

Impact of the COVID-19 Era on Routine Child Immunization Coverage and Resurgence of Measles and Pertussis

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Abstract

Review Article

The COVID-19 virus has impacted routine immunization services targeting children across the world. Through this paper, the authors aim to assess the situation that is happening. This review aims to assess how and to what extent routine childhood immunization coverage has declined during the COVID-19 pandemic, early signals that suggest the resurgence of measles and pertussis and what this means for policy and health system resilience. We combined the latest world and regional proof on changes in coverage, timeliness and completion of core childhood vaccines. We did administrative evidence, modelling studies and outbreak reports to take into account inequities by region, income level and vulnerable groups. All WHO regions saw coverage declines during the pandemic, with recovery being heterogeneous and widening gaps in settings with pre-existing under-immunization. New information shows many delays, many zero-dose pockets, and increasing outbreaks of measles and pertussis in areas where coverage has dropped below herd-immunity thresholds. Catch-up campaigns, additional outreach, and digital trackers were deployed by health systems, though implementation is uneven and under-resourced. Disruptions due to COVID-19 resulted in an immunity gap and renewed measles and pertussis transmissions. We need catch-up strategies that last, recovery plans that focus on equity, and monitoring and evaluation systems for routine immunizations.

Keywords: COVID-19; Routine childhood immunization; Measles; Pertussis; Herd immunity.

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1. INTRODUCTION

Despite significant gains in routine immunization in recent decades, the COVID-19 epidemic has caused widespread disruption, raising fears of resurgent transmission of vaccine-preventable diseases (Basu *et al.*, 2023). Disruption of health services and decreased demand for vaccinations, driven by clinic closures, staff reallocation, supply chain interruptions, patient hesitancy, school closures, and limitations of digital or telehealth options, have hampered access to vaccinations (Causey *et al.*, 2021). The extent of the disruption was unexpected, as were delays in service recovery following the relaxation of physical distancing measures (O. C. Ota *et al.*, 2021). Modelling studies show markedly higher future incidence of measles and pertussis associated with observed coverage declines (Ota *et al.*, 2021).

Routine immunization is a critical public-health intervention—one that has been severely disrupted during the COVID-19 pandemic across many regions of the world (Dinleyici *et al.*, 2021). Transient interruptions in immunization coverage can precipitate surges of

vaccine-preventable diseases, particularly for highly transmissible pathogens for which immunity wanes rapidly after the completion of the primary series (Basu *et al.*, 2023). A growing body of evidence suggests a resurgence of measles and pertussis in various contexts, closely aligned with observed declines in coverage and vaccination delays, though in many countries the pandemic has yet to complete its course (Ota *et al.*, 2021).

2. BACKGROUND ON ROUTINE IMMUNIZATION AND HERD IMMUNITY

Routine immunization encompasses the delivery of all vaccines included in the national schedule of a country (Plans-Rubió, 2021). Globally, the five vaccines recognized as essential for immunization during early childhood comprise the diphtheria-tetanus-pertussis vaccine (DTP), the measles-containing vaccine (MCV), the poliovirus vaccine (POL), the hepatitis B vaccine (HBV), and the Bacillus Calmette-Guérin vaccine (BCG) (Kaur, 2023). The vaccine-preventable diseases targeted by this package remain endemic in many low- and middle-income countries, with routine immunization programs preventing an estimated 3

million to 5 million deaths annually (Causey *et al.*, 2021). Measles and pertussis are classified among the highest-priority diseases with respect to herd immunity, requiring that vaccination coverage exceed the respective thresholds of 92% and 94% to limit endemic circulation (O. C. Ota *et al.*, 2021).

Delivery of vaccination services is crucial to maintaining child immunization coverage (Blanc *et al.*, 2024). Many countries operate a two-pronged system comprising either stand-alone or integrated immunization activities, whereby routine administration of vaccines takes place at regular intervals, supplemented by community-based catch-up campaigns (Shah *et al.*, 2024). Catch-up campaigns aim to curb the spread of vaccine-preventable diseases (VPDs) among children who have missed due vaccinations (Shah *et al.*, 2024). Such interventions often target the entire population of children yet to receive at least one dose of a particular vaccine (Mahachi *et al.*, 2022). Audit of immunization registers to identify uninoculated individuals and organization of catch-up clinics for specific vaccines are standard methods adopted by routine immunization systems to promote recovery (Kabwama *et al.*, 2025).

Owing to disruptions, routine immunization coverage has declined within all WHO regions (Shet *et al.*, 2022). Regional trends reveal that the absolute number of missed doses remains higher than pre-pandemic levels in the Eastern Mediterranean and South-East Asia regions (Causey *et al.*, 2021). Furthermore, children residing in WHO European and Western Pacific regions have reported the greatest relative declines in coverage (Ota *et al.*, 2021). COVID-induced restrictions caused diminished opportunities to receive vaccinations, as parental attendance at health facilities declined following closure of schools and daycare centers (Shet *et al.*, 2024). The lack of school entry requirements in combination with the higher average number of doses administered before school entry contributed to more pronounced disruptions among older cohorts (Evans *et al.*, 2023). Consequently, the median age at which children completed the third dose of DTP (DTP3) and the first dose of measles-containing vaccine (MCV1) rose from 4.2 and 4.4 months to 5.0 and 6.9 months, respectively (Basu *et al.*, 2023).

3. DISRUPTION DURING THE COVID-19 ERA: CAUSES AND EXTENT

Routine child immunization contributes to protection against vaccine-preventable diseases, and interruptions in implementation may compromise community health (Pettoello-Mantovani *et al.*, 2025). Disruption of routine immunization during the COVID-19 era was multi-faceted, including interruption of service delivery, shift of financial resources, contingency planning failure, lockdown measures, social distancing requirement, confinement at home, increased poverty and unemployment, change in patient behaviour, and vaccine hesitancy due to misinformation (Kaushik *et al.*,

2025). The extensive interruption of health services during COVID-19 may leave a huge backlog of children and adults due for vaccination, posing a renewed risk of preventable diseases (O. C. Ota *et al.*, 2021). Several strategies are required to catch up on COVID-19 vaccination deliveries and address missed routine immunizations (Sayem *et al.*, 2025).

4. CONSEQUENCES FOR ROUTINE IMMUNIZATION COVERAGE

Routine vaccination coverage was adversely affected during the COVID-19 era, with reports of large, uneven declines in many settings followed by only partial recovery, renewed drops in some areas, and signs of measles and pertussis resurgence (Ota *et al.*, 2021). These effects have yet to be systematically quantified or compared across regions, highlighting the need for a broad, policy-oriented assessment of the subject. Such analysis may enable stakeholders to identify specific problems in their own contexts, allowing targeted measures to restore coverage and prevent further upsurges of vaccine-preventable diseases (Basu *et al.*, 2023).

Comprehensive reviews have documented the global and national disruption to routine vaccination services and coverage during the COVID-19 pandemic across diverse settings (Aguinaga-Ontoso *et al.*, 2025). Coverage for DTP3, MMR, and other core vaccines dropped significantly in the United States and many parts of Europe, with declines persisting into 2022 despite catch-up initiatives (Aguinaga-Ontoso *et al.*, 2024). A systematic analysis of coverage across 24 low- and middle-income countries showed a median decrease in DTP3 of ten percentage points during 2020, with 85 million children estimated to have remained without a first dose (O. C. Ota *et al.*, 2021). Substantial declines also occurred in logistics, outreach, and associated COVID-19 testing services (Evans *et al.*, 2023).

In these regions, disruptions were linked to both service availability (reduced hours, staff reassignments) and client demand (perception of irregular vaccines, attention diverted to COVID-19, movement restrictions) (Udofia *et al.*, 2021). Yet policy responses have generally focused on upholding service delivery rather than overcoming specific challenges in restoring vaccine uptake (Hasan *et al.*, 2023). A systematic account of the nature, timing, and geographic distribution of administrative disruptions relating to routine childhood vaccination during the COVID-19 pandemic may therefore facilitate targeted action to restore coverage (Kabagenyi *et al.*, 2022).

5. EVIDENCE OF MEASLES AND PERTUSSIS RESURGENCE

Measles and pertussis epidemics tend to re-emerge after public health interventions when the coverage of routine childhood vaccination declines below a critical threshold (Plans-Rubió, 2021). Observed

trends show that the pandemic has disrupted a range of routine health services on the global and national levels, including immunization services, thereby raising the concern that coverage of measles-containing and pertussis vaccines may have declined below the target levels in several countries (Plans-Rubió, 2025). Recent estimates indicate that coverage dropped substantially during the immediate phase of the pandemic, even though important public health measures, such as nationwide lockdowns and stay-at-home orders, were still in effect (O. C. Ota *et al.*, 2021). Furthermore, early warnings of potential resurgence have appeared in countries with a history of large measles outbreaks or recent decline in coverage (Gambrell *et al.*, 2022).

Quality and timeliness of primary vaccinations against diphtheria-tetanus-pertussis (DTP3) and measles (MCV1) constitute key indicators for monitoring the health system's capacity to maintain immunization services and for signalling possible resurgence of the disease (Marszalek *et al.*, 2025). In various regions, the resumption of routine immunization services is observed; however, early monitoring of an aggregation of indicators suggests that countries at high risk of coverage decline and resurgence of vaccine-preventable diseases urgently need tailored interventions to restore routine immunization services without delay (Maugeri *et al.*, 2024).

6. REGIONAL VARIATIONS AND EQUITY CONSIDERATIONS

Routine immunization plays a critical role in preventing vaccine-preventable diseases (Ota *et al.*, 2021). Immunization coverage requires sustained efforts under normal circumstances, and the COVID-19 era sharply affected routine immunization service delivery and demand, increasing the need for precise policy-oriented analysis (Nabia *et al.*, 2023). Disruptions caused a decline in coverage; measles and pertussis are two diseases for which the analysis documents early indicators of resurgence (Dinleyici *et al.*, 2021).

Routine immunization coverage varied across regions and income categories during 2019–2022 (Kaur, 2023). Regions with poor pre-COVID coverage levels were particularly affected. Equitable recovery from coverage losses—vital for protecting vulnerable populations—remains challenging (Lai *et al.*, 2023). The analysis examines regional discrepancies by income level, urban-rural status, health system capacity, and inclusion of those with human immunodeficiency virus (Jones, 2024). Disproportionate declines occurred for disadvantaged and displaced children through insufficient health service access and information systems when outreach resumed (O. C. Ota *et al.*, 2021).

7. HEALTH SYSTEM RESILIENCE AND ADAPTIVE MEASURES

Health system resilience is evident in adaptive measures pursued to restore routine child immunization

(World Health Organization, 2023). Counties have intensified catch-up campaigns, extended immunization programs into supplementary activities, implemented community outreach, and adopted digital tools for reminders and vaccine status tracking (Sayem *et al.*, 2025). Supply chain innovations have facilitated easier vaccine procurement and distribution (Causey *et al.*, 2021). Nevertheless, these measures often require significant additional investments beyond core immunization services, vary in readiness for rapid deployment, and incur costs that may prevent implementation in resource-constrained settings (Liu *et al.*, 2024).

8. PUBLIC HEALTH IMPLICATIONS AND POLICY RESPONSES

COVID-19 disruptions to routine immunization endanger children, compromising long-term health (Maltezou *et al.*, 2022). Children receiving no routine vaccinations are 87 times more likely to die than vaccinated peers over 23 imminent causes like measles and pertussis (O. C. Ota *et al.*, 2021). Policy action is needed to restore prior coverage levels and mitigate rising risks of vaccine-preventable disease (Kaur, 2023).

A catch-up agenda can recommence routine programs while protecting health gains. Strategies can build on integrated COVID-19 responses that sustain initiatives for immunization across health systems (World Health Organization, 2023). New policy frameworks can inform actions by diverse authorities, including governments, multilateral organizations, and humanitarian partners (Masresha *et al.*, 2020).

9. METHODS FOR MONITORING AND EVALUATION

Monitoring and evaluation are crucial for assessing vaccination performance and identifying gaps (Scharf *et al.*, 2021). Well-established immunization information systems (IIS) facilitate tracking vaccine coverage over time and characterizing remaining underserved populations (Vigizzi *et al.*, 2025). Although data quality and completeness are often problematic, IIS-generated indicators can be used to evaluate routine vaccination activities (Masresha *et al.*, 2020).

Different types of indicators are useful for considering processes and impact: Indicators for direct monitoring include the number of doses given, coverage rates, timeliness, and completion rates (Oduoye *et al.*, 2024). Timeliness refers to the age at which doses are typically administered, whereas completion rates measure the proportion of children who receive all essential doses by a critical age (Namageyo-Funa, 2024). These indicators disaggregate by age and vaccine type to specify needs for catch-up (Chong *et al.*, 2023). Impact indicators—such as disease incidence and presumed vaccine-preventable deaths—are critical for gauging immunity loss (Kiang *et al.*, 2025). Reports of vaccine-derived polio and measles outbreaks provide early signs

of resurgence, particularly in areas where routine immunization levels have declined (Lubanga *et al.*, 2024).

To assess declines in routine immunization coverage and signals of emerging measles and pertussis resurgence during the COVID-19 era, the analysis evaluates both coverage and impact indicators at global and regional levels, with an emphasis on marginalised populations and vulnerable groups (Ota *et al.*, 2021). Coverage metrics express the extent of reduction, while disease indicators signal when and where remaining gaps jeopardise immune protection (Maltezou *et al.*, 2022).

10. CONCLUSION

COVID-19 caused disruptions to routine childhood immunization service delivery, contributing to declines in coverage (Sharma *et al.*, 2021). Evidence suggests these declines are substantial and persistent, with vaccination farther behind on catch-up schedules (Causey *et al.*, 2021). The declines coincide with rising numbers of measles and pertussis outbreaks and incidents (Cardoso *et al.*, 2022). Children missed vaccinations and routine visits during the pandemic, raising concerns about catch-up vaccination (Ota *et al.*, 2021).

COVID-19 also disrupted routine services, yet health systems implemented adaptive measures and maintained or restored coverage (Spayne and Hesketh, 2021). Coverage loss occurred more widely and earlier in high-income countries, coordinating policy and data responses (Chen *et al.*, 2022). These countries must sustain momentum to restore coverage and prevent subsequent declines (Flood *et al.*, 2021).

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