

Vital Surveillances

Vaccination Status and Incidences of Measles, Mumps, and Rubella — Worldwide, 2014–2023

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ABSTRACT

Introduction: Measles, mumps, and rubella remain significant global health threats despite being vaccine-preventable diseases. The World Health Organization aims to achieve regional elimination of measles and rubella by 2030, yet substantial disparities in vaccination coverage and disease incidence persist across regions. We analyzed global vaccination and disease data to provide evidence for optimizing immunization strategies.

Methods: The study analyzed World Health Organization data on measles, mumps, and rubella from 2014–2023. Our analysis included vaccine types, recommended vaccination schedules, coverage rates, supplemental immunization activities, and disease incidence. We employed descriptive epidemiological methods for data synthesis and analysis.

Results: All countries implemented ≥ 1 measles-containing vaccine dose, with 190 (97.9%) countries using a ≥ 2 -dose schedule. Global 2nd dose of measles-containing vaccine coverage increased from 59% to 74% during the study period. High-income regions maintained $>90\%$ coverage, while the African Region reported the lowest coverage (70% for the 1st dose and 49% for the 2nd dose of measles-containing vaccine). Supplemental immunization activities helped address coverage gaps but required integration with routine immunization systems. Rubella vaccine was implemented in 90.2% of countries, while mumps vaccine adoption remained lower at 63.9%. The African Region experienced high incidence rates for both measles (551.8 per million) and rubella (21.9 per million). The COVID-19 pandemic disrupted vaccination coverage (3%–5% decline globally), with the African Region experiencing a post-pandemic U-shaped resurgence in cases. China's transition to the measles, mumps, and rubella vaccine has reduced mumps incidence to below 100 cases per million by 2020.

Conclusions: While global control of measles, mumps, and rubella has progressed, inequities in

vaccination coverage and pandemic-related disruptions threaten elimination goals. Strengthening routine immunization systems is critical. Achieving the World Health Organization's 2030 targets will require sustained investment in health systems and implementation of equity-focused innovations.

Measles, mumps, and rubella are highly contagious viral diseases that pose a significant public health challenges. Measles presents with fever and generalized rash, potentially causing severe complications, including pneumonia, diarrhea, and subacute sclerosing panencephalitis, which can be fatal. While mumps is generally milder than measles, it can affect the salivary glands and lead to serious complications involving the testicles, ovaries, and central nervous system. Rubella typically causes mild illness; however, infection during early pregnancy can result in congenital rubella syndrome (CRS). In 2020, the World Health Organization (WHO) published the “2021–2030 Global Measles and Rubella Strategic Framework,” which outlines the goal to achieve and sustain regional measles and rubella elimination by 2030 (*1*).

Vaccination represents the most effective and cost-efficient strategy for preventing measles, mumps, rubella, and CRS. However, vaccination schedules and coverage vary considerably across countries and regions. This study analyzes immunization schedules, coverage rates, and disease incidence patterns across the six WHO regions — African Region (AFR), Eastern Mediterranean Region (EMR), European Region (EUR), Region of the Americas (AMR), South-East Asia Region (SEAR), and Western Pacific Region (WPR) — to provide evidence for optimizing immunization strategies.

METHODS

The study obtained publicly available data for the

period 2014–2023 from the WHO website (<https://www.who.int/data/immunization>). Data on reported cases and incidences, which from the surveillance systems of member states, along with vaccination policies, were reported through the WHO/United Nations Children's Fund (UNICEF) Joint Reporting Form on Immunization (JRF). Regional and global WHO/UNICEF Estimates of National Immunization Coverage (WUENIC) was calculated by WHO/UNICEF (2). We employed descriptive epidemiological methods for data analysis and reporting, using Microsoft Excel 2016 (Microsoft Corp., Redmond, WA, USA) for all analyses.

RESULTS

Measles-Containing Vaccine (MCV) Schedules

In 2023, all countries implemented at least one routine MCV dose, and 190 countries (97.9%) used ≥ 2 MCV doses (Table 1). The measles, mumps, and

rubella vaccine (MMR) was used in 139 countries (71.6%), while measles-rubella vaccine (MR) was implemented in 53 countries (27.3%). Twenty-seven countries used standalone measles vaccine, and 9 used measles-mumps-rubella-varicella vaccine (MMRV). Two or more MCV doses have been consistently used in EUR since 2006, SEAR since 2016, AMR since 2018, EMR since 2022, and WPR since 2023. The proportion of AFR countries implementing two MCV doses increased substantially from 42.6% in 2014 to 91.5% in 2023 (Table 2).

The 1st dose of measles-containing vaccine (MCV1) is administered at 9 months of age in most African Region and South-East Asia Region countries, with a second dose at 15–18 months. In the Eastern Mediterranean Region, high-income countries like the United Arab Emirates administer MMR vaccine at 12 months, while lower-income countries like Afghanistan use single-antigen measles vaccines, with the first dose at 9 months and the second at 15–18 months. In the European Region, the first dose is generally

TABLE 1. Number of member states adopting different types of measles-containing vaccines in the six WHO regions in 2023.

No. of doses	Vaccine	AFR	EMR	EUR	AMR	SEAR	WPR	Total
1	MV	3						3
	MR	1						1
2	MV+MV	12	4					16
	MV+MR						1	1
	MV/MR+MR					1		1
	MV/MMR+MMR		3				1	4
	MV/MM/MMR+MV/MM/MMR			1				1
	MR+MR	27	3		1	5	8	44
	MR+MMR					1		1
	MR/MMR+MMR				1			1
	MR/MMR+MR/MMR						1	1
	MMR+MMR	4	8	42	30	3	12	99
	MMR+MMRV			1	1		2	4
	MMR+MMR/MMRV			1				1
	MMR/MMRV+MMRV				1			1
	MMR/MMRV+MMR/MMRV			3	1			4
	MMRV+MMRV			3				3
3	MR+MR+MR		1			1	1	3
	MMR+MMR+MMR		1	2				3
	MV/MMR+MMR+MMR		1					1
4	MR+MR+MR+MR						1	1
Total		47	21	53	35	11	27	194

Abbreviation: WHO=World Health Organization; MV=measles vaccine; MR=measles and rubella vaccine; MMR=measles, mumps and rubella vaccine; MMRV=measles, mumps, rubella, and varicella vaccine.

TABLE 2. Measles-containing vaccination status of the six WHO regions, 2014–2023.

Index	Year	AFR (n=47)	EMR (n=21)	EUR (n=53)	AMR (n=35)	SEAR (n=11)	WPR (n=27)	GLOBAL (n=194)
No. of the Member States using ≥2 MCV doses (%)	2014	20 (42.6)	20 (95.2)	53 (100)	29 (82.9)	9 (81.8)	23 (85.2)	154 (79.4)
	2015	25 (53.2)	20 (95.2)	53 (100)	29 (82.9)	10 (90.9)	23 (85.2)	160 (82.5)
	2016	25 (53.2)	20 (95.2)	53 (100)	31 (88.6)	11 (100)	24 (88.9)	164 (84.5)
	2017	26 (55.3)	20 (95.2)	53 (100)	32 (91.4)	11 (100)	25 (92.6)	167 (86.1)
	2018	26 (55.3)	20 (95.2)	53 (100)	35 (100)	11 (100)	26 (96.3)	171 (88.1)
	2019	32 (68.1)	20 (95.2)	53 (100)	35 (100)	11 (100)	26 (96.3)	177 (91.2)
	2020	34 (72.3)	20 (95.2)	53 (100)	35 (100)	11 (100)	26 (96.3)	179 (92.3)
	2021	37 (78.7)	20 (95.2)	53 (100)	35 (100)	11 (100)	26 (96.3)	182 (93.8)
	2022	42 (89.4)	21 (100)	53 (100)	35 (100)	11 (100)	26 (96.3)	188 (96.9)
	2023	43 (91.5)	21 (100)	53 (100)	35 (100)	11 (100)	27 (100)	190 (97.9)
No. of the Member States reporting MCV2 coverage (%)	2014	17 (36.2)	20 (95.2)	51 (96.2)	29 (82.9)	9 (81.8)	23 (85.2)	149 (76.8)
	2015	23 (48.9)	20 (95.2)	51 (96.2)	29 (82.9)	9 (81.8)	23 (85.2)	155 (79.9)
	2016	25 (53.2)	20 (95.2)	52 (98.1)	31 (88.6)	11 (100)	23 (85.2)	162 (83.5)
	2017	26 (55.3)	20 (95.2)	52 (98.1)	32 (91.4)	11 (100)	24 (88.9)	165 (85.1)
	2018	26 (55.3)	20 (95.2)	52 (98.1)	35 (100)	11 (100)	25 (92.6)	169 (87.1)
	2019	32 (68.1)	20 (95.2)	52 (98.1)	35 (100)	11 (100)	26 (96.3)	176 (90.7)
	2020	34 (72.3)	20 (95.2)	52 (98.1)	35 (100)	11 (100)	26 (96.3)	178 (91.8)
	2021	37 (78.7)	21 (100)	52 (98.1)	35 (100)	11 (100)	26 (96.3)	182 (93.8)
	2022	41 (87.2)	21 (100)	52 (98.1)	35 (100)	11 (100)	26 (96.3)	186 (95.9)
	2023	43 (91.5)	21 (100)	52 (98.1)	35 (100)	11 (100)	27 (100)	189 (97.4)
MCV1 coverage (min–max)	2014	69 (44–99)	79 (46–99)	94 (56–99)	93 (68–99)	87 (74–99)	96 (65–99)	84 (44–99)
	2015	68 (42–99)	80 (46–99)	94 (56–99)	93 (69–99)	88 (70–99)	96 (57–99)	84 (42–99)
	2016	68 (37–97)	81 (46–99)	93 (42–99)	92 (69–99)	89 (73–99)	96 (46–99)	85 (37–99)
	2017	69 (37–99)	81 (46–99)	95 (58–99)	88 (69–99)	91 (77–99)	96 (41–99)	85 (37–99)
	2018	70 (41–99)	82 (46–99)	95 (42–99)	91 (69–99)	93 (77–99)	96 (37–99)	86 (37–99)
	2019	71 (40–99)	82 (46–99)	96 (33–99)	87 (64–99)	94 (75–99)	96 (37–99)	86 (33–99)
	2020	69 (41–97)	82 (46–99)	94 (24–99)	86 (45–99)	88 (74–99)	95 (44–99)	83 (24–99)
	2021	67 (36–97)	80 (46–99)	95 (18–99)	85 (58–99)	87 (44–99)	92 (35–99)	81 (18–99)
	2022	68 (37–99)	80 (46–99)	94 (33–99)	84 (52–99)	94 (67–99)	93 (41–99)	83 (33–99)
	2023	70 (41–99)	79 (45–99)	95 (24–99)	85 (65–99)	91 (28–99)	92 (52–99)	83 (24–99)
MCV2 coverage (min–max)	2014	10 (3–99)	63 (42–99)	89 (57–99)	78 (15–99)	59 (28–99)	92 (53–99)	59 (3–99)
	2015	17 (8–99)	68 (37–99)	89 (57–99)	78 (21–99)	66 (31–99)	92 (55–99)	63 (8–99)
	2016	22 (16–99)	73 (40–99)	88 (31–99)	80 (26–99)	75 (25–99)	93 (45–99)	67 (16–99)
	2017	24 (18–99)	73 (38–99)	91 (75–99)	75 (25–99)	79 (59–99)	93 (1–99)	68 (1–99)
	2018	25 (23–99)	73 (39–99)	91 (76–99)	84 (31–99)	81 (67–99)	93 (28–99)	70 (23–99)
	2019	33 (4–99)	75 (37–99)	92 (68–99)	72 (13–99)	83 (71–99)	93 (20–99)	71 (4–99)
	2020	39 (14–99)	75 (36–99)	91 (60–99)	73 (24–99)	80 (60–99)	93 (27–99)	71 (14–99)
	2021	40 (1–86)	75 (4–99)	91 (10–99)	77 (37–99)	79 (42–98)	91 (20–99)	71 (1–99)
	2022	44 (1–98)	75 (8–99)	91 (60–99)	76 (30–99)	86 (0–98)	92 (25–99)	73 (1–99)
	2023	49 (18–94)	73 (13–99)	91 (62–99)	75 (40–99)	85 (16–99)	90 (21–99)	74 (13–99)

Abbreviation: WHO=World Health Organization; MCV=measles-containing vaccine.

administered at 12–15 months, with the second dose given at 5–12 years. In the Region of the Americas, the first dose is usually given at 12 months, with Caribbean countries scheduling the second dose for 18 months. Mainland South American countries administer the second dose at preschool ages (4–6 years). In the Western Pacific Region, the first dose is typically administered between 9 and 12 months, with most countries administering the second dose at 15–18 months. Malaysia has the world's youngest first-dose schedule (six months), followed by China at 8 months.

In 2023, 175 (90.2%) and 124 (63.9%) countries have introduced rubella and mumps vaccines, respectively. China began using a two-dose MMR schedule in 2020, replacing its previous MR-MMR schedule.

Supplemental Immunization

During the study period, 737 measles-rubella supplemental immunization activities (SIAs) were conducted globally. Congo (37), India (36), Malaysia (36), and South Sudan (30) conducted the most. During 2017–2019 and 2023, India conducted multiple SIAs with MR vaccine for children 9 months to 15 years, reaching over 10 million children annually.

During 2014–2022, 19 countries conducted 26 SIAs for adolescents and young adults using vaccines with rubella components, MR and MMR. Brazil, Colombia, Kazakhstan, Oman, and Viet Nam delivered over 1 million additional immunization doses. Azerbaijan, Egypt, Oman, El Salvador, and Vietnam achieved over 90% coverage of their target populations through SIAs.

Coverage

During 2014–2023, global MCV1 coverage has been sustained above 80%, ranging between 81% (2021) and 86% (2018–2019). The 2nd dose of measles-containing vaccine (MCV2) coverage increased from 59% to 74% during 2014–2023 (Table 2). EUR and WPR have maintained high coverage levels. In 2023, MCV1 coverage levels were 95% and 92%, respectively, with MCV2 coverage of 91% and 90%. SEAR followed closely, with MCV1 coverage ranging from 87% to 94% and MCV2 coverage increasing from 59% to 86%. AMR had long-term stability in MCV1 coverage, consistently achieving 85%–90%. However, MCV2 coverage remained below 70% in some low- and middle-income countries, like Haiti and Bolivia. In AFR, MCV1 coverage has remained around 70%, while MCV2 coverage has seen significant

improvement, rising from 10% in 2014 to 49% in 2023. EMR coverage was complex - Gulf countries like Bahrain had 99% coverage for MCV1 and MCV2, while Yemen and Somalia had coverage rates below 50% for both doses in 2023.

All regions experienced declines in vaccination coverage between 2020 and 2021, with average reductions of 3%–5%.

The global rubella vaccination rate has shown significant progress, increasing from 44% in 2014 to 72% in 2022, though with a slight decline to 71% in 2023. AFR has the lowest vaccination rates, albeit with a gradual upward trend. EMR has demonstrated notable improvement, with coverage rising from approximately 40% to 68%–69% between 2022 and 2023. SEAR has achieved remarkable increases — from below 20% to over 80% since 2018. EUR, WPR, and AMR have sustained high and stable coverage, consistently exceeding 80%.

Incidences of Measles, Mumps, Rubella, and CRS

Figure 1 illustrates the incidence trends during the study period. Measles incidence was lowest in AMR, ranging from 0.1 to 32.6 cases per million population, while AFR consistently reported the highest rates (35.9–551.8 per million). Mumps incidence in EUR remained relatively low (4.4–31.9 per million). SEAR experienced high mumps incidence during 2014–2018 (213.2–413.2 per million), followed by a significant decline from 2019 onward. In contrast, AFR has shown a concerning upward trend in mumps incidence since 2018, reaching 761.5 per million in 2023. In China, mumps incidence ranged from 124.6 to 182.6 per million during 2014–2018 before declining substantially; since 2020, the incidence has remained below 100 per million.

EUR maintained low rubella incidence, remaining below 1 per million since 2018. Incidence rates in EMR and SEAR ranged between 0.8 and 6 per million. WPR experienced a significant rubella resurgence in 2019, followed by a steady decline to below 1 per million since 2021. AFR consistently reported higher rubella incidence, ranging from 3.6 to 21.9 per million.

The proportion of countries reporting CRS increased from 60.3% in 2014 to 73.2% in 2023, with annual reported cases ranging from 142 to 1,534. EMR and SEAR reported relatively high CRS incidence, ranging from 0.1 to 0.7 per 10,000 live births.

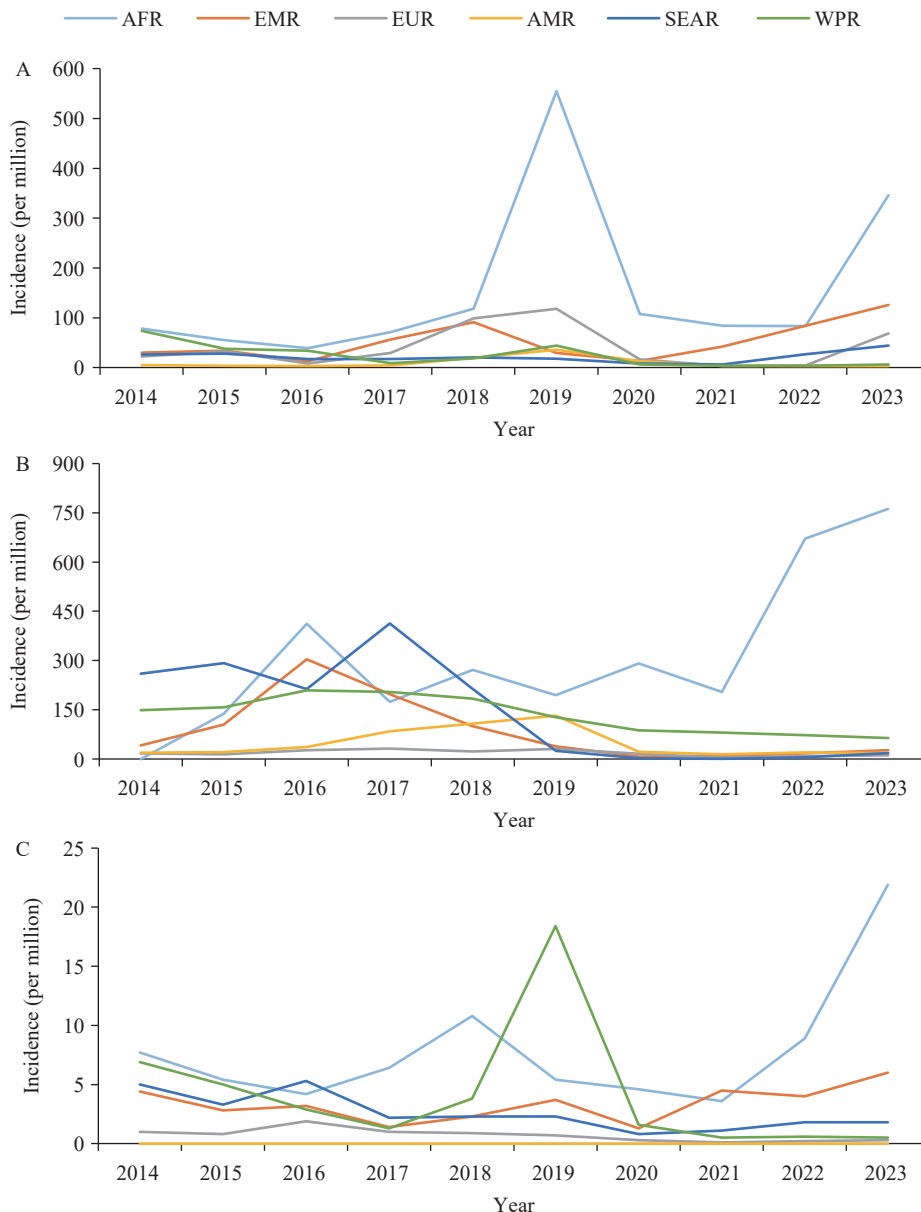


FIGURE 1. Reported (A) measles, (B) mumps, and (C) rubella incidences in the six WHO regions, 2014–2023. Abbreviation: WHO=World Health Organization; AFR=African Region; EMR=Eastern Mediterranean Region; EUR=European Region; AMR=Region of the Americas; SEAR=South-East Asia Region; WPR=Western Pacific Region.

In 2020, incidence of all three diseases declined across all WHO regions, with the exception of mumps in AFR, and remained at relatively low levels throughout the coronavirus disease 2019 (COVID-19) pandemic (2020–2022). Disease incidence began to increase in the post-pandemic period.

DISCUSSION

This analysis of 10 years of WHO data on measles, mumps, and rubella provides a comprehensive evaluation of global progress toward disease control

from both epidemiological and immunization strategy perspectives. Our findings underscore the critical role of vaccination in reducing the global burden of these diseases while highlighting persistent regional disparities in coverage and disease incidence.

The near-universal implementation of two-dose MCV schedules reflects global consensus on their necessity, yet significant coverage gaps persist. These disparities reflect not only healthcare infrastructure deficiencies but also challenges such as political instability, vaccine hesitancy, and armed conflict that perpetuate disease transmission (*1*) and impede measles

elimination efforts (3). UNICEF, in collaboration with partner organizations, is developing MR-containing microarray patches to improve vaccine accessibility and equity. While AFR has made remarkable progress in increasing MCV2 coverage, persistently high measles incidence indicates that vaccination rates must be further improved. Integration of rubella and mumps vaccines into national programs remains uneven, with mumps vaccination lagging globally due to cost considerations and perceived lower urgency compared to measles and rubella. Although global mumps vaccination rate data are unavailable, based on adoption ratios and country-specific research, coverage is likely below the threshold required for effective control (4).

The COVID-19 pandemic exposed the fragility of immunization systems, causing a global decline in coverage and reversing years of progress. Recovery has been uneven, with the slowest rebounds occurring in low-income countries (5). While most regions had recovered by 2023, the U-shaped incidence curves in AFR highlight how external shocks disproportionately affect vulnerable populations. This underscores the imperative to build resilient health systems capable of sustaining routine immunization during crises.

An inverse correlation between vaccination coverage and disease incidence is clearly evident across regions. The AMR, maintaining MCV1 coverage >85%, has sustained the world's lowest measles incidence and achieved rubella elimination in 2015 (6). Conversely, the AFR's persistently high measles incidence directly corresponds with its lower MCV1 and MCV2 coverage rates. Rubella elimination in AMR depended not only on high coverage but also on gender-sensitive strategies — including prenatal screening, targeted vaccination of women, and robust CRS surveillance — approaches that may be under-prioritized in AFR and parts of the EMR (7).

Vaccination schedules and vaccine formulations significantly influence disease epidemiology. The later administration of MCV2 in EUR and South America (up to 12 years of age) contrasts markedly with the earlier second doses implemented in Africa and Asia (15–18 months). While older-age MCV2 schedules align effectively with school-based immunization programs, they risk leaving young children vulnerable for several years. China's early MCV1 administration at 8 months likely contributes to low measles incidence. In June 2020, China transitioned to a two-dose MMR schedule, effectively changing from a one-dose to a two-dose mumps vaccination program. The

subsequent significant decrease in mumps incidence demonstrates that a two-dose mumps vaccine regimen provides superior disease control (8). Additionally, non-pharmaceutical interventions implemented during the COVID-19 pandemic may have indirectly reduced respiratory disease transmission, further supporting mumps reduction efforts.

SIAAs effectively bridge coverage gaps, particularly in high-burden areas (9). India's large-scale MR campaigns and Brazil's adolescent-focused SIAAs demonstrate the scalability and potential impact of these efforts. However, long-term success depends on integrating these campaigns with robust routine immunization systems (10). The resurgence in AFR post-2022 — despite previous SIAAs — underscores the necessity for continuous investment in routine immunization infrastructure.

China's immunization achievements — consistently maintaining >90% coverage with measles and rubella-containing vaccines and reducing measles and rubella incidences to <1/million — position the country close to elimination of both diseases (11–13). Nevertheless, a persistent mumps burden, although declining, indicates that China lags behind countries in EUR, AMR, and SEAR in this regard, suggesting that routine immunization with two doses of MMR vaccine should be further strengthened.

This study has several limitations. Disease surveillance methods vary in sensitivity across regions and likely underrepresent true incidence, especially in areas with weaker surveillance systems, particularly for mumps and rubella. Additionally, the proportion of countries reporting data varies by WHO region, potentially affecting the assessment of disease trends.

In conclusion, global efforts against measles, mumps, and rubella have achieved notable milestones, yet persistent disparities and emerging challenges highlight the need for sustained investment in immunization programs. Strengthening health systems, addressing vaccine inequities, and leveraging innovative strategies will be critical to achieving the WHO 2030 elimination targets.

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