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Impact of COVID-19 Pandemic on Child Basic Immunisation Coverage in Tanzania: An Interrupted Time Series Analysis

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Abstract

The COVID-19 pandemic posed significant challenges to healthcare systems globally, including Tanzania, disrupting essential health services, including child basic immunisation programmes. Using an interrupted time series (ITS) analysis, we analysed how the pandemic influenced child fundamental immunisation trends across three key tears: 2020 (partial lockdown), 2021 (introduction of COVID-19 vaccination programmes), and 2022 (post-pandemic recovery phase). The results reveal a slight decline in immunisation coverage in 2020, with no significant impacts when this year is used as an intervention point. However, a sharp decline in 2021 indicates a more substantial disruption in immunisation services, coinciding with the implementation of COVID-19 vaccination campaigns. When 2021 is considered the intervention year, the study finds significant immediate and prolonged impacts, suggesting that the combination of pandemic fatigue, the reallocation of health resources, and public fear may have exacerbated the decline in immunisation rates. By 2022, immunisation coverage showed signs of recovery. These findings highlight the complex and evolving nature of the pandemic's impact on child immunisation services. This study highlights the need for targeted interventions to restore and maintain essential health services, particularly in global health emergencies. Recommendations include improving healthcare resource allocation during crises, strengthening public health messaging, and expanding community outreach to mitigate long-term service disruptions.

Keywords: Immunisation, vaccination, DPT3, COVID-19 and Tanzania

1. Introduction

The COVID-19 pandemic has exerted significant pressure on healthcare systems globally, disrupting essential services such as basic child immunisation[1] (Blanchet et al., 2020; Dalton et al., 2023; Sangeda et al., 2024; Shayo et al., 2023; Wassenaar et al., 2024). For a complete child basic immunisation coverage, a child must receive Bacillus Calmette Guerin (BCG), pentavalent 3 (Diphtheria, Pertussis and Tetanus(DPT))3, Oral Polio Vaccine (OPV)3 and measles vaccines before reaching the age of 12 months (The United Republic of Tanzania, 2016). However, full basic immunisation for a child is proxied by the third dose of the DPT vaccine (Sangeda et al., 2024). In low- and middle-income countries (LMICs) like Tanzania, the effects of the pandemic have been particularly complex due to limited resources, fragile healthcare infrastructure, and competing health priorities (Dalton et al., 2023). Although Tanzania implemented a partial lockdown in 2020 and promoted COVID-19 precautions (Hamisi et al., 2023; Sangeda et al., 2024), the country faced challenges in maintaining routine health services. Among these services, child basic immunisation is critical in safeguarding public health by preventing vaccine-preventable diseases and reducing child

[1] Immunisation and vaccination are often used interchangeably.

mortality rates (Dalton et al., 2023; Sangeda et al., 2024; Thomas et al., 2022; Wassenaar et al., 2024).

The pandemic's impact on immunisation services has raised concerns about potential declines in vaccination coverage, mainly as healthcare systems shifted resources towards managing COVID-19 (Blanchet et al., 2020; Chandir et al., 2020; Sangeda et al., 2024). Despite the initial efforts to control the virus and maintain routine services, there were sharp fluctuations in immunisation coverage, particularly in 2021, when Tanzania initiated its COVID-19 vaccination campaigns. (Mfinanga et al., 2023). While 2020 saw only a slight decline in child basic immunisation coverage, a more significant drop was observed in 2021, with a subsequent recovery in 2022. These trends suggest that the pandemic's indirect effects on healthcare services may have varied depending on the specific timeline and interventions implemented (Sangeda et al., 2024).

Using interrupted time series (ITS) analysis, we evaluate the impact of the COVID-19 pandemic shock on child basic immunisation coverage in Tanzania, focusing on the immediate and prolonged effects as suggested by Bernal et al. (2017), based on two potential intervention years, 2020 and 2021. The study provides valuable insights into the health system's capacity to manage essential services during the pandemic and identifies areas for improvement in future healthcare crises.

2. Literature review

2.1. Theoretical literature

This study is grounded in health systems resilience theory and Andersen's behavioural model of health services use.

Health systems resilience focuses on preparing for, absorbing, adapting and recovering from shocks while sustaining core functions like immunisation. (Holling, 1973; Kruk et al., 2015). It highlights three critical capacities: absorptive (maintaining services during a crisis), adaptive (adjusting to resource shifts or new demands) and recovery (restoring disrupted services). This framework is relevant for examining how healthcare systems respond to crises, such as the COVID-19 pandemic, which challenged immunisation delivery through resource diversions and service disruptions (Blanchet et al., 2017).

Andersen's behavioural model of health services use explains healthcare utilisation based on three factors: predisposing (caregiver demographics, beliefs), enabling (healthcare access and resources) and need (perceived urgency of care) (Andersen, 1968, 1995). It offers insights into demand-side and supply-side influences on immunisation access, such as how caregiver fears, logistical barriers or resource reallocation during crises affect healthcare decisions. Together, these frameworks provide a comprehensive lens for analysing child immunisation trends during disruptions.

2.2. Empirical literature

Health crises, such as pandemics and epidemics, often strain healthcare systems, diverting resources and attention from routine services to emergency responses (Blanchet et al., 2020). Previous research highlights the adverse effects of such crises on immunisation coverage, particularly in LMICs, where healthcare infrastructure is often fragile and under-resourced (Ghinai et al., 2013). During outbreaks like the Ebola crisis in West Africa (2014-2016), a significant decline in immunisation coverage was observed, leading to a resurgence of preventable diseases such as measles (Wesseh et al., 2017). These trends emphasise the vulnerability of essential health services in the face of widespread health emergencies. However, evidence on the impact of the COVID-19 pandemic on immunisation services in sub-Saharan Africa, and Tanzania

specifically, remains limited, necessitating further investigation.

Tanzania has made considerable strides in improving immunisation coverage over the past two decades, largely due to its Expanded programme on Immunisation (EPI), which provides vaccines to protect children against preventable diseases such as polio, measles and diphtheria (The United Republic of Tanzania, 2016). However, like many LMICs, Tanzania's health system faces challenges, including limited healthcare personnel, inadequate infrastructure in rural areas and resource constraints, which can impact the delivery of routine services (Blanchet et al., 2020; The United Republic of Tanzania, 2016).

Before the COVID-19 pandemic, Tanzania's immunisation coverage rates were high thanks in part to a strong vaccine supply chain and efforts to improve outreach in rural areas (The United Republic of Tanzania, 2016). However, the advent of the pandemic raised concerns about whether the health system could maintain such progress amidst competing demands, including the need for COVID-19 testing and vaccinations. Pre-COVID-19 financial and human resources were meant for the provision of health services, but post-COVID-19, the unit or spaces, human and financial resources were reallocated for COVID-19 management, creating a shortage in healthcare services provision. (Shayo et al., 2023).

The COVID-19 pandemic has caused extraordinary disruptions to healthcare services globally. A study conducted in Tanzania during the early stages of the pandemic reported significant reductions in access to routine healthcare, including immunisation, maternal care and outpatient services. (Abbas et al., 2020). Chandir et al. (2020) highlighted that disruptions in immunisation programmes due to COVID-19-related lockdowns and movement restrictions could result in secondary public health crises, with outbreaks of vaccine-preventable diseases posing additional risks to vulnerable populations. However, the health services faced challenges due to procurement disruptions and medical supplies distributions as a result of border closures and restrictions on international flights (Shayo et al., 2023).

In sub-Saharan Africa, where health systems are already stretched thin, the pandemic's effects were expected to be particularly pronounced. (Blanchet et al., 2020). A study by Chandir et al. (2020) Pakistan, for example, found a sharp decrease in child vaccination rates during the pandemic due to fears of COVID-19 exposure, healthcare facility closures and shifts in health policy priorities. Similar findings have been reported in other LMICs, where immunisation campaigns were paused or delayed, potentially increasing child mortality rates (Hogan et al., 2020).

A qualitative study in Tanzania focusing on discussions with healthcare workers highlighted an association between COVID-19 and a decline in vaccination services (Shayo et al., 2023). Immunisation programmes were disrupted due to the rescheduling of the clinic services and the shortage of vaccines, which affected both mothers and children. Patients also conformed to the vaccine shortages, further hindering child immunisation efforts. Additionally, several mothers expressed fear of COVID-19 infections, leading some to withdraw from immunisation programmes (Shayo et al., 2023). Quantitative studies also demonstrate the disruptions of immunisation coverage during the pandemic, such as the study by Sangeda et al. (2024) covering five regions in Tanzania using the autoregressive integrated moving average (ARIMA) model and studies by Hamisi et al. (2023) and Mfinanga et al. (2023) showing an increase in COVID-19 vaccination efforts due to changes in presidential leadership.

However, there is limited research examining these disruptions in the broader Tanzanian context, especially concerning the government's unique response to COVID-19, which involved a partial lockdown and later introduction of COVID-19 vaccination efforts.

2.3. The COVID-19 pandemic in Tanzania: policy and healthcare implications

Tanzania's response to the COVID-19 pandemic was distinct in comparison to other countries in the region (Hamisi et al., 2023). Initially, the country adopted a more relaxed approach, opting for partial lockdown measures and encouraging citizens to adhere to preventive guidelines such as social distancing and mask-wearing (Hamisi et al., 2023; Sangeda et al., 2024; Shayo et al., 2023). This strategy, coupled with low reported COVID-19 cases, raised questions about the broader impact of the pandemic on routine health services like basic child immunisation.

In 2021, Tanzania's health policy underwent a significant shift with the COVID-19 vaccination programme, marking a turning point in the country's response to the pandemic (Hamisi et al., 2023). This change was largely influenced by the transition in presidential leadership from the late John Pombe Magufuli to Samia Suluhu Hassan, which brought a new approach focused on vaccination programme efforts (Hamisi et al., 2023). However, literature shows that the timing and resource allocation for this programme affected the delivery of other health services (Abbas et al., 2020; Shayo et al., 2023), contributing to the decline in routine immunisation coverage during the pandemic. Understanding the full impact of these shifts is critical for informing future crisis responses and ensuring that routine services are not neglected during emergencies.

2.4. Interrupted time series analysis in evaluating health interventions

ITS analysis has been widely used in public research to evaluate the effects of policy changes or shocks, such as pandemics, on healthcare outcomes. The approach allows researchers to assess changes in trends over time before and after an intervention, offering insights into both short-and long-term effects (Bernal et al., 2017). This method has been applied in various contexts to assess the impact of healthcare disruptions, including those caused by the COVID-19 pandemic (Aguinaga-Ontoso et al., 2024).

In LMICs, ITS analysis has been used to evaluate the effects of health interventions on immunisation rates, maternal care and infectious disease management. For instance, a study in Uganda used ITS analysis to measure the impact of COVID-19 on maternal and child health services, finding significant declines during the initial stages of the pandemic (Roberton et al., 2020). However, such studies remain limited in Tanzania, particularly in terms of child basic immunisation coverage during the COVID-19 pandemic, making this research an important contribution to the literature.

3. Materials and Methods

3.1. Data and variables

To effectively apply ITS analysis, it is essential to have both pre- and post-intervention data, a fundamental requirement for this research design (Linden, 2015, 2017). We utilised time series data from 2013 to 2023, sourced from UNICEF and WHO, which are publicly accessible at UNICEF immunisation coverage data (accessed on 12 September 2024). The dataset spans seven years before and four years after the intervention, similar to those employed in the study by Aguinaga-Ontoso et al. (2024). The period was chosen to ensure the inclusion of recent vaccination practices, policies and healthcare trends, which are

particularly relevant to understanding the impact of COVID-19. Additionally, selecting this period minimises historical bias, as data from earlier years may reflect different socio-political or healthcare contexts, potentially introducing confounding factors.

The dependent variable is child basic immunisation coverage, proxied by the DPT3 vaccine. Children were considered fully immunised if they received the third DPT dose. The independent variable time, represented by the year, with the intervention period marked by two key events: the 2020 onset of the COVID-19 pandemic and the 2021 launch of COVID-19 vaccination campaigns.

3.2. Empirical analysis

The study employed ITS analysis to assess the impact of the COVID-19 pandemic in 2020 and the subsequent vaccination campaign in 2021. It is well known that randomised control trials (RCT) have often been used for impact evaluations. However, it is unsuitable if the study unit is at the population level. (Bernal et al., 2017; Linden, 2015, 2017). Quasi-experimental design studies, including the ITS approach, are appropriate when studying a single unit at the population level, and the outcome variable has several observations pre- and post-intervention (Bernal et al., 2017; Linden, 2015, 2017). Segmented OLS regression as among the ITS approach was used in this study; the method is more adaptable to use (Linden, 2015, 2017; Munga et al., 2023; Odes et al., 2023). The econometrics model for analysis is shown in equation (1) below.

$$DPT3_t = \beta_0 + \beta_1 Time + \beta_2 Intervention_t + \beta_3 Time * Intervention_t + \varepsilon_t \quad (1)$$

Where:

$DPT3_t$ represents outcome variable, number of DPT3 doses administered at year t,

$Time$ represents a period, calendar year,

$Intervention_t$ represents a dummy intervention year (assigned the value of 0 pre-intervention and 1 post-intervention period),

$Time * Intervention_t$ represents the interaction term,

β_0 represents the starting level of an outcome variable,

β_1 represents the slope of the outcome variable,

β_2 represents the immediate or change level of an outcome variable,

β_3 represents the sustained effect of an intervention and

ε_t Represents an error term.

The coefficients β_2 and β_3 must be statistically significant (Linden, 2015, 2017). The coefficient β_3 estimates the magnitude and significance of the intervention effect, the positive value indicates an improvement in the outcome variable due to intervention and a drop otherwise.

Additionally, ITS analysis has a variety of advantages and disadvantages. Among the advantages includes the fact that research can be conducted at the population level rather than the individual level, and the study design can control for the secular trend impacts more effectively compared to the observational (Linden, 2015, 2017; Munga et al., 2023; Penfold & Zhang, 2013). The study design's major disadvantage is its assumption that the outcome variable will not change without any policy,

programme or intervention (Linden, 2015, 2017; Penfold & Zhang, 2013).

4. Results

The trend in child basic immunisation coverage, as measured by the DPT3 vaccine, shows a complex pattern over the years. Between 2014 and 2028, coverage declined from 97% to 89%, indicating challenges in maintaining high immunisation rates even before the onset of the COVID-19 pandemic. This gradual decline aligns with the literature that points to structural and logistical barriers within the health systems, particularly in reaching underserved populations, especially in rural and hard-to-reach areas (Shayo et al., 2023). In 2019 and 2020, coverage stabilised at 91%, reflecting the healthcare system's resilience during the pandemic's early stages. However, the sharp decline to 86% in 2021 coincided with multiple factors, including leadership transition in Tanzania, pandemic fatigue, reallocation of resources towards COVID-19 vaccination campaigns and increased public hesitancy (Hamisi et al., 2023; Mfinanga et al., 2023; Shayo et al., 2023). Figure 1 shows a strong recovery in 2022 and 2023, with coverage rebounding to 93%, reflecting the restoration of immunisation services after the pandemic-related challenges. The trend for DPT3 is similar to other child immunisations, as shown in Appendix 1.

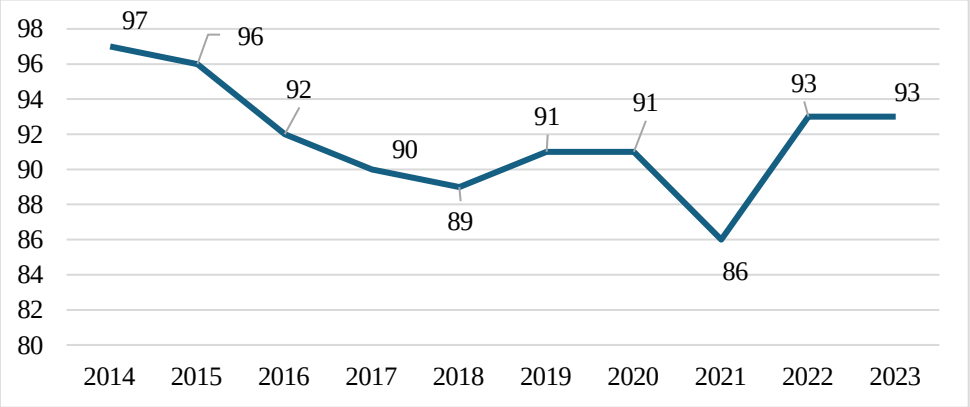

Figure 1: DPT3 trend in Tanzania in percentage

We found changes in DPT3 vaccination coverage in Tanzania using the ITS analysis. The results indicate a general upward trend in child basic immunisation coverage during the intervention period. However, in 2020, there was a minor and statistically insignificant decline, with approximately 29,200 fewer DPT3 vaccines administered. In contrast, a significant decline of 69,700 DPT3 vaccines was observed in 2021, significant at a 10% level (see Table 1).

Additionally, while 2020 showed an insignificant long-term increase of 34,564 DPT3 doses, a significant rise of 81,821 vaccines was recorded in 2021, significant at the 1% level (see Table 1). These findings suggest that COVID-19 notably impacted child basic immunisation coverage in Tanzania, particularly in 2021.

Table 1: Segmented regression analysis for DPT3 vaccination

Variable	The intervention year 2020	*p*-value	Intervention year 2021	*p*-value
Intercept	1,710,536***	0.000	1,707,250***	0.000
Period (year)	33,536***	0.000	35,179***	0.076
Intervention (COVID-19)	-29,200	0.517	-69,700*	0.001
Interaction	34,564	0.110	81,821***	0.000
Post-intervention linear trend	68,100***	0.000	117,000***	0.000

*Note: Asterisk *** 0.01, ** 0.05 and * 0.1*

Furthermore, as shown in Table 1, Figure 2, and Figure 3, there is a significant positive post-intervention linear trend in child immunisation coverage. The results highlight that despite the disruptions in DPT3 vaccination during 2020 and 2021. A recovery trend emerged in 2022. This aligns with the findings of Aguinaga-Ontoso et al. (2024), who also observed a similar rebound in vaccination rates following pandemic-related disruptions.

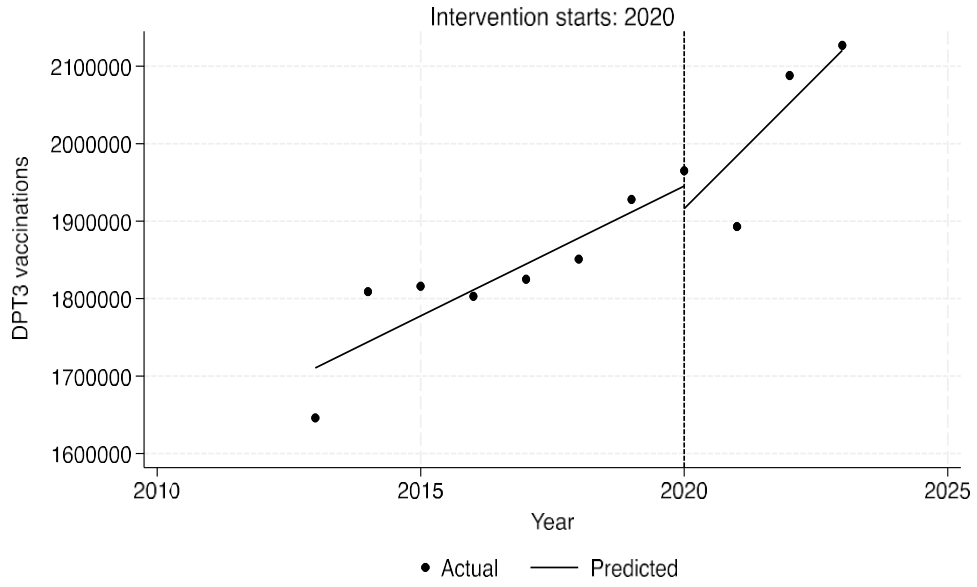

Figure 2: Segmented regression analysis of DPT3 vaccinations for the 2020 intervention year.

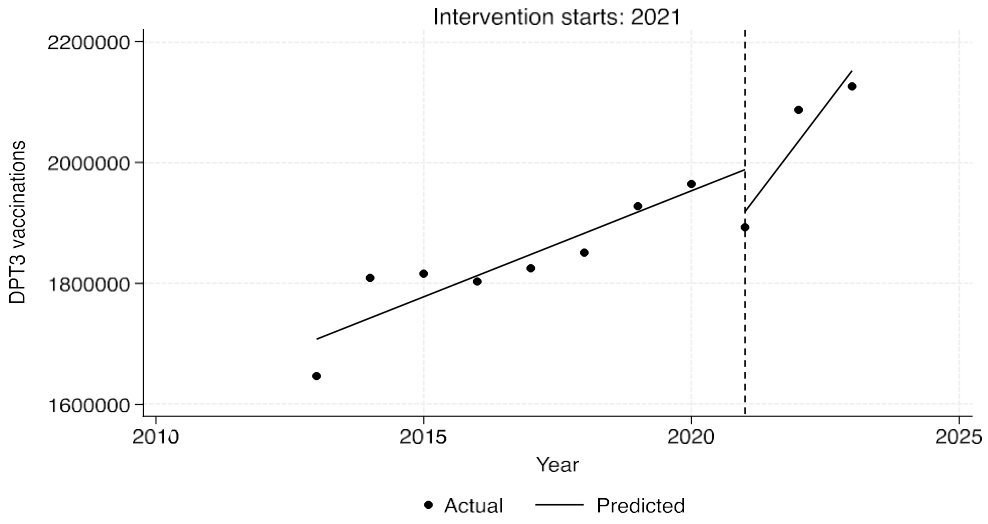

Figure 3: Segmented regression analysis of DPT3 vaccinations for the 2021 intervention year.

5. Discussion of findings

The findings align with the theoretical framework based on the health systems resilience theory; the healthcare system partially absorbed the pandemic's impact in 2020, struggled to adapt in 2021 due to resource diversion, and began recovery in 2022. Also, based on Andersen's behavioural model of health services use, the pandemic disrupted enabling factors like resource availability, while fears of COVID-19 and reallocation to vaccination campaigns reduced immunisation access. Recovery in 2022 emphasised restoring enabling factors to meet healthcare needs.

The findings of this study reveal a complex relationship between the COVID-19 pandemic and child basic immunisation coverage in Tanzania. The analysis, using ITS, demonstrated different effects depending on the chosen intervention years. With 2020 as the intervention year, no significant short-term but significant long-term impacts of the pandemic shock on immunisation rates were observed (Dalton et al., 2023). However, when 2021 was used as the intervention year, significant disruptions were found, highlighting the influence of Tanzania's evolving COVID-19 response and health system dynamics during this period.

5.1. Understanding the 2020 trends

The slight decline in child basic immunisation coverage observed in 2020 aligns with Tanzania's partial lockdown measures, which were less stringent compared to other countries (Mfinanga et al., 2023; Sangeda et al., 2024). The government's decision not to impose a full lockdown but rather encourage citizens to follow preventive guidelines likely mitigated a more severe immediate disruption to healthcare services (Hamisi et al., 2023), including child basic immunisation. The healthcare system, though under pressure, may have adapted to the pandemic by reallocating resources without completely halting routine immunisation programmes (Abbas et al., 2020). This could explain the lack of significant short-run effects when using 2020 as the intervention year.

However, the slight decline indicates that some challenges persisted, particularly due to public fear of attending health facilities and the reallocation of healthcare personnel and resources to pandemic response efforts (Shayo et al., 2023). This reflects findings from other LMICs, where similar trends were observed in the early stages of the pandemic. (Abbas et al., 2020). Even though Tanzania's initial response was less disruptive to routine services, it still had an impact on basic child immunisation coverage.

5.2. The sharp decline in 2021

The sharp decline in child basic immunisation coverage in 2021 is more concerning. This drop coincides with the implementation of Tanzania's COVID-19 vaccination campaign (Hamisi et al., 2023), which may have diverted resources and attention from routine immunisation programmes (Sangeda et al., 2024). Healthcare workers and resources were likely shifted towards the distribution and administration of COVID-19 vaccines, which would have strained an already limited healthcare system (Shayo et al., 2023). Furthermore, public health campaigns and messaging may have focused more heavily on COVID-19 prevention and vaccination, potentially leading to reduced awareness or prioritisation of routine child basic immunisation efforts.

This result highlights the broader challenge faced by LMICs during the pandemic: balancing the urgent need to respond to COVID-19 with the continued delivery of essential health services. In many settings, the introduction of COVID-19 vaccination programmes worsened existing resource constraints, leading to disruptions in routine healthcare, particularly for children (Roberton et al., 2020). This shift may have been especially acute in Tanzania, where the health system already faces significant infrastructural and financial limitations.

5.3. Immunisation coverage recovery in 2022

The recovery in immunisation coverage observed in 2022 suggests that the health system regained its footing after the initial pandemic shock and rollout of COVID-19 vaccines. This rebound may reflect improvements in public health infrastructure and a return to routine healthcare service delivery as the

immediate pressure of the pandemic eased. By 2022, healthcare workers would likely have adjusted to the dual demands of administering COVID-19 vaccines and providing routine immunisation services. Additionally, as public fear of COVID-19 exposure in healthcare settings diminished, parents may have felt more comfortable bringing their children in for vaccinations.

This recovery is consistent with the broader pattern in global immunisation trends, where a decline in coverage during the peak of the pandemic is followed by a gradual restoration of services as countries adapt to the new normal (Abdelhafiz & Alorabi, 2020). However, this trend raises important questions about the sustainability of immunisation programmes during protracted health emergencies and highlights the need for resilience in healthcare systems to maintain routine services even in times of crisis.

5.4. The role of Tanzanian's unique COVID-19 responses

Tanzania's response to the COVID-19 pandemic, which evolved significantly between 2020 and 2021, had a direct impact on child basic immunisation services. The country's initial reluctance to impose stringent lockdowns may have contributed to the muted effects seen in 2020. In contrast, significant effects were observed in 2021, when there was a change in the presidential political regime, which aligns with the introduction of more focused public health interventions, including the COVID-19 vaccination programmes. This shift in health policy priorities reflects a broader challenge in LMICs, where the rollout of COVID-19 vaccines placed added pressure on already overstretched healthcare systems (Blanchet et al., 2020).

Tanzania's case highlights the importance of careful health policy planning during pandemics to ensure that routine healthcare services are not sidelined in the pursuit of pandemic response measures. As seen in this study, the impact of COVID-19 on child basic immunisation coverage was not immediate but rather unfolded as the pandemic response evolved, particularly with the introduction of COVID-19 vaccines in 2021. This finding emphasises the need for a balanced approach that considers both the urgent demands of the pandemic response and the continued delivery of essential services like immunisation.

5.5. Implications for the future pandemic responses

The results of this study provide valuable insights into how health systems in LMICs can be better prepared for future pandemics (Blanchet et al., 2020). The observed delayed impact in Tanzania suggests that the health system initially managed to meet pandemic's demands without significantly disrupting routine services. However, as the pandemic response intensified in 2021, the strain on immunisation services became more pronounced.

To avoid such disruptions in future health crises, Tanzania and LMICs should consider strategies for integrating pandemic response efforts with routine healthcare delivery. This could involve strengthening healthcare infrastructure, increasing the workforce, and ensuring that essential services are protected even during emergencies. Additionally, public health campaigns should emphasise the importance of continuing routine vaccinations during pandemics to prevent secondary health crises caused by outbreaks of vaccine-preventable diseases.

5.6. Robustness check

The sensitivity analysis using 2018 and 2019 as the intervention years revealed insignificant short-term and long-term impacts of COVID-19 on child immunisation (see Appendix 2), with no noticeable trend shift in 2019 (see

Appendix 3). These results were similar to those observed in 2020, when Tanzania implemented a partial lockdown but differed from 2021, when the COVID-19 vaccination campaigns were actively promoted.

6. Conclusion

This study provides critical insights into the impact of the COVID-19 pandemic on child basic immunisation services in Tanzania. The findings highlight the importance of timing and healthcare system priorities in determining the extent of service disruptions. While no significant short-term but significant long-term effects were observed in 2020, the sharp decline in immunisation coverage in 2021 highlights the challenges of balancing routine healthcare with emergency responses such as the COVID-19 vaccination campaigns. The subsequent recovery in 2022 demonstrates the system's capacity for resilience but also calls attention to the need for improved preparedness in managing essential health services during pandemics.

The implications of these findings are twofold. First, healthcare systems must strengthen their capacity to maintain routine services even during public health emergencies. Second, there is a need for policies that integrate routine services, such as child immunisation, with emergency responses, ensuring that essential healthcare is not compromised. By enhancing health system resilience, improving resource allocation, and reinforcing public communication, Tanzania and similar countries can mitigate the adverse effects of future health crises on essential services like child basic immunisation.

Limitations of the study

Data quality and availability

The study's reliance on available national immunisation data from UNICEF may affect its accuracy due to potential issues such as incomplete reporting, inconsistent record-keeping or delayed submissions, particularly in rural areas and underserved regions. While these limitations could obscure the pandemic's impacts, especially where health services disruptions were severe, the robustness and reliability of UNICEF's dataset remain well-recognised. Over the past two decades, global immunisation data quality has significantly improved. Although the Demographic and Health Survey (DHS) dataset could be an alternative, its periodicity and structure in the Tanzanian context are less suitable for ITS analysis.

Intervention years assumptions

The use of 2020 and 2021 as intervention years may not fully capture the dynamic and evolving nature of the pandemic's impact on immunisation services. The effects of COVID-19 on health systems could have started earlier or extended beyond the chosen periods, especially given Tanzania's unique response strategies.

Confounding factors

This study did not account for other factors that may have influenced immunisation rates during the pandemic, such as concurrent public health policies, socioeconomic disruptions, or unrelated healthcare initiatives. However, the primary focus was to analyse how policy changes targeting COVID-19 affected child immunisation.

Mitigation strategies

To minimise biases, the study relied on including visual trend evaluations to validate the ITS assumptions. Future research could complement ITS with mixed-methods approaches, incorporating qualitative data to capture a more nuanced understanding of these influences.

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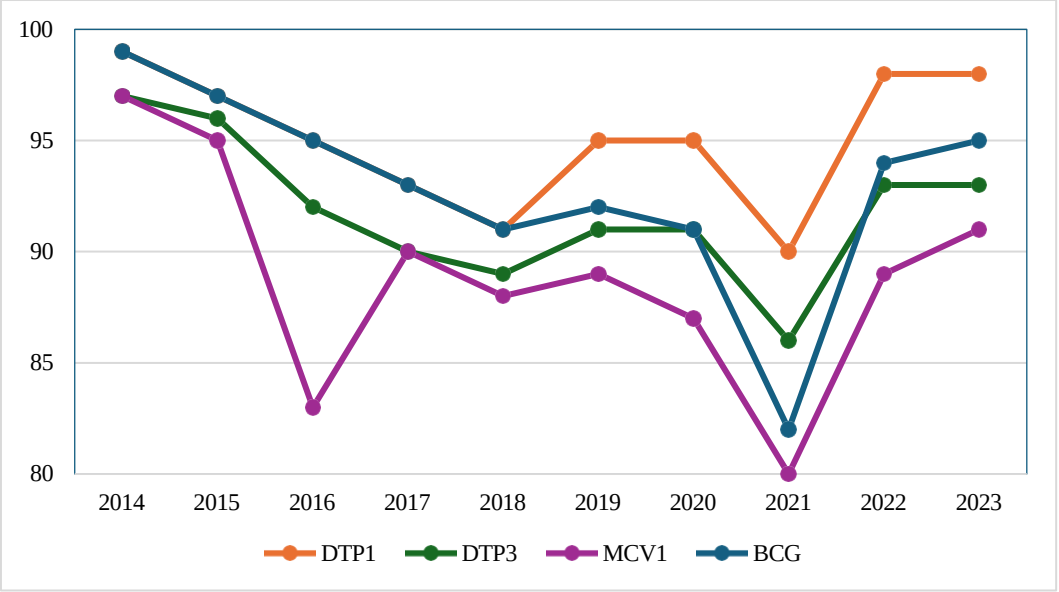
APPENDICES

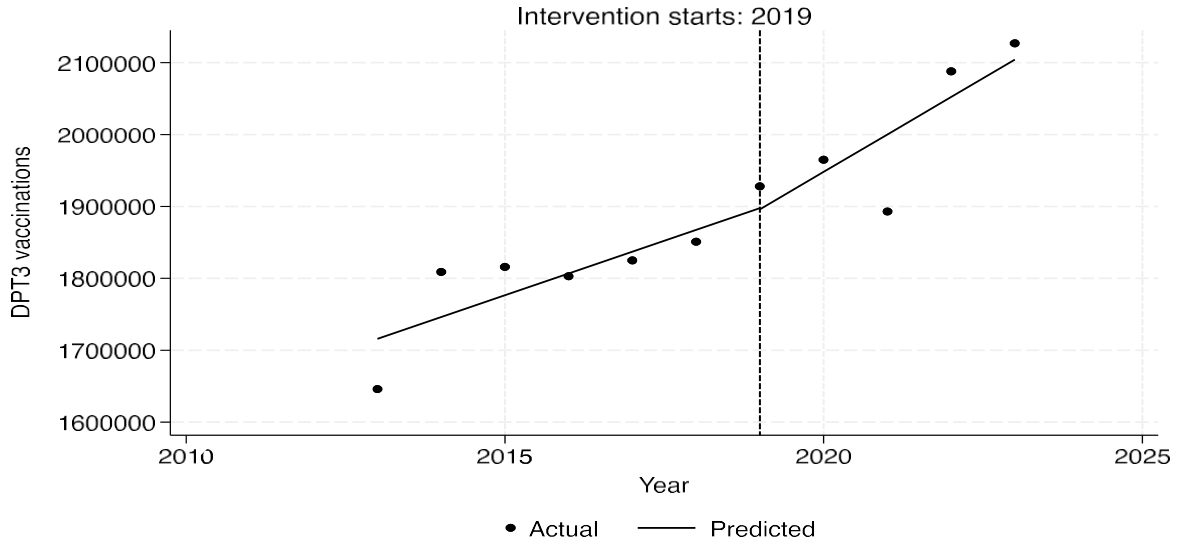


Appendix 1: Child basic immunisation trend in Tanzania in percentage

Appendix 2: Segmented regression analysis for DPT3 vaccination

Variable	Intervention year 2018	*p*-value	Intervention year 2019	*p*-value
Intercept	1,709,400***	0.000	1,715,952***	0.000
Period (year)	35,200**	0.023	30,286**	0.012
Intervention (COVID-19)	-37,800	0.810	-16,667	0.974
Interaction	15,885	0.910	21,814	0.195
Post-intervention linear trend	51,087***	0.000	52,100***	0.000

*Note: Asterisk *** 0.01, ** 0.05 and * 0.1*



Appendix 3: Segmented regression analysis of DPT3 vaccinations for the 2019 intervention year