MCV2, Libya, 2000–2025.

The comparison showed notable differences between WUENIC estimates and administrative and government-reported coverage. In 2018, for example, WUENIC estimated DTP1 coverage at 74%, whereas administrative and government-reported coverage were 99% and 98%, respectively. This discrepancy illustrates the difficulty of interpreting national immunization coverage from a single data source.

The WUENIC confidence grades also indicated limited empirical

support for the national estimates. Every available estimate from 2009 onward, including all those shown in Tables 2 and 3, carried a grade-1 (one-star) code, the lowest grade; codes of 2 or 3 appeared only for selected indicators between 2000 and 2008 (Supplementary Table S1). The reported coverage values should therefore be interpreted as national estimates with important underlying data limitations rather than precise measurements of vaccination uptake.

3.3. DTP dropout

The absolute difference between DTP1 and DTP3 coverage remained small during 2000–2017, ranging from 0 to 4 percentage points, with the largest differences (4 percentage points) in 2002 and 2003. No difference was observed during 2005–2010, when both indicators were 98%.

From 2018 to 2023, the absolute DTP dropout remained at 1 percentage point annually. However, this small difference occurred alongside substantially lower overall coverage, with DTP1 at 74% and DTP3 at 73%. The absolute dropout increased to 4 percentage points in 2024 and 7 percentage points in 2025; in 2025, DTP1 coverage was 97% and DTP3 coverage 90%, corresponding to a relative dropout of approximately 7.2% (Table 4; Fig. 4).

Table 4. DTP dropout, coverage-based zero-dose proxy and derived numbers of children not reached, Libya, 2000–2025

Year	DTP1 (%)	DTP3 (%)	DTP1–DTP3 gap (percentage points)	Relative DTP dropout (%)	Zero-dose proxy (%)	Surviving infants (UNPD)	Estimated zero-dose children	Estimated children not receiving DTP3
2000	97	94	3	3.1	3	112,693	3,381	6,762
2001	96	94	2	2.1	4	116,809	4,672	7,009
2002	97	93	4	4.1	3	121,542	3,646	8,508
2003	99	95	4	4.0	1	126,428	1,264	6,321
2004	99	97	2	2.0	1	131,749	1,317	3,952
2005	98	98	0	0	2	137,712	2,754	2,754
2006	98	98	0	0	2	140,858	2,817	2,817
2007	98	98	0	0	2	142,598	2,852	2,852
2008	98	98	0	0	2	144,101	2,882	2,882
2009	98	98	0	0	2	145,477	2,910	2,910
2010	98	98	0	0	2	151,090	3,022	3,022
2011	99	98	1	1.0	1	155,913	1,559	3,118
2012	99	98	1	1.0	1	138,004	1,380	2,760
2013	98	96	2	2.0	2	140,574	2,811	5,623
2014	96	94	2	2.1	4	143,869	5,755	8,632
2015	98	97	1	1.0	2	141,725	2,835	4,252
2016	98	97	1	1.0	2	139,566	2,791	4,187
2017	99	97	2	2.0	1	136,931	1,369	4,108
2018	74	73	1	1.4	26	134,708	35,024	36,371
2019	74	73	1	1.4	26	132,572	34,469	35,794
2020	74	73	1	1.4	26	130,905	34,035	35,344
2021	74	73	1	1.4	26	128,675	33,456	34,742
2022	74	73	1	1.4	26	125,729	32,690	33,947
2023	74	73	1	1.4	26	122,610	31,879	33,105
2024	90	86	4	4.4	10	120,454	12,045	16,864
2025	97	90	7	7.2	3	119,145	3,574	11,915

Absolute dropout = DTP1 − DTP3 (percentage points); relative dropout = [(DTP1 − DTP3)/DTP1] × 100; zero-dose proxy = 100 − DTP1. Estimated counts were calculated by applying the coverage complement to UNPD surviving-infant estimates for the same year and rounded to the nearest whole number; they are derived estimates, not enumerated counts of individual children. UNPD, United Nations Population Division.

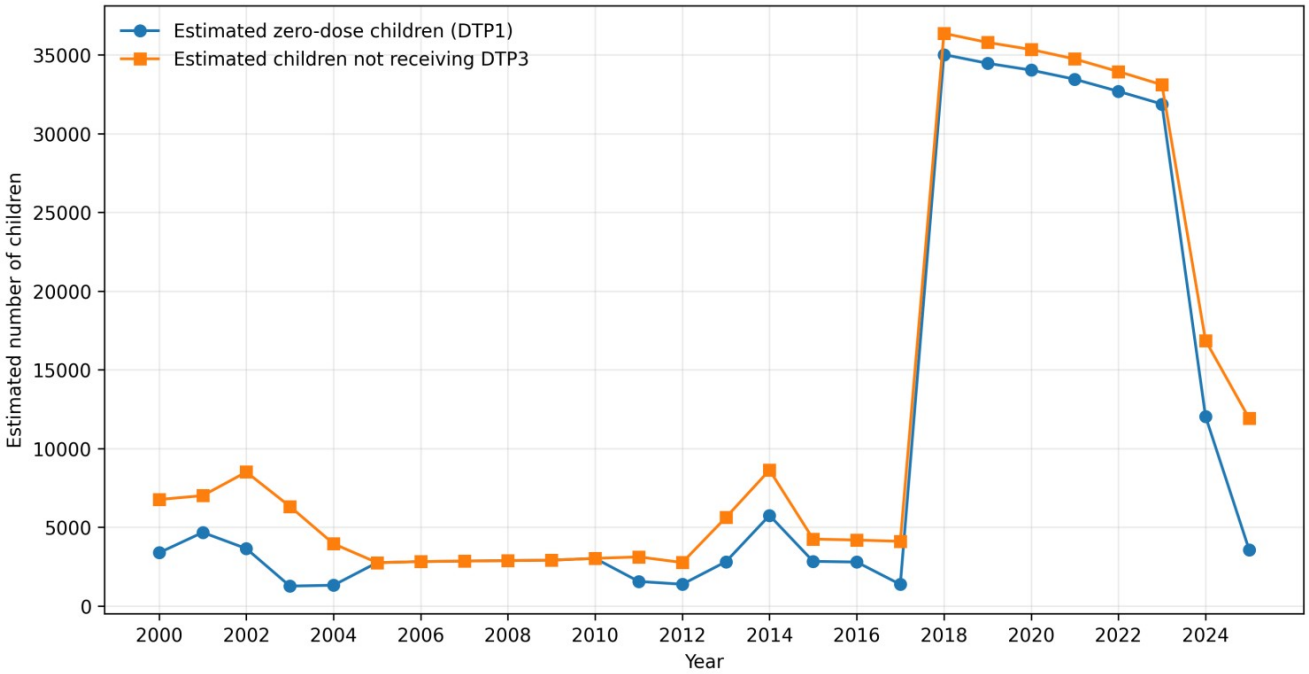

Fig. 4. Derived estimates of the numbers of infants not receiving DTP1 (zero-dose proxy) and not receiving DTP3, based on UNPD surviving-infant estimates, Libya, 2000–2025.

Using the commonly applied program threshold of 10% for DTP1–DTP3 dropout, the relative dropout estimates remained below this level throughout the study period, including 7.2% in 2025. However, dropout should be interpreted together with DTP1 coverage, which reflects initial access to vaccination. The 2018–2023 period was thus characterized by low estimated access (DTP1, 74%) despite low estimated dropout (1.4%), whereas 2025 showed high estimated access (DTP1, 97%) with dropout below the 10% threshold. This combined interpretation distinguishes problems of reaching children from problems of completing the vaccination series.

3.4. Coverage-based zero-dose proxy

The coverage-based zero-dose proxy was low during 2000–2017, ranging from 1% to 4%. It increased to 26% in 2018 and remained at that level through 2023, reflecting DTP1 coverage estimates of 74% during those years. The proxy declined to 10% in 2024, as DTP1 coverage increased to 90%, and to 3% in 2025, corresponding to DTP1 coverage of 97% (Table 5). These findings indicate a substantial improvement in the national DTP1 coverage estimate by 2025 compared with 2018–2023.

Table 5. Estimated numbers of zero-dose children and children not receiving DTP3 in selected birth cohorts, Libya

Year	Surviving infants	DTP1 coverage	Estimated zero-dose children	DTP3 coverage	Estimated children not receiving DTP3
2019	132,572	74%	34,469	73%	35,794
2025	119,145	97%	3,574	90%	11,915

Numbers were derived by multiplying the proportion not covered by DTP1 or DTP3 by the corresponding UNPD estimate of surviving infants. They are approximate population estimates based on WUENIC coverage values and should not be interpreted as independently enumerated counts of unvaccinated children.

3.5. Comparison with preliminary MICS findings

Preliminary findings of the MICS 2024–2025 were referenced in the WUENIC country comments for the 2025 revision. For the 2023 birth cohort, the reported preliminary coverage values were 89% for DTP1, 81% for DTP3, 79% for MCV1 and 65% for MCV2. For the 2022 birth cohort, preliminary values included 82% for DTP1, 74% for DTP3, 83% for BCG and 70% for the complete rotavirus series (Table 2). These survey findings provide an important independent source of information for interpreting recent WUENIC estimates. However, the survey values refer to specific birth cohorts and should not be compared directly with annual national estimates without considering differences in target cohort, measurement method and survey documentation.

4. Discussion

This study described national childhood immunization coverage trends in Libya from 2000 to 2025 using the 2025 revision of WUENIC. Three broad phases were identified: relatively high estimated coverage during 2000–2017, lower estimated coverage during 2018–2023, and an increase in estimated coverage during 2024–2025. The most notable finding was the marked reduction in all four core indicators in 2018, followed by several years of unchanged estimates and higher estimates in 2024 and 2025.

4.1. Long-term trends in immunization coverage

During 2000–2017, WUENIC estimates generally indicated high childhood immunization coverage in Libya. DTP1 coverage was consistently above 95%, and DTP3 and MCV1 coverage also remained high. MCV2 coverage increased from 81% in 2001 to 97% during 2007–2012 before declining to 94% in 2017. These estimates should, however, be interpreted in light of the supporting evidence and the grade of confidence assigned by WHO and UNICEF.

The country comments indicate that the 2011 DTP1 estimate of 99% was based on interpolation because no accepted empirical data were available, and they state that actual coverage was likely lower during the period of civil strife [3]. The high estimates reported for 2011 should therefore not be interpreted as independently verified coverage. In 2012, the estimate was informed by reported data but was challenged by another data source, and the 2014 estimate was informed by administrative data, with no explanation provided by the program for the adjustment of the official government estimate. These observations highlight the limitations of relying exclusively on national point estimates when the underlying data sources are incomplete or inconsistent.

A decline was observed in several vaccine indicators in 2013–2014; in 2014, DTP3 coverage was 94%, MCV1 coverage 93% and MCV2 coverage 92%. This period coincided with renewed armed conflict and instability in Libya. Although the temporal overlap is noteworthy, the ecological nature of the data does not allow the decline to be attributed directly to conflict-related factors.

An important finding was the marked reduction in WUENIC estimates in 2018, when DTP1, DTP3, MCV1 and MCV2 estimates decreased to 74%, 73%, 73% and 72%, respectively, although the corresponding administrative coverage values remained substantially higher (DTP1, 99% against a WUENIC estimate of 74%). This discrepancy indicates that the 2018 estimate did not simply reflect reported administrative coverage but was influenced by contextual information and assumptions about service disruption. The WUENIC country comments provide important information about the estimation process during 2018–2023 [3]. For 2018, the immunization program reported three months of vaccine stockouts at national and subnational levels, and WHO and UNICEF reduced the estimates on the assumption that immunization services were unavailable during the stockout period. For 2019 and subsequent years, the estimates continued to reflect reported service disruption, vaccine stockouts and assumptions about the severity of interruption. Two months of stockouts were reported in 2021 and three in 2022, and the 2022 comments noted that official government estimates were based on average administrative coverage from previous years, despite reports that up to 90% of primary health care facilities were closed in some areas in 2021 (Supplementary Table S2).

The identical WUENIC estimates for 2018–2023 should therefore not be interpreted as evidence of stable annual coverage. Rather, they reflect the estimation approach and the limited availability of reliable evidence with which to quantify annual changes in service delivery. They are particularly difficult to interpret because administrative and government-reported coverage remained much higher during most of this period; DTP1 administrative coverage, for example, ranged from 95% to 99% between 2018 and 2023, whereas the WUENIC estimate remained at 74%.

The 2023 country comments reported six months of vaccine stockouts but also indicated that vaccines were received late in the year and catch-up activities were conducted, and they acknowledged that WUENIC might underestimate actual coverage. The 2018–2023 series should therefore be interpreted as estimates shaped by contextual assumptions and data limitations rather than as direct annual measurements of vaccination uptake. Although the decline coincided with reported stockouts and disruptions in service delivery, the substantial discrepancy between WUENIC and administrative estimates suggests that differences in data availability, reporting practices and estimation assumptions may also have contributed, so the decline should not be attributed exclusively to reduced vaccine uptake. Independently validated vaccination records and population-based surveys are needed to determine the extent to which it represents actual reductions in coverage.

4.2. Increase in estimated coverage, 2024–2025

WUENIC estimates increased substantially in 2024 and 2025. DTP1 coverage increased from 74% in 2023 to 90% in 2024 and 97% in 2025, DTP3 from 73% to 86% and then 90%, while MCV1 and MCV2 reached 93% and 85%, respectively, in 2025.

The country comments qualify these increases. For 2024, the number of administered doses increased during the first months of the year after catch-up activities following the 2023 stockouts, and the comments warned that reported coverage might be overestimated. For 2025, WHO and UNICEF noted the difficulty of distinguishing doses delivered through routine services from those administered during catch-up activities, again raising the possibility of overestimation [3].

The preliminary MICS findings provide an important independent comparison. For the 2023 birth cohort, the preliminary values cited in the WUENIC comments were 89% for DTP1, 81% for DTP3, 79% for MCV1 and 65% for MCV2, lower than the corresponding 2025 WUENIC estimates for several antigens, particularly MCV2. However, the survey findings relate to a specific birth cohort, whereas WUENIC estimates are annual national estimates, and differences in target population and measurement approach should be considered before the discrepancy is interpreted.

The 2023 country comments suggested that WUENIC might

underestimate actual coverage after late vaccine receipt and catch-up activities, whereas the preliminary MICS findings for the 2023 cohort were lower than several recent WUENIC estimates. These observations are not necessarily contradictory, because they refer to different estimation periods and data sources, but they show the need for validation against the final MICS report, including its sampling methodology, vaccination-card verification procedures and regional findings, and for better documentation of routine and catch-up doses. The increase in 2024–2025 should accordingly be described as an increase in estimated coverage rather than definitive evidence of a complete recovery of routine immunization services.

4.3. DTP dropout and completion of vaccination

The absolute DTP1–DTP3 coverage gap was small during 2018–2023, at 1 percentage point, but this should not be interpreted as evidence of consistently successful completion of the schedule. Both estimates remained low (74% and 73%) and were identical across six consecutive years, and because they were reported as rounded whole percentages shaped by WUENIC estimation assumptions, the 1-point difference may reflect rounding and estimation procedures rather than a reliably measured annual dropout pattern.

In 2025, the absolute gap increased to 7 percentage points, corresponding to a relative dropout of approximately 7.2%, indicating that estimated third-dose coverage remained below first-dose coverage. This increase should be interpreted in the context of catch-up vaccination: first doses given to previously unvaccinated older children may increase the DTP1 numerator more rapidly than DTP3, because completion of the subsequent doses takes time. In addition, the WUENIC comments indicate that routine and catch-up doses could not be clearly distinguished in the 2025 reported data.

The difference between DTP1 and DTP3 represents a population-level coverage gap and does not directly identify individual children who started but did not complete the series. Similarly, the difference between MCV1 and MCV2 should be interpreted as a national coverage gap rather than an individually observed dropout rate. Both indicators are useful for monitoring program performance but should be interpreted alongside overall coverage levels, data sources and confidence grades.

4.4. Zero-dose proxy and immunization equity

The coverage-based zero-dose proxy increased to 26% during 2018–2023 and declined to 3% in 2025. These values are the complement of the corresponding DTP1 estimates and should not be interpreted as independently measured prevalence. Translated into approximate numbers using UNPD estimates of surviving infants, the derived number of zero-dose children was approximately 34,469 in 2019 and 3,574 in 2025, and the corresponding numbers of children not receiving DTP3 were approximately 35,794 and 11,915, respectively.

The apparent reduction in the estimated number of zero-dose children between 2019 and 2025 should be interpreted cautiously, because the underlying estimates were affected by discrepancies between data sources, assumptions about service disruption and possible overestimation of recent administrative coverage. These derived numbers are not independently enumerated counts and do not confirm that the IA2030 zero-dose reduction target has been achieved [5].

National estimates may conceal important differences in access to vaccination between geographic areas and population groups in Libya. Children living in underserved areas, including parts of the south (Fezzan), internally displaced communities, and migrant and refugee populations may face additional barriers to routine immunization, and population movement and uncertain target-population denominators may also affect administrative reporting. National-level data cannot identify which groups account for the largest share of zero-dose children; regional and population-specific data from household surveys and immunization registers are needed to identify these gaps and guide targeted interventions.

4.5. Public health implications

The substantial discrepancy between WUENIC estimates and administrative coverage during 2018–2023 highlights the need to strengthen the quality and completeness of vaccination reporting and to improve the accuracy of target-population denominators. Routine and catch-up doses should be recorded separately, to avoid overestimating routine coverage when previously unvaccinated older children receive additional doses.

If the lower estimates for 2018–2023 reflect substantial gaps in actual vaccination, children born during these years may represent cohorts that require assessment of their vaccination status and targeted catch-up activities. This is particularly important for measles prevention, because MCV2 coverage was estimated at 85% in 2025, below the 95% two-dose coverage target commonly used for measles elimination. Measles outbreaks reported in Libya in 2023, concentrated in the south and west, and the subnational measles and rubella vaccination campaign launched in 15 southern municipalities in 2025 further emphasize the need for strengthened surveillance, catch-up vaccination and outbreak preparedness [8,9].

The findings also support regional immunization monitoring, particularly in underserved southern areas and among displaced and migrant populations. Strengthening defaulter tracking, improving vaccine supply management, documenting doses administered through supplementary activities, and comparing administrative data with household survey findings may improve the accuracy of national estimates and help identify children who remain unreached by routine services.

4.6. Strengths and limitations

A key strength of this study is its use of the 2025 WUENIC revision and its inclusion of multiple vaccine indicators, administrative coverage, official government estimates, population denominators and country-specific comments, which together provide information on discrepancies between data sources and on the assumptions that shaped national estimates over time.

Several limitations should be acknowledged. WUENIC estimates are modelled national point estimates without conventional statistical confidence intervals; the grade of confidence indicates the empirical support for each estimate but does not quantify statistical uncertainty. Every estimate from 2009 onward carried the lowest grade of confidence, indicating limited direct supporting evidence or conflicting data sources. The marked decline in 2018 and the unchanged estimates through 2023 were influenced by country-specific assumptions about vaccine stockouts and service disruption and should not be interpreted as verified annual changes in coverage. Administrative coverage may be affected by inaccuracies in both the number of administered doses and the target-population denominator, which is particularly relevant in Libya because population movement and displacement may complicate estimation of the number of children eligible for vaccination. Recent estimates may also be affected by the inclusion of catch-up doses in administrative numerators, as routine and catch-up activities were not always clearly distinguished. Preliminary MICS findings were available only through the WUENIC country comments, and the final survey report and its regional breakdown could not be incorporated. The derived zero-dose and no-DTP3 numbers are approximate estimates based on national coverage and surviving-infant figures rather than enumerated children.

Finally, some antigens were unavailable for certain years, and hepatitis B birth-dose and some other indicators were not available as separate variables. The ecological design also precludes individual-level interpretation and causal conclusions. The findings should therefore be interpreted as an assessment of national estimates and their supporting data rather than as direct measurements of the vaccination status of individual children.

5. Conclusion

The 2025 revision of the WHO/UNICEF national immunization coverage estimates shows substantial variation in estimated childhood immunization coverage in Libya between 2000 and 2025, together with important discrepancies between WUENIC estimates and administrative and government-reported coverage, particularly during 2018–2023. Country-specific comments indicate that estimates for this period were shaped by reported vaccine stockouts and assumptions about service disruption, whereas recent increases may have been affected by catch-up activities and possible overestimation of routine coverage.

By 2025, WUENIC estimated DTP1 coverage at 97%, DTP3 at 90%, MCV1 at 93% and MCV2 at 85%. Although the coverage-based zero-dose proxy was 3%, this estimate should be interpreted cautiously because of low grades of confidence and discrepancies with preliminary independent survey findings. Improving administrative data quality, distinguishing routine from catch-up vaccination, validating national estimates against independent surveys and identifying underserved populations are essential to ensure that all children in Libya receive and complete their recommended vaccination schedules.

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Declarations

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Ethics approval and consent to participate: Not applicable. This study analyzed publicly available, aggregated national immunization coverage estimates (WUENIC) and did not involve human participants, identifiable individual-level data or human biological materials; formal ethical approval was therefore not required under the applicable institutional requirements. Consent to participate and consent for publication were not applicable.

Data availability: The data analyzed in this study are publicly available from the WHO/UNICEF Estimates of National Immunization Coverage (WUENIC), 2025 revision, at https://immunizationdata.who.int/. The derived indicators presented in this article were calculated from the published national coverage estimates using the formulae given in section 2.3.

Use of generative AI: The authors did not report the use of generative artificial intelligence tools in the preparation of this manuscript.

Supplementary material: Supplementary File S1 (completed GATHER checklist), Supplementary Table S1 (WUENIC confidence-grade codes by vaccine indicator and year, 2000–2025)

and Supplementary Table S2 (summary of country-specific evidence and estimation comments for selected years) are available with the online version of this article.

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