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Contributions of the Measles Follow-Up Vaccination Campaign to Improving the Vaccination Coverage of Children Aged 6 - 59 Months in the Democratic Republic of the Congo in 2019

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Abstract

Background: In accordance with its measles elimination strategic plan 2012-2020, the Democratic Republic of the Congo (DRC) organized a follow-up vaccination campaign against measles from October to December 2019 in 26 provinces. This study aims to establish the contribution of this supplementary vaccination campaign to protecting children against measles. **Methods:** The survey was carried out in November 2020 among households of the DRC, according to the 2018 revised version of the World Health Organization's stratified cluster sampling method, using multiple stage sampling. It targeted 280 children aged 6 - 59 months per stratum or province, with 10 children in each of the 28 selected clusters. Data collection using tablets with centralized and real-time data processing was preceded by enumeration to refine the household sampling frame. Clusters and households were selected by random draw. Data collected with CS Pro 7 software were analyzed with SPSS, Epi info 7 and Excel software to determine indicators and make before-after comparisons using the McNemar test, at a precision threshold of 5%. **Results:** Of the 8535 surveyed children, 89.5% were vaccinated

during the follow-up campaign and 81.6% were vaccinated before. Only 3.7% had correctly completed campaign vaccination cards. Estimated vaccination coverage increased from 80.8% before the campaign to 92.6% after the campaign ($p \ll 0.001$). Vaccination coverage after campaign against measles improved in all provinces ($p < 0.001$) except Bas-Uele and Maniema. Thirteen provinces reached the national coverage target of 95%, compared to five before the campaign. The proportion of zero-dose children dropped significantly after this campaign from 19.2% to 7.4% ($p \ll 0.001$), and even fell below 1% in six provinces. **Conclusion**: This measles vaccination campaign improved overall vaccination coverage by 10% and reached more unvaccinated children. Efforts must continue to improve the retention of vaccination card, the adherence of unvaccinated children and the effectiveness of routine vaccination.

Keywords

Measles, Democratic Republic of the Congo, Child under 59 Months, Vaccination Campaign

1. Introduction

Measles is a highly contagious infectious disease that still causes many cases and deaths each year, despite the existence of an effective vaccine since 1960. It is most prevalent in developing countries, particularly in sub-Saharan African countries [1]. The Democratic Republic of the Congo is also concerned, especially in 2019 when 253 health zones were in measles epidemic and 311,471 suspected cases, including 6045 deaths, were reported, compared with 45,165 and 65,098 suspected cases in 2017 and 2018 respectively. These numerous cases are recorded while from 2017 to 2019, the administrative vaccination coverage varied between 91% and 92% [2].

Between 2000 and 2015, the reported annual global incidence of this disease fell by 75%, from 146 to 35 cases per million population, and the number of deaths was down by 79% [1].

During the decade 2000-2010, overall immunization coverage for the first dose of measles vaccine increased from 72% to 85%, remaining between 84% and 86% over the period 2010-2019 [3] [4]. Supplementary immunization activities have contributed to these results as in 2015, they immunized 184 million people against measles [3].

Based on the vaccine's effectiveness and successes, the World Health Organization has included vaccination as a central pillar of the global measles elimination action plan adopted in 2012. This plan has been translated into regional or national elimination plans in each WHO region and country, with the goal of eliminating measles and rubella in five of the six WHO regions by 2020 [5]. Measles elimination strategies include achieving 95% or higher coverage with two doses of routine measles vaccine and the implementation of supplementary

immunization activities in areas with low coverage or high-risk populations [1]

Although measles vaccination has saved millions of lives, data indicate that progress towards the elimination goal has slowed since 2010 [3].

The Democratic Republic of the Congo (DRC) is also affected by this situation since, despite the significant progress recently made in the fight against vaccine-preventable diseases, it is experiencing persistent circulation of the measles virus with the frequent appearance outbreaks in several provinces in recent years. In accordance with the resolution of the WHO Regional Committee for the African Region, adopted in November 2011 and its 2012-2020 national strategic plan for measles elimination, the country systematically organizes, every three years, a national measles follow-up vaccination campaign program throughout its territory [6]. This campaign enables the country to offer a second opportunity to unvaccinated or under-vaccinated children and to protect all children, particularly susceptible ones.

After the 2016 edition, the Ministry of Health, supported by its partners including the World Health Organization (WHO), the United Nations Children's Fund (UNICEF) and the Global Alliance for Immunization and Vaccines (GAVI), organized a new edition of the national measles follow-up vaccination campaign from October to December 2019 in the 26 provinces. This study is part of the post-campaign survey prescribed by the WHO to ensure the quality of the said campaign and the effectiveness of target achievement [7]. It aims to determine the contributions of this follow-up measles vaccination campaign to the vaccination coverage of children in the DRC in 2019.

2. Study Methods

2.1. Survey Framework

The cross-sectional survey took place in the 26 provinces of the DRC. In each province, the collection took place in the villages/neighborhoods/avenues of the enumeration areas which are subdivisions of almost equal size defined by the National Institute of Statistics during the 2017 MICS-Palu survey. All areas, which constitute the clusters, benefited from the measles follow-up vaccination campaign during October to December 2019.

2.2. Type and Population of the Study

This is a descriptive cross-sectional study with an analytical aim. It is a quasi-experimental study with a before-after comparison of measles vaccination data for children aged 6 - 59 months during the campaign.

Study is made up of children aged 6 - 59 months from households covered by the measles campaign carried out from October to December 2019. In the households, the children's parents/caregivers were interviewed on the various aspects of the campaign to assess children's immunization status.

The only inclusion criterion was the presence in the household of a child aged 6-59 months at the time of the campaign.

2.3. Sampling and Sample Size

It is a household survey carried out in accordance with the approach prescribed by the WHO [8]. This is a multistage stratified cluster survey in which each of the 26 provinces was a stratum and the location of the cluster, urban or rural, was considered.

The sampling was carried out with the support of the National Institute of Statistics (INS). The sample was constituted by systematic random selection of enumeration areas constituting the clusters or primary sampling units (PSU), at the first stage, then by simple random selection of households, at the second stage. The children found in the selected households were all enrolled. The number of clusters to be surveyed in a province was distributed between urban and rural settings, proportionally to the population size of the health zones.

The sampling frame used for the survey was updated and refined through enumeration by an independent team to determine the enumeration areas or clusters, and then identify and number the households in the selected clusters.

Calculated by considering the expected vaccination coverage target of 95% for the vaccination campaign, a desired precision of the estimate of ±7%, the statistical confidence level of the estimate of 95%, a non-response rate of 15%, an intra-cluster coefficient of 1/6, a number of at least 10 targets per cluster (in 15 households) and a cluster effect of 2.5, the minimum estimated sample size was 280 children, *i.e.* 420 households to be surveyed in each stratum. For the whole country, the minimum expected sample size was 7280 children in 728 clusters of ten (10) children each. Children fulfilling the inclusion criteria were enrolled exhaustively in each selected household.

Sample size calculation

- Minimum sample size = TEE * EPS = 110 * 2.503 = 275.33 (*i.e.*, approximately 280)

- Number of clusters = 280/10 = 28

- Number of households per cluster

$$= \frac{\text{Cluster size}}{\text{Household size} \times \%\ \text{eligible children}} \times \text{non response rate}$$

$$= 10/(5 \times 16\%) \times 1.18 = 14.75\ \textit{i.e.}\ (15)\ \text{households}$$

2.4. Data Collected and Organization of Collection

Information was collected from the parents/caregivers on the children's characteristics as sex, age during the campaign, place of residence, and their vaccination status before the campaign (routine vaccination) and after the campaign (routine or vaccination campaign). The vaccination campaign card and the vaccination record were the evidence collected on the vaccination status. Refusal or absence of a child was resolved by two household revisits.

The contribution of the campaign was assessed using the vaccination status (vaccinated or not vaccinated) of the children after the campaign versus before. It was positive when vaccination coverage increases or when the proportion of children not vaccinated against measles or "zero doses" decreased.

The collection was carried out using tablets/android phones used to collect the data via an entry mask designed with CS Pro 7.3 software.

2.5. Data Processing and Analysis

Data collection took place in a single phase, from November to December 2020. The data entered during collection and transferred to the warehouse are processed in real time by controllers to detect, document and eliminate inconsistencies and errors.

The data analyses, carried out with SPSS, Epi info 7 and Excel software, considered stratification (weighting) and the cluster effect. The weighting variable was integrated into the database for the calculation of the indicators, with a 95% confidence interval. These are the vaccination coverage before the campaign and after the campaign according to the history and the vaccination card, the proportions of zero-doses children for overall and according to children's characteristics. The ratio of the proportions of zero-doses before the campaign versus after the campaign was calculated to estimate the significance of change. A bivariate analysis was performed using the McNemar test to compare the estimated vaccination coverage before and after the campaign as well as the proportions of zero doses, at a significance level $p = 0.05$.

2.6. Ethical Considerations

The research protocol has received the favorable opinion of the National Ethics Committee of the Ministry of Scientific Research and the authorization of the National Institute of Statistics. The oral informed consent of the head of household and the respondent was obtained before administration of the questionnaire. The confidentiality and anonymity of the respondents were respected.

3. Results

3.1. Sample Description

The number of respondents during data collection was 8535 children, of whom 12 did not have complete information. The planned number of participants was reached and 100% of the clusters were covered in the 26 provinces.

• Distribution of participants according to their characteristics

Of the 8535 children, the groups that were most represented in relation to their characteristics were the males (51.5%), the 36 - 59 months age group (48.9%) and, at the time of the survey, those living in rural areas (78.9%). The surveyed children were often dependent on their mother (84.9%). The parents/caregivers of the children were often uneducated (40.6%) or had an education level not exceeding primary school (36.9%). They were married (87.4%) and practiced mainly catholic Christian religion (26.7%), Protestant (40.0%). More than nine out of ten respondents were followers of Christianity or "other Christians religious movements" (Kimbanguism, Jehovah's witnesses, the Anglican Church, and the revealed or evangelical churches) (**Table 1**).

Table 1. Distribution of respondents according to their socio-demographic characteristics during the 2019 measles follow-up vaccination post-campaign survey in the DRC (n = 8523).

Characteristics	Number	Proportion (%)
Sex		
Male	4388	51.5
Female	4135	48.5
Age during the campaign (months)		
12 to 23	910	10.7
24 to 35	2110	24.8
36 to 59	4170	48.9
6 to 11	80	0.9
60 months or more*	1253	14.7
Place of residence of the child		
Rural	6725	78.9
Urban	1798	21.1
Child's parent/caregiver		
Mother	7235	84.9
Father	624	7.3
Grandfather/grandmother	419	4.9
Others	245	2.9
Educational level of the parent/caregiver		
No level	3458	40.6
Primary	3145	36.9
Secondary	1663	19.5
Higher/university	255	3.0
Religion of the parent/caregiver		
Catholic	2277	26.7
Protestant	3411	40.0
Muslim	151	1.8
traditional	346	4.1
Without religion	207	2.4
Other (explain, list)	2129	25.0
Marital status of the parent/caregiver		
Single	520	6.1
Married	7447	87.4
Divorced/separated	282	3.3
Widower	272	3.2

*These targets were not eligible; there was either no compliance with the instructions of the campaign, or error on the age declared by the parents, especially since the survey took place more than six months after the campaign.

3.2. Campaign Vaccination Coverage

• Campaign vaccination coverage by card or history

Among the respondents, 89.5% were vaccinated during the follow-up campaign and 81.58% before ($p \ll 0.001$). The campaign vaccination coverage according to the card was 5.85% and 3.7% had a correctly completed card. Routine vaccination coverage according to the card (3.75%) was even lower among the respondents. (Table 2) Both for routine vaccination and the campaign, the vaccination coverage did not differ significantly according to the sex and the person in charge of the child.

Among respondents, vaccination coverage of the campaign was significantly higher among children vaccinated before the campaign (95.14%) than unvaccinated (64.71%) ($p \ll 0.001$). This was not the same for the child's place of residence, nor his sex, nor his age group, nor the caregiver, nor caregiver characteristics.

Before the campaign, children were more vaccinated in rural areas (82.56%) than in urban areas (77.92%) ($p \ll 0.001$).

3.3. Effect of the Campaign on Children's Vaccination against Measles

• Analysis of vaccination coverage by province before and after the campaign

The vaccination coverage of children aged 6 - 59 months, according to history or card, was estimated by considering the weighting of the units enrolled in the study. This estimated coverage for all children increased from 80.84% before the campaign to 92.56% after the campaign ($p \ll 0.001$).

Post-campaign vaccination coverage estimated according to card or history was high in the provinces of Kwango (99.73%), Haut-Uele (99.41%), Lomami (99.05%), North Kivu (98.95%), and low in the provinces of Ituri (67.07%) and Kasai Oriental (82.32%).

According to Table 3 below, except in Bas-Uele and Maniema, measles vaccination coverage improved significantly following the campaign ($p \ll 0.001$).

• Analysis of vaccination coverage before and after the campaign according to the socio-demographic characteristics of the children

Vaccination coverage after the campaign was significantly higher than before, regardless of the sex, age and residence place of the child. As before the campaign, measles vaccination coverage after the campaign was higher in rural areas (92.74%) than in urban areas (90.29%), among girls (93.23%) than in boys (91.96%), among children aged 24 months and older than among those aged under 24 months ($p \ll 0.001$). After the campaign, the number of provinces that reached the national coverage target of 95% was thirteen compared with five before the campaign, and only one province had coverage below 80% ($p \ll 0.001$) after the campaign compared with eight (*i.e.* nearly a third of the number of the provinces) before (Table 4).

• Effect of the 2019 measles follow-up vaccination campaign on zero-dose children in the DRC

Table 2. Vaccination coverage according to the card/record or the history of respondents by socio-demographic characteristics for routine vaccination (before the campaign) and for the 2019 measles follow-up vaccination campaign in the DRC.

Characteristics	Routine vaccination coverage			Campaign vaccination coverage			p-value
	Number (%)	Wilson 95% CI (%)		Number (%)	Wilson 95% CI (%)		
Vaccinated (n = 8523)							
Yes (story and/or card)	6953 (81.58)	80.74	82.39	7631 (89.53)	88.87	90.17	**≪0.001**
According to card only	320 (3.75)	3.37	4.18	499 (5.85)	5.38	6.37	**≪0.001**
According to correctly completed card				317 (3.72)	3.34	4.14	
According to the child's place of residence							
Rural (n = 6725)	5552 (82.56)	81.63	83.45	6046 (89.90)	89.16	90.60	**≪0.001**
Urban (n = 1798)	1401 (77.92)	75.94	79.78	1585 (88.15)	86.58	89.57	**≪0.001**
According to the sex of the child							
Male (n = 4388)	3566 (81.27)	80.09	82.39	3924 (89.43)	88.48	90.30	**≪0.001**
Female (n = 4135)	3387 (81.91)	80.71	83.05	3707 (89.65)	88.68	90.54	**≪0.001**
According to the age group of the child							
6 - 11 months (n = 80)	42 (52.50)	41.02	63.79	43 (53.75)	42.24	64.97	**≪0.001**
12 - 23 months (n = 910)	694 (76.26)	73.39	78.91	766 (84.18)	81.66	86.40	**≪0.001**
24 - 35 months (n = 2110)	1717 (81.37)	79.66	82.98	1907 (90.38)	89.05	91.56	**≪0.001**
36 - 59 months (n = 4170)	3495 (83.81)	82.66	84.90	3803 (91.20)	90.30	92.02	**≪0.001**
60 months or older (n = 1253)	1005 (80.21)	77.91	82.32	1112 (88.75)	86.88	90.38	**≪0.001**
According to the child's parent/caregiver							
Mother (n = 7235)	5905 (81.62)	80.71	82.49	6486 (89.65)	88.92	90.33	**≪0.001**
Father (n = 624)	510 (81.73)	78.51	84.57	553 (88.62)	85.89	90.88	**≪0.001**
Grandfather/grandmother (n = 419)	346 (82.58)	78.65	85.91	381 (90.93)	87.80	93.32	**≪0.001**
According to the education level of the child's parent/caregiver							
No level (n = 3395)	2707 (79.73)	78.35	81.05	3043 (89.63)	88.56	90.61	**≪0.001**
Primary (n = 3070)	2476 (80.65)	79.22	82.01	2738 (89.19)	88.04	90.24	**≪0.001**
Secondary (n = 1575)	1380 (87.62)	85.90	89.15	1417 (89.97)	88.39	91.36	**0.025 < p < 0.05**
Higher/university (n = 238)	198 (83.19)	77.83	87.71	222 (93.28)	89.31	96.11	**≪0.001**
According to the marital status of the child's parent/caregiver							
Single (n = 378)	280 (74.07)	69.43	78.23	328 (86.77)	82.98	89.82	**≪0.001**
Married (n = 7370)	6041 (81.97)	81.07	82.83	6618 (89.80)	89.08	90.47	**≪0.001**
Divorced/separated (n = 273)	224 (82.05)	76.97	86.42	236 (86.45)	81.81	90.27	<0.10
Widowed (n = 257)	216 (84.05)	78.99	88.30	238 (92.61)	88.70	95.49	**0.001 < p < 0.005**
According to vaccination status before the campaign							
Vaccinated before (n = 6953)				6615 (95.14)	94.61	95.62	**≪0.001***
Unvaccinated before (n = 1570)				1016 (64.71)	62.32	67.04	

n = sample size, *This is the comparison of two groups, "vaccinated before" and "unvaccinated before". This is not a "before and after" comparison.

Table 3. Distribution by province of estimated (weighted) vaccination coverage according to the card or history for before and after the 2019 measles follow-up vaccination campaign in the DRC.

Province	Before the campaign (%)			After the campaign (%)			p-value
	Weighted coverage	Wilson 95% CI		Weighted coverage	Wilson 95% CI		
Bas-Uele	87.62	87.49	87.76	87.82	87.68	87.95	$0.025 < p < 0.05$
Equateur	82.88	82.79	82.98	88.98	88.90	89.06	$\ll 0.001$
Haut-Katanga	85.97	85.91	86.02	98.39	98.37	98.41	$\ll 0.001$
Haut-Lomami	91.31	91.25	91.37	93.35	93.30	93.41	$\ll 0.001$
Haut-Uele	89.79	89.68	89.90	99.41	99.39	99.44	$\ll 0.001$
Ituri	49.33	49.25	49.41	67.07	67.00	67.14	$\ll 0.001$
Kasaï	61.45	61.37	61.52	88.52	88.47	88.57	$\ll 0.001$
Kasaï Central	90.05	90.01	90.09	96.87	96.85	96.89	$\ll 0.001$
Kasaï Oriental	68.79	68.72	68.85	82.32	82.26	82.37	$\ll 0.001$
Kinshasa	95.67	95.65	95.69	96.53	96.50	96.55	$\ll 0.001$
Kongo central	97.55	97.53	97.58	98.06	98.04	98.08	$\ll 0.001$
Kwango	97.89	97.86	97.93	99.73	99.72	99.74	$\ll 0.001$
Kwilu	85.07	85.01	85.12	96.99	96.97	97.02	$\ll 0.001$
Lomami	83.79	83.71	83.88	99.05	99.03	99.07	$\ll 0.001$
Lualaba	85.18	85.13	85.23	91.83	91.79	91.86	$\ll 0.001$
Maniema	94.68	94.64	94.73	94.70	94.66	94.75	$0.1 < p < 0.9$
Mayi-Ndombe	91.29	91.20	91.38	93.26	93.18	93.34	$\ll 0.001$
Mongala	79.01	78.94	79.09	83.14	83.07	83.20	$\ll 0.001$
Nord Kivu	49.68	49.59	49.76	98.95	98.93	98.97	$\ll 0.001$
Nord Ubangi	96.36	96.32	96.41	99.45	99.43	99.46	$\ll 0.001$
Sankuru	94.69	94.65	94.74	99.55	99.53	99.56	$\ll 0.001$
Sud Kivu	99.05	99.03	99.07	99.34	99.33	99.36	$\ll 0.001$
Sud Ubangi	75.96	75.87	76.05	93.48	93.43	93.53	$\ll 0.001$
Tanganyika	32.72	32.61	32.82	87.73	87.65	87.80	$\ll 0.001$
Tshopo	73.09	73.00	73.18	86.75	86.68	86.82	$\ll 0.001$
Tshuapa	82.91	82.81	83.02	95.81	95.76	95.87	$\ll 0.001$
DRC	80.84	80.83	80.86	92.56	92.56	92.57	$\ll 0.001$

The proportion of zero-doses among children aged 6 - 59 months decreased considerably after this campaign, falling below 1% in six provinces. At national level, grossly, it fell from 19.16% to 7.44% ($p \ll 0.001$), *i.e.*, a reduction of almost two thirds (Table 5).

In sixteen (16) provinces, the number of measles vaccine zero-doses before the campaign was halved or more after the campaign. Apart from Bas-Uele and Maniema provinces, the decrease was significant in all provinces. The largest decreases were noted in Nord-Kivu, Sankuru, Haut-Uele, Lomami, Kwango, Haut-Katanga, Nord Ubangi ($p \ll 0.001$).

Table 4. Estimated (or weighted) measles vaccine coverage according to card or history by socio-demographic characteristics of children before and after the 2019 measles follow-up vaccination campaign in the DRC.

Characteristics	Estimated vaccination coverage before campaign (routine)			Estimated vaccination coverage after the campaign			p-value
	Number (%)	Wilson 95% CI (%)		Number (%)	Wilson 95% CI (%)		
Vaccinated (N = 28,938,798)							
Yes (history/card)	23,394,499 (80.84)	80.83	80.86	26,787,151 (92.56)	92.56	92.57	≪0.001
Vaccinated according to the child's place of residence							
Rural (N = 26,882,451)	21,803,090 (81.11)	81.09	81.12	24,930,382 (92.74)	92.73	92.75	≪0.001
Urban (N = 2,056,347)	1,591,409 (77.39)	77.33	77.45	1,856,769 (90.29)	90.25	90.33	≪0.001
Vaccinated according to the sex of the child							
Male (N = 15,161,942)	12,036,143 (79.38)	79.36	79.40	13,942,591 (91.96)	91.94	91.97	≪0.001
Female (N = 13,776,856)	11,358,356 (82.45)	82.43	82.47	12,844,560 (93.23)	93.22	93.25	≪0.001
Vaccinated according to the child's age group							
6 - 11 months (N = 176,226)	83,806 (47.56)	47.32	47.79	110,836 (62.89)	62.67	63.12	≪0.001
12 - 23 months (N = 3,193,318)	2,357,087 (73.81)	73.76	73.86	2,864,164 (89.69)	89.66	89.73	≪0.001
24 - 35 months (N = 6,972,390)	5,643,287 (80.94)	80.91	80.97	6,496,071 (93.17)	93.15	93.19	≪0.001
36 - 59 months (N = 14,080,291)	11,820,993 (83.95)	83.94	83.97	13,214,409 (93.85)	93.84	93.86	≪0.001
60 months or more (N = 4,516,573)	3,489,326 (77.26)	77.22	77.29	4,101,672 (90.81)	90.79	90.84	≪0.001
Based on achievement of national measles coverage target (N = 26)							
≥95%	13 (50.00)			5 (19.23)			0.025 < p < 0.05
≥80% and <95%	12 (46.15)			13 (50.00)			0.1 < p < 0.9
<80%	1 (3.85)			8 (30.77)			0.01 < p < 0.025

N = estimated size of the population.

4. Discussion

4.1. Analysis of Campaign Results

Vaccination coverage by campaign card or history for the whole country, which was 89.53% among respondents compared to 81.58% ($p \ll 0.001$) for routine vaccination, indicates that the campaign target of 95% was not achieved. This campaign coverage is higher than the 38% measles-rubella coverage recorded by a mass campaign against cholera, polio, and measles-rubella among a displaced population and the 80.2% obtained by a vaccination campaign in rural areas of Tamil Nadu [9] [10]. Lower (68.6%) and similar (90.5%) coverage were reported by two post-campaign surveys conducted in India [11] [12].

Higher coverage was achieved in the vaccination campaign conducted in 47 counties in Kenya (95% (95% CI: 94% - 96%)) [13] and among children aged six months to 5 years in an area with a high prevalence of malnutrition in Niger (96%) [14].

Table 5. Distribution by province of the estimated proportion according to card or history of measles vaccine zero-dose before and after the 2019 measles follow-up vaccination campaign in the DRC.

Province	Estimated zero-dose before campaign (%)			Estimated zero-dose after campaign (%)				
	Number (%) C1	Wilson 95% CI (%)		Number (%) C2	Wilson 95% CI (%)		Ratio C1/C2	p-value
Bas Uele (N = 237,410)	29,382 (12.38)	12.24	12.51	28,926 (12.18)	12.05	12.32	1.02	0.025 < p < 0.05
Equateur (N = 579,116)	99,119 (17.12)	17.02	17.21	63,798 (11.02)	10.94	11.10	1.55	≪0.001
Haut-Katanga (N = 1,584,350)	222,310 (14.03)	13.98	14.09	25,493 (1.61)	1.59	1.63	8.71	≪0.001
Haut-Lomami (N = 824,676)	71,671 (8.69)	8.63	8.75	54,802 (6.65)	6.59	6.70	1.31	≪0.001
Haut-Uele (N = 303,361)	30,980 (10.21)	10,10	10.32	1777 (0.59)	0.56	0.61	17.31	≪0.001
Ituri (N = 1,581,732)	801,432 (50.67)	50,59	50.75	520,883 (32.93)	32.86	33.00	1.54	≪0.001
Kasai (N = 1,469,451)	566,536 (38.55)	38.48	38.63	168,664 (11.48)	11.43	11.53	3.36	≪0.001
Kasai Central (N = 2,036,795)	202,712 (9.95)	9.91	9.99	63,729 (3.13)	3.11	3.15	3.18	≪0.001
Kasai Oriental (N = 1,742,415)	543,888 (31.21)	31.15	31.28	308,127 (17.68)	17.63	17.74	1.77	≪0.001
Kinshasa (N = 2,755,451)	119,316 (4.33)	4.31	4.35	95,730 (3.47)	3.45	3.50	1.25	≪0.001
Kongo central (N = 1,330,492)	32,544 (2.45)	2.42	2.47	25,826 (1.94)	1.92	1.96	1.26	≪0.001
Kwango (N = 698,908)	14,725 (2.11)	2.07	2.14	1876 (0.27)	0.26	0.28	7.82	≪0.001
Kwilu (N = 1,517,067)	226,570 (14.93)	14.88	14.99	45,599 (3.01)	2.98	3.03	4.96	≪0.001
Lomami (N = 750,927)	121,693 (16.21)	16,12	16.29	7150 (0.95)	0.93	0.97	17.02	≪0.001
Lualaba (N = 1,847,786)	273,879 (14.82)	14.77	14.87	151,054 (8.17)	8.14	8.21	1.81	≪0.001
Maniema (N = 870,123)	46,263 (5.32)	5.27	5.36	46,076 (5.30)	5.25	5.34	1.004	0.1 < p < 0.9
Mayi-Ndombe (N = 369,936)	32,205 (8.71)	8.62	8.80	24,925 (6.74)	6.66	6.82	1.29	≪0.001
Mongala (N = 1,154,618)	242,314 (20.99)	20.91	21.06	194,714 (16.86)	16.80	16.93	1.25	≪0.001
Nord Kivu (N = 1,448,937)	729,166 (50.32)	50.24	50.41	15,223 (1.05)	1.03	1.07	47.9	≪0.001
Nord Ubangi (N = 698,963)	25,430 (3.64)	3.59	3.68	3868 (0.55)	0.54	0.57	6.58	≪0.001
Sankuru (N = 945,268)	50,187 (5.31)	5.26	5.35	4300 (0.45)	0.44	0.47	11.67	≪0.001
Sud Kivu (N = 1,136,845)	10,828 (0.95)	0.93	0.97	7454 (0.66)	0.64	0.67	1.44	≪0.001
South Young (N = 913,566)	219,623 (24.04)	23.95	24.13	59,537 (6.52)	6.47	6.57	3.69	≪0.001
Tanganyika (N = 751,419)	505,577 (67.28)	67.18	67.39	92,208 (12.27)	12.20	12.35	5.48	≪0.001
Tshopo (N = 901,859)	242,670 (26.91)	26.82	27.00	119,497 (13.25)	13.1	13.32	2.03	≪0.001
Tshuapa (N = 487,328)	83,279 (17.09)	16.98	17.19	20,408 (4.19)	4.13	4.24	4.08	≪0.001
DRC (N = 28,938,798)	5,544,299 (19.16)	19.14	19.17	2,151,647 (7.44)	7.43	7.44	2.58	≪0.001

However, routine coverage for the first dose of measles vaccine is higher than that reported by a longitudinal study in Nigeria (54.0% in 2018) [15] but lower than that recorded during a survey (98.9% (95% CI: 98.2% - 99.6%)) in Lincang City, Yunnan Province, China [16].

Vaccination coverage according to a document presented by the child was low for the campaign (5.85%) as for routine vaccination (3.75%); and only 3.72% of

children had a correctly completed vaccination card for the campaign. This low availability of vaccine support corroborates previous observations made both in the DRC and in other countries when estimating DTP3 vaccination coverage [17]. It was similar to that observed among children aged 12 - 23 months in Kenya (26% for MCV1) [13] but contrasted with Tounkara's [18] findings in Mali which reported that 75.9% of surveyed children had vaccination card on the day of the survey with 95.6% vaccination coverage among respondents. It also contrasted with the 66.7% vaccination card availability recorded in the Djoungolo health district in Cameroon [19]. This low availability of vaccine support did not corroborate the improvement in home recordings reported by some authors [20]. In view of the similarity of the low availability of this medium for both campaign and routine vaccination, and disregarding the delay in the survey and possible malfunctions in the supply and distribution of inputs, including campaign vaccination card to those vaccinated, it can be deduced that the possession and conservation of this medium remains a practice that is poorly developed at the level of the children's parents and insufficiently promoted by the vaccination system.

Among the respondents, the vaccination coverage of the campaign was significantly higher among children vaccinated before the campaign (95.14%) than those unvaccinated (64.71%). It did not vary significantly according to the child's place of residence, gender, age group, caregiver, or caregiver characteristics. This was not the case in Kenya where a significant variation in the campaign vaccination coverage, according to the education level of the mother, the household status, the child's schooling and other factors was noted [13].

The low coverage observed among children under 24 months and particularly those aged 6 - 11 months (62.89%; 95% CI: 62.67% - 63.12%) exposed them to the epidemic risks reported in Nigeria where 70.8% of measles confirmed cases were unvaccinated and measles incidence was highest among children aged 9 - 11 months (524 cases per million) [15]. Before the campaign, children were more vaccinated in rural areas (82.56%) than in urban areas (77.92%).

4.2. Analysis of the Contributions of the Vaccination Campaign

Estimated vaccination coverage of children aged 6 - 59 months, according to the history or the card, had increased from 80.84% before the campaign to 92.56% after ($p \ll 0.001$). This significant increase recorded in 24 of the 26 provinces in the DRC, and particularly in the provinces of Kwango (99.73%), Haut-Uele (99.41%), Lomami (99.05%), Nord Kivu (98.95) allowed half of the provinces (50%) to achieve 95% or more vaccination coverage, compared to less than 20% of the provinces before the campaign ($p \ll 0.001$). The 67% coverage of the only province which was below 80% after the campaign, compared to eight before, was close to the regional average of 66% noted in 2019 for the first dose of measles vaccine in the West Africa region [21].

Such a significant contribution was reported in Kenya where measles vaccina-

tion coverage was 96% (95% CI: 94% - 97%) among children aged 12 - 23 months after a vaccination campaign in 47 counties [13].

It follows that, as also reported in Kenya where it led to achieve 4% of zero-dose [13], this campaign induced a considerable reduction of the proportion of zero-dose children aged 6 - 59 months which fell from 19.16% to 7.44% ($p \ll 0.001$) at national level (a reduction of nearly two-thirds) and was below 1% in six provinces.

These results support the implementation of supplementary vaccination activities as part of the measles elimination strategy, especially in countries with underperforming vaccination system [22], particularly in view of the vaccination contribution to reducing the measles incidence and deaths [3] [4].

The persistence of low coverage in some provinces results from inaccessibility often due to conflicts and insecurity (case of Ituri) or the persistence of practices or behaviors unfavorable to vaccination. This stems from the observation of no link between vaccination coverage and the children's characteristics on the one hand and on the other hand from the higher proportion of vaccinated among already vaccinated children before the campaign than among those unvaccinated before. Both these findings and the paradox of the low vaccination coverage of children in urban areas where the knowledge level about vaccination is often higher than in rural areas, as reported in Senegal [22], indicate that maintaining and strengthening the gains of this follow-up campaign will require an effective response to the reasons for non-vaccination among these unvaccinated before the campaign.

4.3. Quality of Survey Results

The objectives set for the study were achieved because 100% of the provinces and expected targets were covered. The use of a validated approach for the survey [8], of the CAPI method for digitalized collection and of GPS for the electronic tracking of surveyors during the process, the control of the sampling process, and the low use of substitution clusters (less than 5% compared to the 10% planned) ensured better quality to the survey and particularly to the data collection.

However, limitations remain due to the small number of health zones enrolled per province, the systematic exclusion of few areas recognized as inaccessible (mainly due to insecurity) before the start of the survey and the low availability of vaccination documents among children's parents, leading to essentially consider statements. Despite the relative similarity between the data from vaccination documents and the mothers' declarations, significant discrepancies can also be noted between these two sources [17] [23], and the declarations could be tainted by memory bias, especially as this survey was carried out more than six months after the vaccination campaign.

5. Conclusion

The measles follow-up vaccination campaign, which took place in 2019, effec-

tively vaccinated children aged 6 - 59 months in the 26 provinces of the DRC. By ensuring the vaccination of children unvaccinated by routine vaccination sessions, this campaign improved measles vaccination coverage, bringing it to 92.56%, reducing the proportion of zero-doses by nearly two-thirds. These results, although important, mask the failure to achieve the target of 95% vaccinated children set at the national level. Given the persistence of the gap in adherence to vaccination between those vaccinated before the campaign and zero-dose children, actions should focus on removing the reasons for non-vaccination at all levels.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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