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Post-Campaign Evaluation of Diphtheria Vaccination Coverage in Somalia Following the 2025–2026 Outbreak Response

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Abstract

Background: Although a protective vaccine is available, diphtheria reemerged in Somalia starting in mid-2023, with an outbreak reported throughout the country in 2025. In response, the Federal Ministry of Health (FMoH) developed a diphtheria outbreak response plan in 2025, launching a vaccination campaign with the first round conducted on 16–20 December 2025 and the second round on 8–13 February 2026. The vaccination campaign was a mass public health push to rapidly deliver Pentavalent and Td vaccines to children in Somalia regardless of past vaccination status, to stop the diphtheria outbreak. During the campaign, under-5 children received Pentavalent vaccines, while 5–15-year-olds received Diphtheria and Tetanus (Td). This study aims to evaluate the post-campaign coverage of diphtheria vaccines in the three most stable states in Somalia, namely the Benadir region, Puntland, and Galmudug states. **Methods**: The post-campaign coverage survey (PCCS) was conducted from 18 to 21 July 2026 in Benadir, Galmudug, and Puntland states. A two-stage cluster sampling design was employed, whereby 362 clusters were randomly selected from a national sampling frame covering all accessible districts, villages, and nomadic areas across the three states. The sample size was calculated according to the WHO 2018 manual, resulting in the selection of 120 clusters and 1335 households from each state, culminating in a total of 4093 interviews and covering 9184 children. Surveys were carried out by 152 trained personnel equipped with the KoboCollect app for digital data collection. Ethical approval was obtained from the Somali National University Ethical Committee. **Results**: Among the children, 49.7% were aged 0 to <5 years, and 50.3% were aged 5 to 15 years. Weighted data indicated that 84.1% of children aged 0 to 15 years across the three states received at least one dose of the diphtheria vaccine during the campaign (95% CI: 80.4% to 87.2%). Among those vaccinated, only 25% of children under 5 years of age and 36% of children aged 5 to 15 years received two doses. Vaccination coverage varied significantly by state: Puntland reported the highest coverage at 93.9%, while Galmudug had the lowest at 75.4% (95% CI: 69.2–80.7%), and Benadir showed intermediate coverage at 80.3% (95% CI: 74.5–85.1%). Geographically, internally displaced persons (IDPs) and nomadic populations had the lowest coverage rates, at 71.9% (95% CI: 55.0–84.2%) and 72.6% (95% CI: 57.9–83.7%), respectively. The primary reason for children not being vaccinated was a lack of awareness about the vaccination campaign. **Conclusions**: Although the diphtheria outbreak response campaign achieved high overall vaccination coverage, important coverage gaps persisted among underserved populations and in Galmudug state. Future outbreak responses should prioritize equitable vaccine delivery, community engagement, and strengthening routine immunization services. Future PCCS surveys

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should apply locally informed design-effect assumptions to enhance the accuracy and efficiency of coverage estimates.

Keywords: vaccination; diphtheria outbreak; Somalia; conflict affected countries

1. Background

Diphtheria primarily affects children younger than 15 years of age, with the highest risk observed among individuals who are unvaccinated or immunocompromised [1]. Before the widespread introduction of vaccination, the disease was a leading cause of illness and death among children [2]. In Somalia, the disease resurfaced in mid-2023, underscoring persistent immunity gaps and vulnerabilities in outbreak detection, preparedness, and response [3]. Despite the availability of a protective vaccine, diphtheria has resurfaced in Somalia since mid-2023, which underscores considerable immunity gaps and weaknesses in the country's outbreak preparedness. By August 2025, Somalia had reported a total of 1811 suspected diphtheria cases and 89 deaths, resulting in an overall case fatality rate (CFR) of 5% [4]. The situation is exacerbated by the aid cut that interrupted the vaccination campaigns [5]. However, the reported distribution of diphtheria cases across Somalia may largely reflect differences in the performance of state-level health information and reporting systems. States with stronger health infrastructure, such as Puntland, are more likely to detect and report cases, whereas conflict-affected regions such as Hirshabelle, South West, and Jubaland may experience substantial underreporting [6]. Consistent with its comparatively stronger surveillance and reporting system, Puntland recorded 756 cases and 29 deaths, with the highest concentrations reported in Galkayo (384 cases, 8 deaths) and Garowe (237 cases, 7 deaths) [7]. Neighboring Galmudug state reported 112 cases and 6 deaths primarily in Galkayo and Hobyo. States with weak data reporting systems, in which large parts of the state are controlled by non-state actors, such as South-West State, registered 177 cases and 3 deaths; Hirshabelle state reported 23 cases and 1 death, while Jubaland confirmed 2 cases [7]. Somaliland reported cases in some areas [7].

Acknowledging the gravity of the situation, the Federal Ministry of Health (FMoH) of Somalia developed a Diphtheria Outbreak Response Plan in 2025. The plan was presented to Gavi, the Vaccine Alliance, and entailed a targeted approach in 50 high-risk districts. The vaccination campaign was launched with the first round in 2025, followed by a second round in 2026. The vaccination campaign was a mass public health push to rapidly deliver Pentavalent and Td vaccines to children in Somalia regardless of past vaccination status, to stop the diphtheria outbreak. During the campaign, under-5 children received Pentavalent vaccines, while 5–15-year-olds received Diphtheria and Tetanus (Td). These initiatives were crucial for combating diphtheria, aiming to safeguard vulnerable populations, bolster immunity, and enhance health resilience against Somalia's diverse challenges. In May 2026, the WHO Somalia Immunization Technical Advisory Group recommended a diphtheria post-campaign coverage estimation survey following WHO survey guidance [8], which would be conducted by an independent organization. The aim was to estimate, compare and classify diphtheria coverage attained after the 2025 and 2026 vaccination campaigns in three states in Somalia. In response to this call, an independent organization conducted a post-campaign coverage survey (PCCS) to assess the uptake of at least one dose of diphtheria-containing vaccine among children aged 0 to 59 months and those aged 5 to 15 years who were targeted during the immunization campaign. The survey was implemented in Puntland, Galmudug, and the Benadir region, where security conditions permitted reliable data collection. Both quantitative and qualitative data were gathered,

including information on the reasons for non-vaccination. The findings provided a comprehensive evaluation of the campaign's planning, implementation, and reach, generating valuable evidence to inform future vaccination strategies.

2. Methodology

2.1. Survey Setting

The PCCS was conducted in Puntland and Galmudug states and the Benadir region. We included all districts targeted during the diphtheria vaccination campaign in 2025 and 2026. We also included remote and hard-to-reach areas, such as nomadic populations, IDPs and underserved communities in rural areas.

We ensured that every person in the target districts has a non-zero probability of being selected. To obtain our sample, we used a sampling frame that was provided by the WHO country office. The sample frame had a complete list of clusters in the three states, except 2 inaccessible districts located in Galmudug (Elbur and Galhareri). The entire districts in Puntland and Benadir states were accessible and included in the PCCS.

In addition, in the Benadir region, three accessible districts, Darussalam, Gubadley, and Garasbaley, had no pre-existing clusters in the sampling frame despite being covered by the vaccination campaign. To address this gap, we collaborated with local authorities to create clusters using administrative maps (15 clusters in Darussalam, 11 in Gubadley, and 13 in Garasbaley). Based on administrative boundaries and in consultation with district administrators, we then randomly selected clusters from these newly established frames for the survey.

2.2. Survey Population

Our target population was all children aged <5 years and 5 to 15 years in three states covered by immunization campaign for at least one dose of diphtheria vaccine. We interviewed parents/caregivers over 15 years old, living in selected districts, and who consented to participate in the survey. Parents or caregivers younger than 15 years, and those who did not consent to participate, were excluded from the survey.

This study utilized a quantitative method to estimate, compare and classify vaccination coverage attained after a diphtheria vaccination campaign in the aforementioned three states. The survey followed a two-stage cluster sampling methodology, consistent with the WHO guidelines for post-campaign coverage evaluation [8]. A structured questionnaire was designed to systematically collect data on geographic, demographic, and socio-contextual factors, along with public perceptions and communication practices related to immunization. Prior to full-scale deployment, a pilot study involving 129 interviews was conducted to evaluate the questionnaire's structure, response validity, and technical functionalities, including skip logic and filter mechanisms, leading to refinement before finalization. The final Somali version of the tool was used to collect the data from the respondents. To standardize data collection, responses related to vaccination status were categorized as "Yes" (received), "No" (not received), or "Do not know " (uncertain about receipt).

Indicators	Parameters Used for the Calculation
Number of strata = 3	Coverage estimates of diphtheria campaign
Expected coverage falls 50–70%	Number of respondents required to estimate the coverage for a simple random sample to be done. This number is derived with the assumption that expected coverage is 50%–70% and with desired precision of 5% (WHO manual 2018)

Indicators	Parameters Used for the Calculation
Desired precision = 5%	To inflate the number of respondents to achieve the same level of precision, taking 10 as the target number of respondents per cluster, ICC of 0.167, and adjusting the variation due to survey weight as 0.5
Effective sample size = 401	
Design effect = 3	
Average number of households to find an eligible child = 1	Three parameters: crude birth rate, infant mortality rate and household size from different literature (DHS-2020, World Bank, and UNICEF)
Non-response rate = 1.11	As there is no similar survey available, we used an estimate of 10%
Total number of completed interviews = 3609	Multiplication of three parameters: number of strata, effective sample size, and design effect
Total number of HH to visit = 4006	Multiplication of total number of completed interviews required, average number of HH to visit to get an eligible child, and non-response rate
Total number of HH to visit per stratum = 1335	Multiplication of sample size, design effect and average number of HH to visit to get an eligible child and total number of completed interviews required
Total number of clusters per stratum = 120	Three parameters were used: effective sample size, design effect and target number of respondents
Total number of HH per cluster = 11	It is the outcome of the average number of HH to visit to get an eligible child, non-response rate and target number of respondents.
Total number of clusters = 360	This is the product of the total number of clusters per stratum and the number of strata

2.3. Sampling Procedure

The survey used a two-stage cluster sampling methodology, aligning with WHO guidelines for post-campaign coverage evaluation [8]. For the first stage of selection, a total of 362 enumeration areas (EAs) were randomly selected from a sampling frame nationwide. The primary sampling unit (PSU) of our survey was the enumeration areas (EAs), or clusters. About 120 EAs were selected randomly from each state. Supervisors and enumerators systematically numbered households with eligible children within each cluster to create comprehensive lists that would facilitate the random selection of households using simple random sampling techniques. This numbering process was completed on the day before the survey. We used the WHO survey report checklist and the PRICSSA guideline [8]. For the second stage of selection, a simple random sampling method was employed to choose households within each enumeration area/cluster (the randomization process is explained below).

2.4. Composition of the Survey Team and the Training of the Fieldwork Teams

The survey was managed by a Project Manager who, in close consultation with the project leader and two co-leaders, oversaw its overall coordination and management. State-level supervisors and district supervisors were responsible for managing the survey in their respective states and districts, ensuring its quality through extensive visits to randomly selected clusters. A two-phase comprehensive refresher training program was provided to the field team, which included state coordinators, district supervisors and enumerators. A total of 152 trained personnel, including state coordinators, district supervisors, and enumerators, were deployed across the three states (Table 1). State and district supervisors oversaw operations within their designated strata, ensuring adherence to established protocols and timelines.

Table 1. Number of teams disaggregated by state.

Position	State/Administration			Total
	Puntland	Benadir	Galmudug	
District Supervisors	18	20	5	43
State coordinator	1	1	1	3
Enumerators	36	40	30	106
Total	55	61	36	152

2.5. Data Collection

The vaccination campaign was implemented on 16–20 December 2025 and 8–13 February 2026, with the evaluation survey conducted from 18 to 21 July 2026 across the three states. A team consisting of two enumerators and a district supervisor was formed to conduct pre-survey visits to the selected clusters within each district in Benadir region and Puntland state, two days prior to the survey commencement, while six enumerators and a supervisor were deployed in Galmudug state.

To monitor data collection across all regions, we implemented a real-time monitoring system using KoboCollect GPS coordinates, v2025.2.3. The system verified the locations of sampled settlements and households, supporting data validation and quality assurance. It enabled supervisors to identify and address data quality or completeness issues promptly and take corrective action when needed. All eligible children in selected households were included in the survey. For each child, vaccination cards were reviewed and photographed, and parents' reports were documented.

2.6. Data Analysis

Prior to data analysis, we conducted data management tasks to ensure the information collected was complete, accurate, and consistent. This included creating new variables and assigning value labels. We used frequencies, cross-tabulations, and descriptive statistics to identify outliers. Survey weights were then applied to estimate vaccination coverage across the three states and overall. Cluster and household weights were calculated according to the methodology and formula described in the WHO Vaccination Coverage Cluster Survey 2018 guidelines [8].

In the analysis phase, descriptive statistics, including frequency counts and proportions, enabled us to summarize the general attributes of the sample. Conversely, inferential statistics were used to estimate general vaccine coverage, featuring point estimates and confidence intervals (Wilson 95% Confidence Intervals), with the application of survey weights. Sampling weights and appropriate commands (e.g., *svy* in Stata) were used. Results were systematically presented in tables and figures, offering a clear visual interpretation of the data. All analyses were conducted using STATA software version 18, ensuring robust and reliable statistical computation.

2.7. Calculation of Survey Weight

In this survey, design weights were computed for every EA and household selected to participate in the survey. The design weight is the inverse of the probability of selecting a household to be interviewed.

The design weight was calculated using the following formula:

$$\text{Household weight for household i} = \frac{1}{\textit{Probability household i was selected into the samples}}$$

The samples were selected through a two-stage process; therefore, the overall probability of household *i* will be the product of the selection probabilities at each stage.

In the first stage, 120 PSUs were selected from every state (stratum).

The probability of selecting PSU_i in stratum h is:

$$P_1 = \frac{PSU_h}{\sum PSU_h}$$

where PSU_h is the number of PSUs to be selected in stratum h and $\sum PSU_h$ is the total number of PSUs in stratum h.

In the second stage, a fixed number (11) of households (SSUs) was selected from each sampled cluster.

The probability of selecting SSUi from PSUi in stratum h is:

$$P_2 = \frac{q}{m}$$

where q is the fixed number of households in PSU_i in stratum h and m is the total number of households in PSU_i in stratum h. Therefore, the household weight will be:

$$Household\ weight = \frac{1}{P_1 * P_2}$$

During the analysis, we carefully considered the following aspects:

a. Sample Description: We used unweighted data to present key demographic information such as gender, literacy levels, decision-making related to vaccination, and reasons for non-receipt of diphtheria vaccines.
b. Overall Coverage: Weighted data was employed to estimate the coverage of diphtheria vaccinations among children under 5 years and those aged 5 to 15 years, applying Wilson 95% confidence intervals for precision.
c. Coverage Verification: Vaccination coverage was validated by analyzing both card records and caregiver recall, using weighted and unweighted data as appropriate.
d. Demographic Analysis: Coverage estimates were further stratified by sex, age groups, and geographical classifications including rural, pastoralist, and urban areas, with weighted Wilson 95% confidence intervals applied.
e. Social and Behavioral Factors: We examined drivers of vaccination uptake using weighted data.

2.8. Ethics

Because survey participation must be exclusively voluntary, freedom to participate was given to participants without any coercion, while the confidentiality of their information was assured to them. Lastly, after they fully understood what was taking place in the study, informed oral consent was obtained from each participant. In addition, the research protocol was approved by the ethical committee of the Somali National University (Number: JUS/KCC&CT/2040/2026). We ensured the removal of all personally identifiable information by anonymizing the data. Pictures were deleted from personal devices and saved on institution-owned, password-protected devices accessible only to the study team. These images will be deleted one year after the report is submitted.

2.9. Study Limitations

- In cases where a vaccination card was unavailable during the interview, the data on vaccination coverage was based on the mother's or caregiver's report. This reliance on personal recollection can introduce recall bias, as the respondents may not accurately remember the vaccination details.
- The survey was conducted approximately five months after the completion of the vaccination campaigns. Combined with the typically low rate of vaccination card

retention in Somalia, these circumstances necessitated relying on parental/caregivers' recall for some respondents, which is susceptible to recall bias.

- The survey covered only accessible areas of Galmudug State. The two inaccessible districts were not in the sampling frame at all; therefore, the study findings do not represent populations residing in those districts.

3. Results

The achieved number of clusters and families interviewed was slightly higher than planned (calculated) because of field implementation factors. We conducted interviews with 4093 families, living in 362 clusters, covering 9184 children across three states (Benadir, Puntland and Galmudug). Among these children, 46.43% were girls and 53.57% were boys. The proportions of children aged under 5 years old and those aged 5 to 15 years were equal, each representing 50% of the study population.

Most children (67.25%) lived in urban areas, followed by 19.26% in rural areas, with 9.44% and 4.05% residing in nomadic areas and IDP camps, respectively (see Table 2).

Table 2. Participants by settlement.

Type of Settlement	Freq.	Percent	Cum.
IDP/Refugee	372	4.0	4.0
Nomadic	867	9.4	13.5
Rural	1769	19.3	32.8
Urban	6176	67.3	
Total	9184	100	

In Puntland, 77.78% of participants were vaccinated within a 30 min walk from home, compared to 60.46% in Galmudug and 40.15% in Benadir, where 32.05% traveled over an hour on foot (see Table 3).

Table 3. Distance to vaccination site by state.

Distance	Stratum (State)			
	Banadir	Galmudug	Puntland	Total
<30 min	40.2	60.5	77.8	68.0
30–60 min	27.8	29.7	15.7	20.3
>1 h	32	9.9	6.6	11.7

Table 4 shows that over half of nomads walked 30 min or more for vaccination, with 27.78% traveling over an hour to reach the site.

Table 4. Distance to vaccination site by settlement.

Distance	Settlement Type				
	IDP/Refugee	Nomadic	Rural	Urban	Total
<30 min	57.5	48.6	87.1	63.9	68.0
30–60 min	37.5	23.6	8.2	23.2	20.3
>1 h	5.0	27.8	4.7	12.9	11.7
Total	100	100	100	100	100

Diphtheria Vaccine Coverage

As shown in Table 5, 0.91% of participants did not know whether their child had received the diphtheria vaccine during the campaign. Furthermore, 15.43% reported that their child had not been vaccinated.

Table 5. Vaccine coverage (Unweighted).

Did the Child Receive Diphtheria Vaccine in 2025–2026?	N	%
Do not know	84	0.91
Not vaccinated	1417	15.43
Yes, vaccination card not seen	5909	64.34
Yes, vaccination card seen	1774	19.32
Total	9184	100%

Notably, 84 participants (0.91%) did not know whether their child had received the diphtheria vaccine during the campaign. Therefore, these participants were excluded from the weighted analysis presented in Table 6, resulting in a total analytical sample of 9100 participants.

Table 6. Diphtheria vaccination coverage (weighted).

	(%)	95% CI (%)	StdErr (%)	DEFF	ICC	N	Weighted N
Three states	84.1	(80.4,87.2)	0.02	20.96	0.45	9100	9115
Banadir	80.3	74.5,85.1	0.03	13.55	0.35	2815	5128
Galmudug	75.4	69.2,80.7	0.03	13.71	0.52	3009	1090
Puntland	93.9	90.7,96.1	0.01	10.69	0.27	3276	2898

The weighted analysis showed that 84.1% of children across the three states received at least one dose of the diphtheria vaccine during the campaign (CI: 80.4–87.2%). Coverage varied significantly by state: Puntland had the highest at 93.9%, Galmudug the lowest at 75.4% (CI: 69.2–80.7%), and Benadir was 80.3% (CI: 74.5–85.1) (see Table 6).

As shown in Table 7, IDPs (71.9, CI: 55.0–84.2) and nomads (72.6, CI: 57.9–83.7) had the lowest coverage of diphtheria vaccine in the three states. There is no significant difference in vaccine coverage between males and females, nor between the two diphtheria antigens administered to children under 5 years and those aged 5 to 15 years.

Table 7. Diphtheria vaccine coverage by geography, age category, sex and literacy (weighted).

Background Characteristics	Children Receiving Diphtheria Vaccine	
Geographic	%	95% CI
IDP/refugee	71.9	55.0–84.2
Nomadic	72.6	57.9–83.7
Rural	87.2	82.1–91.1
Urban	84.3	79.9–87.9
Gender		
Female	82.39	76.9–86.8
Male	84.32	80.9–87.2
Age group		
<5 years	84.25	80.2–87.6
≥5 years	82.73	78.2–86.5
Literacy		
cannot read and write	75.3	69.4–80.4
can read and write	87.61	84.2–90.4

The overall vaccination card seen rate was 19% (CI: 14.84–23.88%). Puntland had the highest rate at 30.44% (CI: 21.50–41.16%), while Benadir had the lowest at 9.24% (CI: 5.72–14.61%) (see Table 8).

Table 8. Diphtheria vaccine validation by state (weighted).

Background Characteristics	By Card		By Recall		Total
	%	95% CI	%	95% CI	N Weighted
Three states	18.95	14.84–23.88	81.05	76.12–85.16	7662
State					
Banadir	9.24	5.72–14.61	90.76	85.39–94.28	4119
Galmudug	29.53	21.18–39.52	70.47	60.48–78.82	821
Puntland	30.44	21.50–41.16	69.56	58.84–78.50	2722

Unexpectedly, nomads exhibit the highest card seen rate at 34.86% (CI: 16.81–58.64), followed by urban residents at 19.02% (CI: 14.40–24.70). In contrast, internally displaced persons (IDPs) have the lowest card seen rate, at 13.4% (CI: 2.98–43.83) (see Table 9).

Table 9. Diphtheria vaccine validation by geography, age category, sex and literacy (weighted).

Background Characteristics	Vaccination Card Seen		Recall	
	%	95% CI	%	95% CI
Geographic				
ID/refugee	13.4	2.98–43.83	86.6	56.17–97.02
Nomadic	34.86	16.81–58.64	65.14	41.36–83.19
Rural	16.81	8.95–29.33	83.19	70.67–91.05
Urban	19.02	14.40–24.70	80.98	75.30–85.60
Gender				
Female	18.27	14.19–23.19	81.73	76.81–85.81
Male	19.53	15.18–24.76	80.47	75.24–84.82
Age group				
Under 5 years	23.2	18.13–29.17	76.8	70.83–81.87
Over 5 years	15.34	11.68–19.88	84.66	80.12–88.32
Literacy				
cannot read and write	14.65	9.52–21.86	85.35	78.14–90.48
can read and write	20.45	15.84–25.99	79.55	74.01–84.16

Table 10 shows that 59.78% of children in the three states received one dose of the diphtheria vaccine during the 2025 and 2026 campaigns (CI: 52.84–66.35), while 31.10% (CI: 25.01–37.91) received two doses. Additionally, 9.12% were unsure about the number of doses. Internally displaced persons (IDPs) and nomadic communities had the lowest two-dose coverage.

Nearly half of the clusters had 100% coverage for diphtheria vaccines, while 37.85% had coverage between 50% and 99.9%, and 12.43% had coverage below 50%.

Figure 1 showed the proportion of children vaccinated against diphtheria in each survey cluster. A total of 9184 children were surveyed across 362 clusters. Of these, 180 clusters achieved full coverage, 137 clusters had coverage between 50% and 99.9%, and 45 clusters had less than 50% coverage, with 16 of them having zero coverage. Of these, 14 are located in South Mudug, while the remaining two are in the Galgudud region, both within Galmudug state.

Regarding the reasons for not vaccinating children by settlement, the most commonly reported reason across all groups was "Did not know about the campaign," except for IDPs,

whose primary reason was "Vaccine not available at the site." This was also the second most cited reason among Nomads, Urban, and Rural communities (see Table 11).

Table 10. Diphtheria vaccine dose by state, geography, age category, sex and literacy (weighted).

Background Characteristics	One Dose		Two Doses		Don't Know
	%	95% CI	%	95% CI	%
Somalia	59.78	52.84–66.35	31.10	25.01–37.91	9.12
State					
Banadir	48.52	39.29–57.86	37.70	28.53–47.85	13.78
Galmudug	78.60	67.45–86.69	20.36	12.34–31.70	1.04
Puntland	71.13	61.43–79.22	24.35	17.27–33.16	4.52
Geographic					
ID/refugee	71.59	44.14–88.93	19.5	7.42–42.42	32.13
Nomadic	46.18	28.09–65.33	36.11	18.80–57.98	17.71
Rural	55.37	41.05–68.86	39.40	27.06–53.26	5.22
Urban	60.56	52.45–68.13	29.89	22.99–37.84	9.55
Gender					
Female	60.09	52.78–66.98	30.53	24.09–37.84	9.38
Male	59.51	52.42–66.23	31.58	25.31–38.59	8.91
Age group					
Under 5 years	66.84	60.04–73.00	25.02	19.69–31.24	8.13
Over 5 years	53.77	45.73–61.62	36.26	28.78–44.47	9.96
Literacy					
can read and write	60.89	52.95–68.29	30.40	23.25–38.40	5.71
cannot read and write	59.39	51.39–66.93	30.29	23.25–38.40	10.31

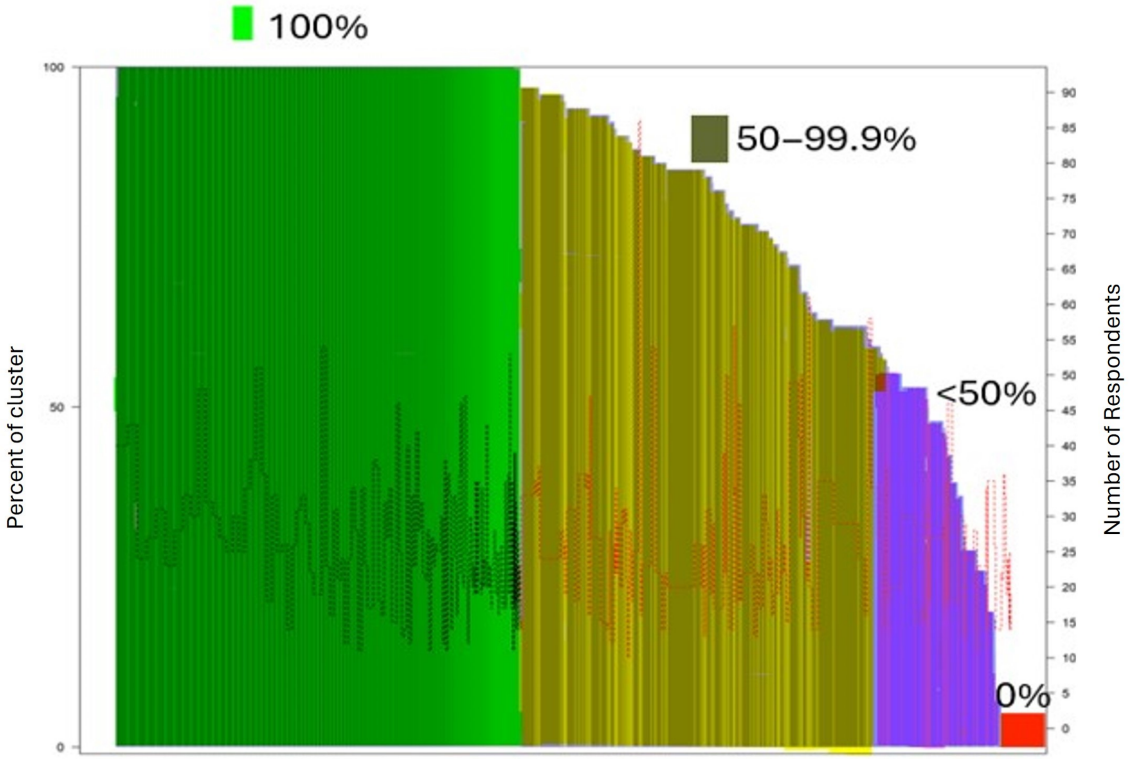


Figure 1. Children in each survey cluster who received the Diphtheria vaccine. **Explanation:** A thin golden line indicates the number of children sampled per cluster. Colors represent vaccination coverage: green for 100%, olive for 50% to 90.9%, purple for less than 50%, and red for no children vaccinated.

Table 11. Reason for not vaccinating the child by type of settlement (unweighted).

Reason for Not Vaccinating the Child	IDP/Refuge	Nomadic	Rural	Urban
Fear of side effects	10.19	2.46	4.14	5.09
Did not know about the campaign	25	40.85	18.05	41.34
Confused with other vaccines	0	0.35	0	2.47
Parent/Guardian was missing	3.7	1.41	6.8	9.9
Fear of injections	10.19	3.17	0.89	3.78
Lack of confidence in the vaccine	6.48	6.69	15.98	4.37
Site of vaccination was not known	0.93	5.99	16.27	0.87
Vaccination hours unsuitable	4.63	3.52	0.89	1.02
Waited too long at the site	0	0.7	0.3	0.44
Site of vaccination too far	0	6.34	24.85	0.44
Vaccine not available at the site	38.89	34.51	13.31	9.17
Missing vaccinator at the site	0	0	4.14	6.26
Not authorized by head of household	0	0	0.89	3.35
Religious beliefs	0	0	0.59	0.15
Child was sick at time of vaccination	3.7	1.41	2.66	2.47
Absent/traveling during the	5.56	1.76	4.73	3.2
Too busy to take child	2.78	0.35	1.48	2.77
Parent/caregiver was sick	0	0	0.3	0.58
Others	0.93	1.06	4.14	6.84

4. Discussion

The overall campaign-related diphtheria vaccination coverage was 84.1%, indicating that a substantial proportion of children in the three surveyed states were vaccinated with at least one dose. It is important to highlight that these states, along with Somaliland, are among the most peaceful and stable regions in Somalia [9]. The high post-campaign diphtheria vaccine coverage in these stable states is encouraging. However, significant portions of the country's southern states, where outbreaks occurred, remain unstudied. Notably, all 16 clusters reporting no vaccination are in Galmudug. This vaccine coverage pattern, which has been observed previously in Somalia, underscores substantial disparities in vaccination coverage across states [9]. For example, Puntland achieved coverage exceeding 93% while other states in this study continue to lag behind. Therefore, Puntland's success offers hope that other Somali states can also attain substantial coverage by sharing best practices.

Regarding settlements, vaccine coverage among IDPs (71.9%) and Nomads (72.6%) is significantly lower compared to rural and urban populations. Their coverage rates fall well below the overall vaccine coverage of 84.1% observed across the three states, highlighting a concerning gap in reaching some of the most vulnerable groups. A similar pattern was seen earlier in measles vaccination in Somalia [9]. Nomads in Somalia are known to have lower access to healthcare than other groups in the country [10]. This disparity exacerbates existing inequities in vaccine access and underscores the urgent need for targeted immunization efforts within these communities.

Similar to previous PCCS findings for measles vaccination in Somalia [9], one of the primary reasons for children not being vaccinated was a lack of awareness about vaccination campaigns. This represents a significant public health challenge, highlighting the urgent need for a well-coordinated national community sensitization and awareness campaign prior to vaccination. Such a campaign should focus on educating families about upcoming vaccination efforts and emphasizing the benefits of immunizing their children. By effectively disseminating this information, families will be better informed of the importance of vaccinations, which can ultimately lead to higher participation rates [11,12]. Furthermore, this awareness campaign could also help address and reduce several other

barriers to vaccination identified in this study, creating a synergistic effect in improving overall vaccine uptake.

Although the design effect observed in this study is significantly lower than what was reported in the 2025 measles PCCS [9], it still remains a concern. Notably, the design effect used for calculating the PCCS sample size was 3, whereas the design effect calculated from the study results is substantially higher at 20.96. The reason for this unexpectedly large design effect is unclear. One possible explanation is that individuals within the same cluster, whether pastoralist, urban, or rural, tend to be more similar to each other, a theory supported by the high intra-cluster correlation (ICC) value. However, the true cause of this large design effect remains uncertain and warrants further investigation.

5. Conclusions

This PCCS found that over four in five children received at least one dose of diphtheria vaccine during the outbreak response campaign, although coverage varied substantially across states and population groups. The findings demonstrate that reactive vaccination campaigns can achieve high coverage in emergency settings, but important immunity gaps remain that may sustain transmission and contribute to future outbreaks. To strengthen outbreak prevention and control, vaccination efforts should prioritize areas with lower coverage, enhance community engagement and risk communication, and improve access to vaccination services for underserved populations. Strengthening routine immunization systems and implementing timely catch-up activities are also essential to prevent the accumulation of susceptible children. From a survey implementation perspective, future PCCS in Somalia should consider using more realistic assumptions for the design effect based on local experience to optimize sample size requirements and resource utilization. Efforts should also be made to improve card-seen rates through better retention of vaccination cards, caregiver education, and strengthened vaccination record systems, thereby reducing reliance on caregiver recall and improving the accuracy of coverage estimates.

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Informed Consent Statement: Participants consented to participate.

Data Availability Statement: Data available on request due to privacy/ethical restrictions.

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