Vaccination Dropout Rates Among Children Aged 12-23 Months in the Urban-Rural Health District of Mont Ngafula II, Democratic Republic of the Congo: A Cross-sectional Study

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Abstract

Background: Globally, 1.8 million children failed to receive the 3-dose diphtheria, tetanus and pertussis (DTP) series every year in the Democratic Republic of the Congo (DRC). Currently, an emergency plan targeting 9 provinces, including the capital of Kinshasa, is launched to reinforce routine immunization. The Mont Ngafula II health district (HD) was the only one to report high vaccination dropout rates over almost five consecutive years. This study aimed to assess issues within the local dynamic system of vaccination services and identify associated risk factors among children aged 12-23 months.

Methods: A cross-sectional household survey was conducted among 418 children in June-July 2019 using a two-stage sampling design. Socio-demographic and perception data were collected through a structured interviewer-administered questionnaire. The distribution of 2017-2018 immunization coverage and dropout rate was extracted from local authority of HD and mapped. Chi-square test and multivariate logistic regression were used to identify predictors of high vaccination dropout. Statistical significance was defined as $p < 0.05$.

Results: Of 14 health areas included in the Mont Ngafula II HD, four reported high vaccine coverage, only one recorded low vaccine coverage and three registered both low vaccine coverage and high dropout rate. Multivariate logistic regression showed the predictors of immunization dropout as follows: no possession of immunization card (aOR = 2.49; 95% CI = 1.25-4.93; $p = 0.010$), living in rural areas (aOR = 1.53; 95% CI = 1.02-2.32; $p = 0.042$), unavailability of seating places (aOR = 7.10; 95% CI = 1.39-36.27; $p = 0.019$), no respect of the order of arrival (aOR = 3.88; 95% CI = 1.48-10.16; $p = 0.006$) during vaccination in health facilities, and the lack of a reminder system on days before the scheduled vaccination (aOR = 2.17; 95% CI = 1.43-3.32; $p < 0.001$).

Conclusion: The poor utilization of immunization services seemed as the main health concern followed by the poor access. Residing in rural areas, no immunization card possession, absence of seating places, no respect of the order of arrival, and the lack of a reminder system were the predictors of vaccination dropout rates. These results advocate for prioritizing targeted interventions and programs that will strengthen interpersonal communication between vaccination service providers and users during vaccination in health facilities as well as implement and extend a reminder system using SMS reminders on days before the scheduled vaccination.

Background

Since the establishment of the Expanded Program on Immunization (EPI) in 1974, vaccines showed a significant impact on vaccine preventable diseases by reducing morbidity, disability and mortality worldwide among children (1, 2). However, children remained not fully immunized with the vaccines of EPI targeted diseases in many parts of the world (3). Considered as a key indicator of immunization programme performance (4, 5), the third dose of vaccine against diphtheria, tetanus and pertussis (DTP3) has not been administered to 19.9 million children worldwide in the first year of life in 2017 (6). The

largest numbers of children who did not receive DTP3, 12.4 million (62%), were concentrated in ten countries: Nigeria, India, Pakistan, Indonesia, Ethiopia, the Democratic Republic of the Congo (DRC), Angola, Iraq, South Africa and Afghanistan (6). Of all the children who did not complete the 3-dose DTP series, 6.2 million (31%) started but did not complete the DTP series (dropout rate) (6).

In the DRC, 1.8 million children failed to receive the 3-dose DTP series every year (7). All that despite improvements for DTP3 coverage at the national level from 25% in 1999 to 81% in 2018 with the partnership of the Global Alliance for Vaccines and Immunization (GAVI) (7). This is even more alarming given that Congolese EPI was targeting to vaccinate 93% of children with the 3 doses of DTP before their first birthday (8). In addition, the DRC adopted the Reaching Every District (RED) approach since 2004. This approach was developed and introduced in 2002 by World Health Organization (WHO), the United Nations Children's Fund (UNICEF) and other partners to improve immunization systems in areas with low coverage (9). However, many children are still susceptible to vaccine-preventable diseases (VPDs) and death. Measles, yellow fever and poliomyelitis outbreaks were reported across the country over the last ten years (10–13).

In 2018, the DRC launched an emergency plan called Mashako to reinforce routine immunization in order to save 220.000 children within 18 months. This plan targeted 9 provinces: Ituri, Kasaï, Haut-Katanga, Mongala, Kwilu, Tanganyika, Tshuapa, Haut-Lomami and the capital of Kinshasa. In the latter that counts 35 health districts (HDs), Mont Ngafula II was the only to record high dropout rates among children aged < 12 months over almost five consecutive years. The EPI's routine reports showed dropout rates for DTP3 dose of 15%, 19%, 10% and 11% in 2014, 2016, 2017 and 2018 respectively (Dataset V1). It is required to develop appropriate strategies for improving routine immunization activities.

The present study aimed to assess the local system of vaccination services at health area (HA) scale and identify determinants of high vaccination dropout rates among children aged 12–23 months in the Mont Ngafula II HD.

Methods

Study area

Mont Ngafula II is located in the western part of Kinshasa. It shares boundaries with five districts: Binza Ozone, Binza Météo, Selembao, Mont Ngafula I, and Masa (in Kongo central province). The HD is subdivided into 14 HA: Antenne, Don Bosco, Kimbwala, Kimbondo, Maman Mubutu, Matadi Kibala, Mambre, Matokame, Mazal, Mitendi, Ngombe, Mbudi and Sans Fil (Fig. 1). The HD has a general pediatric hospital, 107 health centers including 22 health posts. Only 14 health centers deliver EPI vaccines to the target population groups. The main local economic activities are based on agriculture, livestock and fishery products.

Study design and sampling procedure

A cross-sectional household survey was conducted. All children aged 12–23 months, between the 1st of June and the 1st of July 2019, were eligible. We performed a two-stage sampling design according to the WHO (14). Based on the estimated population data per village/neighborhood provided by the HD's authority, 30 clusters were firstly selected through probability proportional to their size using simple random method. The sample size was determined using the following formula: $N = Z^2 \times p(1-p)/d^2$, where N is the sample size, Z (1.96) is the 2-sided level of significant, p is the immunization coverage of the country (45%) as proposed in the study of Baguune at al. (2017) (15) and d is the desired width of the confidence interval. Given a non-response rate of 10%, we found a total sample size of 418 children aged 12–23 months. At the second stage, we used the EPI random walk method (16) to select 14 children from each of the 30 clusters. The starting point was considered as the first household chosen randomly from the geographic centre of each cluster using the spinning bottle method and then continued to the next nearest household in the same direction until 14 eligible children were obtained.

Data collection

A structured questionnaire translated into local language was used for the data collection. Interviewers were previously recruited and trained on the study protocol and the questionnaire use. After the training, a pre-test was conducted on the field to check the reliability and validity of our study tools. The questionnaire included information on socio-demographic characteristics, child immunization status, and perception of respondents (mothers/caregivers) on the organization of vaccinating health facilities. Door-to-door visits were conducted and only consenting respondents of selected children participated in the structured interviewer-administered questionnaire. In case of two or more children aged 12–23 months were found in the same household, the youngest child was selected (16). Information on child vaccination such as dates and doses of each vaccine received was obtained from vaccination cards or respondents' recall if the card was unavailable. Data on routine immunization coverage and dropout rate at HA scale was also extracted from 2017–2018 annual datasets of HD (Dataset V2). According to Congolese routine immunization schedule summarized in Table 1, dropout rate was considered as the percentage of children aged 12–23 months who received the 1st but not the 3rd dose of DTP. It was calculated according to WHO method: [(first dose – last dose)/first dose] × 100 (4).

Table 1
Routine immunization schedule in the DRC

Timing	Vaccine
Birth	Bacillus Calmette-Guerin (BCG) and Oral Polio Vaccine (OPV)
6, 10, 14 weeks	OPV, Diphtheria and Tetanus toxoid with whole cell Pertussis, Haemophilus Influenzae type B and Hepatitis B (DTwPHibHepB) and Pneumococcal Vaccine (PCV) each time
9 months	Measles and Yellow fever

Data analysis

Annual geographic distribution of routine immunization coverage and dropout rate at HA scale was recorded on Microsoft Excel® 2013 files and mapped with QGIS 2.14.4 (Open Source Geospatial Foundation). Shapefile of Mont Ngafula II HD was obtained from the Directorate of Disease Control of the DRC Ministry of Public Health (validated by WHO DRC) and used to generate the map. The latter allowed to assess the dynamic system of vaccination services at HA scale.

Collected data were recorded on Microsoft Excel® 2013 files. All statistical analyses were performed in Statistical Package for Social Sciences (SPSS) version 20.0. Descriptive statistics such as frequencies and percentages were calculated and presented into tables. Children, respondents, household characteristics and respondents' perception differences associated with immunization status (cards and respondents' recall) were tested by the Chi-square test. Adjusted Odds Ratios (aOR) with their 95% confidence intervals (95% CI) were calculated using a multivariate logistic regression model to measure the strength of association between independent predictors and immunization dropout. The threshold of statistical significance was defined as $p < 0.05$.

Results

A total of 418 children and their mother/caregivers were assessed in the study. Overall, 7.7% of the respondents were ≤ 19 years and 0.7% were ≥ 50 years of age. All respondents had a formal education while 69.9% up to secondary level and 12.4% up to tertiary level. More than half (54.5%) of the respondents were unemployed. Nearly, two-third (63.6%) of the respondents lived in urban settings and 92.1% had less than 3 children in their households. The majority of children (90.0%) possessed vaccination card, 50.2% were female and 53.6% were the 3rd or later born in the family (Table 2).

Table 2
Sociodemographic characteristics of participants, Mont Ngafula II HD, DRC, 2019

Variables			Number	Percent (%)
Children characteristics	Child sex	Female	210	50.2
		Male	208	49.8
	Birth order	≤ 2nd	194	46.4
		≥ 3rd	224	53.6
	Card possession	No	42	10.0
		Yes	376	90.0
Respondents' characteristics	Age	≤ 19 years	32	7.7
		20–29 years	209	50.0
		30–39 years	159	38.0
		40–49 years	15	3.6
		≥ 50 years	3	0.7
	Occupation	Professional	28	6.7
		Trader	104	24.9
		Unemployed	228	54.5
		Other	58	13.9
	Education level	Primary	74	17.7
		Secondary	292	69.9
		Tertiary	52	12.4
Household characteristics	Place of residence	Rural	152	36.4
		Urbain	266	63.6
	Type of family	Single parent family	78	18.7
		2-parents family	340	81.3
	Number of children	≤ 2	385	92.1
		≥ 3	33	7.9

Table 3 shows the respondents' perceptions on the organization of vaccinating health facilities of the Mont Ngafula II HD. The large majority indicated a good attitude of health staff during vaccination

(94.0%), the availability of seating (95.0%), the respect of the order of arrival during vaccination (90.0%), and a long waiting time during vaccination (83.0%). More than half (58.9%) of the participants reported the lack of a reminder system on days before the scheduled vaccination.

Table 3
Respondents' perceptions on the organization of vaccinating health facilities, Mont Ngafula II HD, DRC, 2019

Perceptions	Number	Percent (%)
Attitude of health staff during vaccination in health facilities		
Bad	25	6.0
Good	393	94.0
Availability of seating places during vaccination		
No	21	5.0
Yes	397	95.0
Respect of the order of arrival during vaccination		
No	42	10.0
Yes	376	90.0
Waiting time during vaccination in health facilities		
<1 hour	71	17.0
>1 hour	347	83.0
Existence of a reminder system on days before the scheduled vaccination		
No	246	58.9
Yes	172	41.1

Spatial distribution of routine immunization coverage and dropout rate

Figure 2 summarized the spatial distribution of 2017–2018 routine immunization coverage and dropout rate. Four HAs reported high vaccine coverage and high dropout rate: Mitendi, Sans fil, Mbudi and Mambre. Three HAs registered low vaccine coverage and high dropout rate: Matokama, Ngombe and Don Bosco. Only one HA recorded low vaccine coverage and low dropout rate: Dumez.

Sociodemographic characteristics and perceptions of participants associated with dropout status

The analysis of sociodemographic characteristics and perceptions of participants with dropout status based on vaccination cards and respondents' recall is shown in Table 4. Children with vaccination cards

had a lower dropout rate compared to those without it ($p = 0.008$). There were no statistical differences in other sociodemographic characteristics. Children of respondents who reported positive attitude of health staff ($p = 0.005$), availability of seating places ($p < 0.001$) and respect of the order of arrival ($p < 0.001$) during vaccination in health facilities were more likely fully immunized. The lack of a reminder system on days before the scheduled vaccination was found associated with higher dropout ($p < 0.001$).

Table 4
Sociodemographic characteristics and perceptions associated with dropout status

Variables			No Dropout		Dropout		Total	*p-value*
			N	%	N	%	N	
Children characteristics	Child sex	Female	115	54.8	95	45.2	210	0.914
		Male	115	55.3	93	44.7	208	
	Birth order	≤ 2nd	101	52.1	93	47.9	194	0.257
		≥ 3rd	129	57.6	95	42.4	224	
	Card possession	No	15	35.7	27	64.3	42	0.008
		Yes	215	57.2	161	42.8	376	
Respondents' characteristics	Age	≤ 19 years	16	50.0	16	50.0	32	0.148
		20–29 years	124	59.3	85	40.7	209	
		30–39 years	78	49.1	81	50.9	159	
		40–49 years	11	73.3	4	26.7	15	
		≥ 50 years	1	33.3	2	66.7	3	
	Education level	Primary	38	51.4	36	48.6	74	0.247
		Secondary	168	57.5	124	42.5	292	
		Tertiary	24	46.2	28	53.8	52	
	Occupation	Professional	16	57.1	12	42.9	28	0.718
		Trader	62	59.6	42	40.4	104	
		Unemployed	121	53.1	107	46.9	228	
		Other	31	53.4	27	46.6	58	
Household characteristics	Place of residence	Rural	75	49.3	77	50.7	152	0.078
		Urbain	155	58.3	111	41.7	266	
	Type of family	Single parent family	42	53.8	36	46.2	78	0.817
		2-parents family	188	55.3	152	44.7	340	
	Number of children	≤ 2	214	55.6	171	44.4	385	0.431
		≥ 3	16	48.5	17	51.5	33	

Variables			No Dropout		Dropout		Total	*p-value*
Respondents' perceptions	Attitude of health staff	Negative	7	28.0	18	72.0	25	0.005
		Positive	223	56.7	170	43.3	393	
	Availability of seating	No	2	9.5	19	90.5	21	< 0.001
		Yes	228	57.4	169	42.6	397	
	Respect of the order of arrival	No	8	19.0	34	81.0	42	< 0.001
		Yes	222	59.0	154	41.0	376	
	Waiting time	> 1 hour	188	54.2	159	45.8	347	0.443
		< 1 hour	42	59.2	29	40.8	71	
	Reminder system	No	116	47.2	130	52.8	246	< 0.001
		Yes	114	66.3	58	33.7	172	

Predictors of vaccination dropout rates

Table 5 shows independent predictors of immunization dropout. Children without immunization card were more likely to drop out than those who possessed it (aOR = 2.49; 95% CI = 1.25–4.93; $p = 0.010$). Residing in rural areas was associated with vaccination dropout (aOR = 1.53; 95% CI = 1.02–2.32; $p = 0.042$). Unavailability of seating places (aOR = 7.10; 95% CI = 1.39–36.27; $p = 0.019$), no respect of the order of arrival (aOR = 3.88; 95% CI = 1.48–10.16; $p = 0.006$) during vaccination in health facilities and the lack of a reminder system on days before the scheduled vaccination (aOR = 2.17; 95% CI = 1.43–3.32; $p < 0.001$) were perceived significantly associated with dropout rate.

Table 5
Logistic regression of immunization dropout rate and socio-demographic characteristics and respondents' perceptions

Variables		OR	95% CI	*p-value*	aOR	95% CI	*p-value*
Sociodemographic characteristics							
Children characteristics							
Sex of child	Male	1.0					
	Female	1.022	0.70–1.50	0.914	0.98	0.66–1.46	0.909
Birth order	≤ 2nd	1.0					
	≥ 3rd	0.80	0.54–1.18	0.258	0.77	0.50–1.17	0.219
Card possession	Yes	1.0					
	No	2.40	**1.24–4.67**	**0.01**	2.49	**1.25–4.93**	**0.010**
Respondents' characteristics							
Age of respondent	≤ 19 years	1.0					
	> 19 years	1.24	0.61–2.56	0.553	1.09	0.51–2.35	0.825
Education level	Secondary and above	1.0					
	Primary and below	1.197	0.72–1.98	0.484	1.09	0.64–1.85	0.765
Occupation	Without occupation	1.0					
	With occupation	0.84	0.57–1.24	0.379	0.87	0.58–1.30	0.499
Household characteristics							
Place of residence	Urban	1.0					
	Rural	1.43	0.96–2.14	0.078	1.53	**1.02–2.32**	**0.042**
Type of family	2-parents	1.0					

Variables		OR	95% CI	*p-value*	aOR	95% CI	*p-value*
	Single parent	1.06	0.65–1.74	0.817	0.91	0.54–1.57	0.747
Number of children	≤ 2 children	1.0					
	≥ 3 children	1.33	0.65–2.71	0.43	1.51	0.72–3.18	0.278
Respondents' perceptions							
Attitude of health staff	Positive	1.0					
	Negative	3.37	**1.38–8.26**	**0.008**	0.65	0.19–2.23	0.496
Availability of seating	Yes	1.0					
	No	12.82	**2.95–55.77**	**0.001**	7.10	**1.39–36.27**	**0.019**
Respect of the order of arrival	Yes	1.0					
	No	6.13	**2.76–13.60**	**< 0.001**	3.88	**1.48–10.16**	**0.006**
Waiting time	< 1 hour	1.0					
	> 1 hour	1.23	0.73–2.06	0.443	1.03	0.60–1.78	0.917
Reminder system	Yes	1.0					
	No	2.20	**1.47–3.30**	**< 0.001**	2.17	**1.43–3.32**	**< 0.001**

Discussion

The results of this study have shown that half of the HAs of the Mont Ngafula II HD recorded high dropout rates.

More than two-fifth of them also registered low vaccine coverage while only one HA reported exclusively low vaccine coverage.

Concerning the predictors, residing in rural areas and the absence of immunization card, no seating places and no respect of the order of arrival during vaccination in health facilities as well as the lack of a reminder system on days before the scheduled vaccination were significantly associated with high dropout rates among children aged 12–23 months.

Concerning the local system of vaccination services, the poor utilization of vaccine services seemed as the main health concern followed by the poor access at HA scale. Among the HAs that recorded high dropout rates, more than half reported good access but poor utilization of vaccination services (high vaccine coverage and high dropout) while two-fifth registered both poor access and poor utilization vaccination services (low vaccine coverage and high dropout). Furthermore, only one HA reported both poor access and high utilization vaccination services (low vaccine coverage and low dropout). Thus, these results may represent a useful indicator for the risk assessment of vaccination services in the study area.

In the present study, children without immunization card had higher susceptibility to drop out from vaccination services. Not having an immunization card was also found as a predictor of incomplete immunization in other studies from low-income African countries (15, 17, 18). This situation may be related to perception of attitudes of the health staff. As suggested by Baguune et al. (2017), in case of loss of immunization cards, negative attitudes from some health workers unable to provide new vaccination cards induce a reluctance feeling of mothers for new vaccination in health facilities (15). This evidence is also supported by the results from a cross-sectional survey conducted during a polio outbreak in Cameroon in which good perception of immunization services was considered as a determinant of vaccination completeness (19). Thus, we hypothesize that a good reception of health staff can strengthen interpersonal communication and be a major asset for the subsequent use of the immunization services.

This study showed that children residing in rural areas were more likely to drop out compared to their urban counterparts. However, discordant results have been reported in other studies, especially conducted in Asia and Africa. At the contextual level, living in rural areas was associated with breaks in childhood vaccination in India (20) while this characteristic was found protective in a multilevel analysis involving 24 African countries (21). As suggested previously, discrepancies observed would call into question the urban advantage probably due to urban demographic growth and related difficulties of access to health services (20, 22–24).

Respondents perceived that unavailability of seating places and no respect of the order of arrival during vaccination in health facilities were associated with immunization dropout rate. In addition, the lack of a reminder system on days before the scheduled vaccination was also perceived as a predictor to high dropout. This result is similar to studies conducted by Bangure et al. (2015) in Zimbabwe (25), Haji et al. (2016) and Gibson et al. (2017) in Kenya (26, 27). They found that complete immunization was significantly higher among children of mothers/caregivers who received short message service (SMS) reminders than those in control groups. Thus, our findings support the hypothesis that implementing and extending a reminder system using SMS-type messages may contribute to improve substantially immunization services in our context.

Other socio-demographic characteristics considered in the present study were not statistically associated with dropout rate while they were found as predictors of incomplete vaccination. Children (birth order,

sex), parents (education level, religion), and household (number of children) characteristics were significantly related to the children immunization status in several African studies (15, 19, 26, 28–34). Growing number of children, sex discrimination, low parents' education level, and misconceptions from certain religious groups affecting vaccination uptake may lead to immunization dropout (15, 19, 26). The discrepancies observed on these characteristics in our study represent the first limit. They could be explained by our small sample size and some specifics characterizing the objectives assigned and the sample procedures comparatively to other studies.

A second study limitation is that determinants of vaccination dropout rates were assessed from the perspective of the users of vaccination services. Evaluation from the perspective of health systems and providers was not considered. However, determinants of childhood immunization coverage are complex and interrelated. Vaccination depends on a real need for vaccines and health seeking service from users and high-quality service of vaccines offer under the optimal technical, logistical, and operational conditions from providers (35).

Nonetheless, there has been a limited number of research in DRC concerning vaccination dropout (36). To our knowledge, the present study is the first conducted at both fine spatial scale and individual level to understand the main health concern of vaccine services and identify factors related to low vaccination completeness among children aged 12–23 months. An additional strength of this survey is that the result of this study can be extrapolated to the population of the DRC because the survey used a probability sampling technique and the minimum sample size was computed taking into account the formula required to allow each person to be part of the sample.

Conclusion

The poor utilization of immunization services seemed as the main health concern followed by the poor access. Residing in rural areas, no immunization card possession, absence of seating places and no respect of the order of arrival during vaccination in health facilities, and the lack of a reminder system on days before the scheduled vaccination were the predictors of high dropout rates among children aged 12–23 months. These results will serve as a useful tool to prioritize targeted vaccination interventions and programs that will strengthen interpersonal communication between vaccination service providers and users during vaccination in health facilities. In addition, the latter finding advocates for implementing and extending a reminder system using SMS reminders on days before the scheduled vaccination. Adopting such an approach would be even more beneficial for rapid immunization in fighting child morbidity and mortality, especially since it has been shown that the cost is affordable (25, 37, 38).

Further studies including determinants attributable to health workers and immunization services will help to thoroughly explore factors associated with routine vaccination dropout rates among children aged 12–23 months.

Abbreviations

95% CI: 95% confidence intervals

aOR: Adjusted Odds Ratio

BCG: Bacillus Calmette-Guerin

DRC: The Democratic Republic of the Congo

DTP: Diphtheria, tetanus and pertussis vaccine

DTwPHibHepB: Diphtheria and Tetanus toxoid with whole cell Pertussis, Haemophilus Influenzae type B and Hepatitis B vaccine

EPI: Expanded Program on Immunization

GAVI: The Global Alliance for Vaccines and Immunization

OPV: Oral Polio Vaccine

OR: Odds Ratio

PCV: Pneumococcal Vaccine

RED: Reaching Every District

SMS: Short message service

SPSS: Statistical Package for Social Sciences

UNICEF: The United Nations Children's Fund

VPD: Vaccine-preventable disease

WHO: World Health Organization

Declarations

Ethics approval

Ethical approval was obtained from the "Comité d'éthique de la recherche de l'École de Santé Publique, Université de Kinshasa (Research Ethics Committee of the School of Public Health, University of Kinshasa)". After being informed, the respondents' consent was obtained verbally. Data collection was conducted confidentially.

Consent for publication

Our manuscript does not contain any individual person's data.

Availability of data and materials

The datasets generated and/or analysed during this study are available in the:

[Vaccination_dropout_rates_Mont_Ngafula_II_Dataset] repository, [https://www.editorialmanager.com/aoph/download.aspx?id=33405&guid=289f34cc-a2e1-45de-b862-f013c6f0bcf9&scheme=1]

[Dataset V1] repository, [https://www.editorialmanager.com/aoph/download.aspx?id=33406&guid=453a4c34-238a-4d2c-ab4a-7548220d5a91&scheme=1]

[Dataset V2] repository, [https://www.editorialmanager.com/aoph/download.aspx?id=33407&guid=8a0acba5-461b-4eb0-ad95-86eac6486ba2&scheme=1]

Competing interests

The author declare that they have no competing interests.

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Authors' contributions

HCKN conceived the topic, participated in the design, data analysis and interpretation of the study, and wrote the manuscript. FV conceived the topic and participated in data collection. PA conceived the topic, participated in the design of the study. BE participated in the design of the study. BAM conceived the topic, participated in the design of the study and reviewed the manuscript. DB conceived the topic.

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Figures

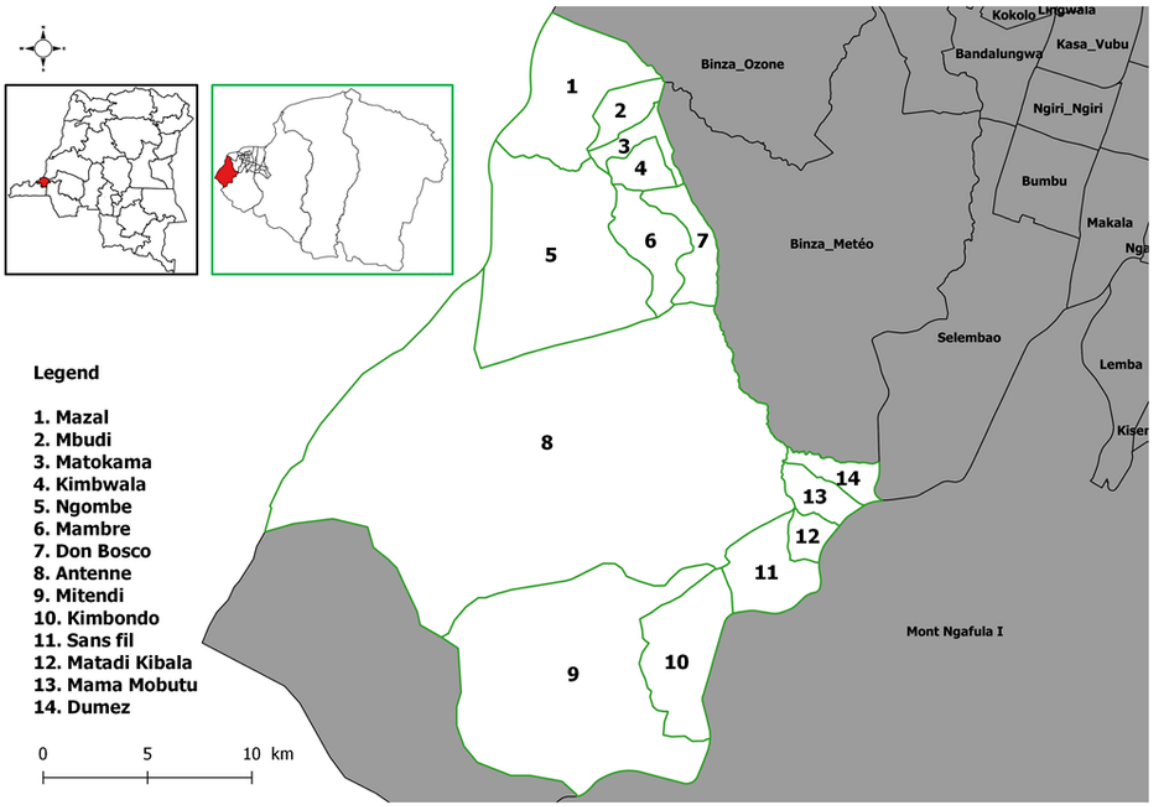

Figure 1

Study area. Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.

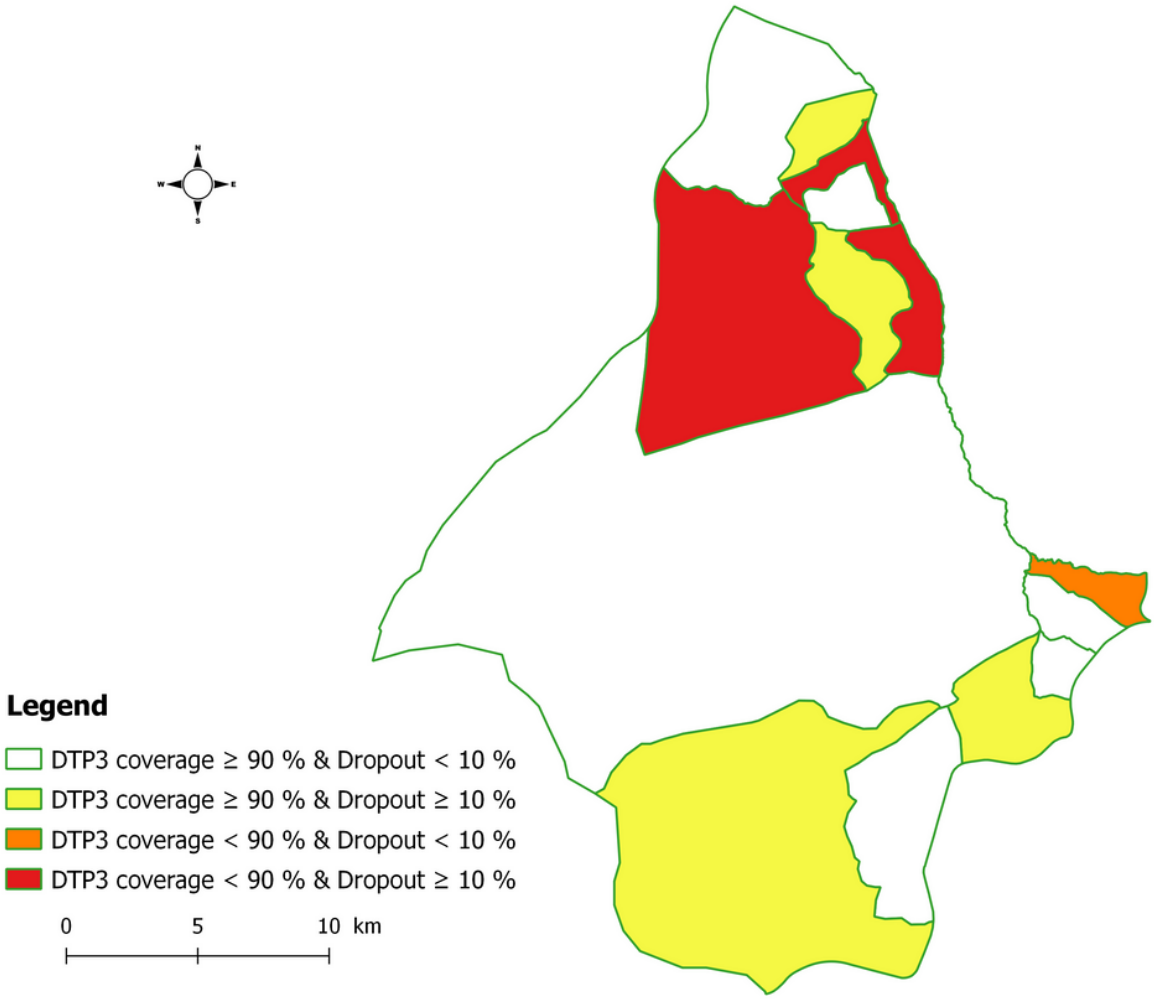

Figure 2

Spatial distribution of 2017-2018 routine immunization coverage and dropout rate. Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- DatasetV1.xlsx
- DatasetV2.xlsx
- VaccinationdropoutratesMontNgafulaIIDataset.xlsx