Correlates of Zero-Dose Status among Children Aged 12–23 Months in the Luambo Health District, Democratic Republic of Congo: A Matched Case-Control Study

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Article

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Abstract: (1) Background: "Zero-dose" (ZD) refers to a child not receiving any doses of the pentavalent (diphtheria-tetanus-pertussis-*Haemophilus influenzae* type b (Hib)-Hepatitis B) vaccine in the routine national immunization schedule. These children are vulnerable to vaccine-preventable diseases (VPDs), and are often already disadvantaged due to poverty, conflict, and lack of access to basic health services. The Luambo health district (HD) is one of the 26 HDs in the Kasai Central Province and has the largest number of ZD children. This study was conducted to examine the factors associated with ZD status in the Luambo HD; (2) Methods: We conducted a mixed study of children aged 12-23 months in the Luambo HD in the Kasai Central Province; (3) Results: A total of 445 children aged 12-23 months were included in the study, including 89 cases and 356 controls. Correlates of zero dose (ZD) status in children aged 12-23 months were mothers who were not receiving Antenatal Care (ANC), of not knowing any VPD, the fact of the children being born in Angola and the fact of the children being born at home. In addition, the perceptions of children's parents influenced child immunization; (4) Conclusions: Missing ANC services during pregnancy leads to home delivery with consequences being lack of knowledge on childhood's VPD and subsequently children not being vaccinated.

Keywords: Luambo health district; Democratic Republic of the Congo; immunization; zero-dose

1. Introduction

Routine childhood immunization is a proven strategy for controlling and eliminating life-threatening infectious diseases [1]. According to the World Health Organization (WHO), vaccination prevents around four million deaths each year. "Zero-dose" (ZD) refers to a child *was* not to have received any doses of the pentavalent (diphtheria-tetanus-pertussis-*Haemophilus influenzae* type b (Hib)-Hepatitis B) vaccine during the routine national immunization schedule [2]. These children are vulnerable to vaccine-preventable diseases, and are often already disadvantaged due to poverty, conflict, and lack of access to basic health services [1,2].

During 2019-2020, the number of zero-dose children varied by WHO region. This number remained stable in the European region at 0.3 million, but increased in the African region (from 7.1 million to 7.7 million), in the American region (from 1.6 million to 1.7 million), the Eastern Mediterranean region (1.8 million to 2.3 million), South-East Asia region (2.0 million to 4.1 million) and in the Western Pacific region (0.9 million to 1.0 million). In 2020, middle-income countries accounted for the highest proportion of zero-dose children (71%; 12.1 million); of these, 4.1 million

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children (24%) came from countries in the African Region, and the South-East Asia region [3]. Low-income countries had 4.5 million (26%) ZD children, that is, those who did not receive any dose of pentavalent [2,3].

In 2020, with the advent of the COVID-19 pandemic, 23 million children worldwide did not receive the vaccines they should have received. Among them, 17.1 million were zero-dose children, indicating insufficient access to vaccination and other health services, and another 5.6 million were only partially vaccinated. Of these 23 million children, more than 60% lived in 10 countries: Angola, Brazil, Ethiopia, India, Indonesia, Mexico, Nigeria, Pakistan, Philippines and the Democratic Republic of the Congo (DRC) [1].

According to vaccination coverage surveys carried out in the DRC, the proportion of ZD children among children aged 12 to 23 months increased from 9.2% to 12.7% between 2014 and 2021 [4–7]. The proportion of ZD children among children aged 12 to 23 months in the Kasaï Central Province was 12.6% in 2021 [7]. In this province, Luambo HD had the highest proportion of ZD children (44.5%), despite the implementation of the Mashako plan since 2020, an emergency plan aimed at relaunching routine vaccination activities to increase vaccination coverage in the DRC [7,8]. Despite the implementation of this plan, immunization coverage remains well below the global target of 90% according to national surveys and WHO/UNICEF estimates [9].

It is therefore essential to investigate the reasons for the existence of zero-dose children in Luambo HD so that the adoption of vaccines is low or stagnant. This study was conducted to examine the factors associated with ZD status of children aged 12-23 months.

2. Materials and Methods

2.1. Study setting

The Luambo HD is one of 26 HDs in the Province of Kasai Central. It is located in the Luiza territory, 285 km from the capital of the Kasai Central Province. It extends over two sectors (Kabelekese and Lueta) with an estimated population of 349,793 inhabitants over an area of approximately 4,320 km² and a density of 81/km². The health district borders Angola which hosts a floating population from Angola and other provinces, particularly in the Kalamba-Mbuji Luambo, Lueta and Muanda Kalendu health areas (HAs) [10]. It comprises 21 health areas (HAs) which organize the routine immunization services, 305 villages, 450 community animation cells (CACs) which are bodies that enable community participation in the effective management of health services and their health problems at the health area level within the framework of primary health care [10].

2.2. Study design

We conducted a mixed-method study incorporating a quantitative case-control component and a qualitative descriptive component among children aged 12-23 months in the Luambo HD.

2.3. Study population

The population of this study consisted of children aged 12 to 23 months residing in the study zone at the time of data collection whose mothers or caregivers consented to participate in the study. We excluded from the study children aged 12-23 months residing in the study zone whose mothers had not consented to participate. We considered as case any child aged 12-23 months residing in the study area and not having received the first dose of pentavalent (Penta-1) routinely as a case in our study. We considered the following as controls:

- Any child aged 12-23 months residing in one of the HAs in the study who received at least one dose of pentavalent routinely before their first birthday but who did not completed the vaccination schedule recommended by the National and certified Expanded Program of Immunization (EPI) either by the vaccination card or by the vaccination register of the health center of the health area (HA).
- Any child aged 12-23 months residing in one of the HA in the study and having received all the antigens provided for in the vaccination schedule recommended by the national EPI before the

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age of 12 months [11] and certified either by the vaccination card or by the vaccination register of the health center of the HA.

2.4. Sampling

The number of children aged 12-23 months to be surveyed was estimated using Stata software, version 15. We used the fact that the mother did not attend antenatal consultations (ANC) during pregnancy as an associated factor with ZD status in children aged 12-23 months, with an odds ratio (OR) of 2.13 as found by Atnafu A et al. [12]. We used a correlation coefficient of 0.2 between matched cases and controls [13], a noninformative proportion of controls for whom mothers had not attended ANC during pregnancy of 50%, a power of 80%, a ratio of 1 case to 4 controls and a nonresponse prediction of 10%. The sample size was thus 445 (including 89 cases and 356 controls).

We carried out cluster sampling at three levels: At the first level, we selected 8 HAs in a simple random from among the 21 HAs in the Luambo health district using a random number generator. The number of cases and controls was distributed equally among all HAs, 11 cases and 44 controls per HA except HA Kasombo Bishi for which 12 cases and 48 controls drawn randomly from the 8 HAs. In the second stage, we selected 4 community animation cells (CAC) from each HA, for a total of 32 CACs. In the third stage we selected the cases and controls separately as follows: the cases were selected by systematic sampling in each selected CAC. In each CAC, with the help of community health workers, we drew up a list of all children aged 12-23 months. For each child, the record indicated whether they were ZD or not, her sex and her age in months. All ZD children were numbered from 1 to Ni, with Ni representing the total number of ZD children in the i^{th} CAC. We calculated the sampling specific step for each CAC, taking into account the number of ZD children by dividing them by the number of ZD children required for the CAC, 3 cases per CAC in 3 CACs and 2 cases in one CAC. To obtain the CAC for 2 children, a random draw was carried out on the 4 CACs. To have the first ZD child be surveyed, we randomly selected a number between 1 and the integer part of the sampling increment. Others ZD children were selected by sequentially applying the sampling step. For each ZD child selected, we selected 4 same-sex controls adjacent to the case on the child record due to 2 fully vaccinated and 2 under vaccinated children. In the qualitative section, we resorted to a reasoned choice of mothers of children aged 12-23 months. To reach saturation based on the mother-child study, three focus groups of 8 mothers of children aged 12-23 months were conducted, one with mothers of fully vaccinated children, one with these ZD children and another with mothers of under vaccinated children.

2.5. Data collection

In the quantitative part, data were collected through face-to-face interviews with mothers, using a structured questionnaire written on paper as a collection tool. In the qualitative part, we collected the data using a dictaphone and a previously developed interview guide. The interviews took place in Tshiluba within Luambo General Referral Hospital in Luambo HA. Each interview lasted between 40 and 60 minutes. Qualitative data collection was performed after all quantitative data collection were collected and took one day. All participants came from the Luambo health area. Interviews were conducted by the principal investigator, following prespecified topic guides. The interview guide was used to collect data on elements relating to mothers' perceptions of child immunization. The principal investigator was assisted by a note-taker who was a supervising nurse from the Luambo HD. All interviews were recorded on audiotape using a dictaphone and then uploaded to a secure box folder. The original audio files are stored a secure box folder for one year after the end of the study, and then destroyed. All participants were given a unique identifier so that the transcriptions could be deidentified. The interviews were transcribed into French for analysis.

2.6. Variables

The outcome of interest *was* not to have received any doses of the pentavalent vaccine. The explanatory variables used were sociodemographic characteristics of the head of household, such as

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age, level of education, profession and religion; characteristics of the mother/caregiver, including her relationship with the child, age, marital status, level of education, occupation, religion, number of children in the household; the child's gender; knowledge of VPD, whether the mothers received ANC during pregnancy and the characteristics of the child, including age, upper arm circumference, place of birth, country of birth and sibling rank.

2.7. Data analysis

The data from the data collection forms were coded and subsenquentely entered into Epidata 3.1 software. Then, the data were exported to Stata 15 software for analysis. We cleaned up the database. We merged and recoded certain modalities of the variables. We summarized categorical variables as proportions. We summarized the quantitative variables using the median with interquartile range (IQR) since their distribution was not normal. We used the Mann-Whitney test to compare medians between cases and controls. We used the chi-square test of homogeneity to compare the different categorical variables between the two groups. The level of statistical significance was set at 0.05. We used conditional logistic regression to study the associations between the independent variables and the dependent variable. All variables with a p value less than or equal to 0.20 in simple regression were candidates for multivariate analysis. Multicollinearity among the independent variables were checked using the variance inflation factor (VIF). A VIF greater than or greater than 10 was indicative of multi collinearity. We found no collinearity between the different independent variables. Study results are presented as odd ratio (OR) or adjusted odd ratio (AOR) with 95% confidence intervals (95%CI).

In the qualitative part, the recordings were listened to several times and transcribed onto a summary sheet. The written transcriptions were entered into the qualitative data management software ATLAS.ti version 7 (2013) (Scientific Software Development, Berlin, Germany) and were coded according to a code dictionary based on the themes included in the transcription guides. interviews to capture emerging themes. We performed thematic analysis for mothers of fully vaccinated children, mothers of undervaccinated children, and mothers of zero-dose children. Next, we developed matrices to facilitate comparisons between transcripts and to maintain the context of the data. Finally, the data were summarized and interpreted. We selected direct quotes representative of the participants' opinions to illustrate the results, without providing the identity of the participants.

2.8. Ethical approval and consent to participate:

The ethics committee of the Kinshasa School of Public Health approved this study before data collection (***approval number: ESP/CE/16/2023***). Authorization was also granted by the health and political-administrative authorities. Before beginning the interview, written informed consent was obtained from the study participants. The research team provided the respondent with information on the nature of the study, its objectives, the risks and benefits involved, the freedom to participate or not without any prejudice, confidentiality and contact details of the person in charge of the study. study for further contact if necessary. Confidentiality was respected by anonymizing the dataset.

3. Results

3.1. Quantitative results

3.1.1. Sample characteristics

The study included a total of 445 children aged 12-23 months, including 89 cases and 356 sex-matched controls, with a ratio of 1 case to 4 controls. Table 1 shows the characteristics of household heads. The median age of heads of household was 34 years (interquartile range (IQR) =27-41) for cases and 35 years (IQR=28-41) for controls. More than eight out of ten heads of household were male in both cases and controls. Approximately 4 out of ten respondents had never been to school among the cases, compared with 2 out of ten among the controls (42.7% versus 20.8%).

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Table 1. Sociodemographic characteristics of the household heads.

Characteristic	Case (n_1=89) n (%)	Control (n_2=356) n (%)	p
Age (years)			
Median and IQR	34 (41-27)	35(41-28)	0.905
Age group (years)			0.943
17-24	15 (16.9)	62 (17.4)	
25-34	35 (39.3)	133 (37.4)	
35 and over	39 (43.8)	161 (45.2)	
Gender head of household			0.951
Male	73 (82.0)	291 (81.7)	
Feminine	16 (18.0)	65 (18.3)	
Religion			0.005
Catholic	18 (20.2)	138 (38.8)	
Protestant	13 (14.6)	42 (11.8)	
Others	58 (67.2)	176 (49.4)	
Ethnic group			0.813
Lualua	44 (49.4)	171 (48.0)	
Others	45 (50.6)	185 (52.0)	
Level of study			<0.001
Never went to school	38 (42.7)	74 (20.8)	
Primary and more	51 (57.3)	282 (79.2)	
Occupation			0.046
Unpaid profession	18 (20.2)	44 (12.4)	
Remunerative profession	71 (79.8)	312 (87.6)	

n = number of subjects; % = percentage; IQR = interquartile range.

Table 2 shows the characteristics of the mothers/caregivers. The median age of mothers/caregivers was 28 years (IQR=23-33) for cases and 27 years (IQR=23-32) for controls. Among respondents, around 98% were mothers of the children in cases and 97% in controls. Approximately one in five respondents' cases lived in a union. More than six out of ten respondents had never been to school among the cases, whereas only four out of ten had done so among controls (66.3% versus 42.7%). Approximately nine out of ten respondents had a gainful occupation in both cases and controls. Approximately only six out of every hundred mothers in cases had made adequate ANC visits (≥4) during their pregnancy in the cases while thirty-eight out of every hundred mothers in the controls had not made any ANC visits during their pregnancy. More mothers of controls were aware of at least one VPD than mothers of cases (95% versus 45.2%).

Table 2. Sociodemographic characteristics of mothers/caregivers.

Characteristic	Case (n_1=89) n (%)	Control (n_2=356) n (%)	p
Age (years)			
Median and IQR	28 (33-23)	27 (32-23)	0.264
Age group (years)			0.720
17-24	34 (38.2)	152 (42.7)	
25-34	42 (47.2)	159 (44.7)	
35 and over	13 (14.6)	45 (12.6)	
Bond with child			0.673
Mother	87 (97.7)	345 (96.9)	
Babysitter	2 (2,3)	11 (3.1)	
Marital status			0.326
Living alone	9 (26.5)	25 (73.5)	

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In union	80 (19.5)	331 (80.5)	
Religion			0.001
Catholic	18 (20.2)	138 (38.8)	
Protestant	13 (14.6)	42 (11.8)	
Others	34 (38.2)	76 (21.3)	
Ethnic group			0.962
Lualua	42 (47.2)	167 (46.9)	
Others	47 (52.8)	189 (53.1)	
Level of study			<0.001
Never went to school	59 (66.3)	152 (42.7)	
Primary and more	30 (33.7)	204 (57.3)	
Occupation			0.007
Unpaid profession	11 (12.4)	27 (7.6)	
Remunerative profession	78 (87.6)	329 (92.4)	
Number of ANC (n_1=87 and n_2=345)			<0.001
Adequate visits (≥4)	5 (5.8)	132 (38.3)	
Inadequate visits (1-3)	25 (28.7)	147 (42.6)	
No visits	57 (65.5)	66 (19.1)	
Knowledge of vaccine-preventable disease			<0.001
Yes	38 (42.7)	339 (95.2)	
No	51 (57.3)	17 (4.8)	

n = number of subjects; % = percentage; IQR = interquartile range.

Table 3 shows the characteristics of the children aged 12-23 months in our study. The median age was 17 (20-14) months in cases and 17 (19-14) months in controls. In addition, the median upper arm circumference (MUAC) was 128 cm (IQR=120-132) in cases and 132 cm (IQR=127-140) in controls. Four out of ten children in the cases were born in Angola, while only approximately one in ten were born in the controls. approximately six out of the ten children among cases were born at home (58.4% versus 6.7%). None of the cases had a vaccination card.

Table 3. Characteristics of children aged 12-23 months.

Characteristic	Case (n_1=89) n (%)	Control (n_2=356) n (%)	p
Age (months)			
Median and IQR	17 (20-14)	17 (19-14)	0.548
Upper arm circumference (cm)			
Median and IQR	128 (132-120)	132 (140-127)	<0.001
Gender of child			0.999
Male	43 (48.3)	172 (48.3)	
Feminine	46 (51.7)	184 (51.7)	
Native country			<0.001
Angola	36 (40.4)	24 (6.7)	
DRC	53 (59.6)	332 (93.3)	
Place of birth			<0.001
Residence	52 (58.4)	26 (7.3)	
Healthcare establishment	37 (41.6)	330 (92.7)	
Vaccination card			<0.001
Yes	0 (0.0)	285 (80.1)	
No	89 (100.0)	71 (19.9)	
Rank in siblings			0.487
1-2nd	34 (38.2)	122 (34.3)	
3rd and above	55 (61.8)	234 (65.7)	

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n = number of subjects; % = percentage; IQR = interquartile range; DRC=Democratic Republic of the Congo. 2. Factors Associated with ZD Vaccine in Children Aged 12 to 23 Months in the Luambo HD.

After adjusting for independent variables, ZD status among children aged 12 to 23 months in the Luambo HD was significantly associated with mothers not having undergone ANC during their pregnancy (ANC ≥4) AOR=4.4 (95% CI=1.2 to 16.3; p=0.023) and not knowing any VDP AOR=13.3; 95% CI=4.6 to 38.4; p <0.001), children born in Angola AOR=3.2; (95% CI=1.1 to 9.8; p=0.046) and being born at home AOR=5.2 (95% CI= 2.1 to 12.5; p<0.001). A Summary of these findings are in Table 4.

Table 4. Bivariate and multivariate analysis of factors associated with "zero dose" status among children aged 12-23 months in the Luambo HD.

Features	Bivariate analysis			Multivariate analysis		
	OR	**95%CI**	**p**	**AOR**	**95%IC**	**p**
Age (years) head of household	1	0.9-1.0	0.788			
Gender of head of household						
Male	1	-				
Feminine	0.9	0.5-1.8	0.937			
Religion of head of household						
Catholic	1	-		1	-	
Protestant	3.7	1.4-7.6	0.006	3.8	0.9-16.8	0.074
Others	2.9	1.6-5.6	0.001	2.7	0.8-8.3	0.087
Ethnicity of head of household						
Lualua	1	-				
Others	0.9	0.4-1.9	0.710			
Education level of head of household						
Never went to school	1	-		1	-	
Primary and more	0.3	0.2-0.6	**<0.001***	0.8	0.3-2.1	0.709
Profession of head of household						
Unpaid profession	1	-		1	-	
Re Remunerative profession	0.5	0.3-1.0	**0.062**	0.8	0.3-2.0	0.589
Age (years) of mothers/guardians	1.0	0.9-1.0	0.434			
Marital status of mothers/guardians						
Living alone	1	-				
In union	0.7	0.3-1.5	0.346			
Education level of mothers/caregivers						
Never went to school	1	-		1	-	
Primary and more	0.3	0.2-0.6	**<0.001***	0.9	0.4-2.2	0.837
Occupation of mothers/caregivers						
Unpaid profession	1			1		
Remunerative profession	0.6	0.3-1.4	**0.020***	0.7	0.2-2.4	0.557
Number of ANCs						
Adequate visits (≥4)	1			1		
Inadequate visits (1-3)	4.8	1.8-12.7	**0.002***	3.2	0.9-10.8	0.056
No visits	21.5	8.1-57.4	**<0.001***	4.4	1.2-15.4	**0.023***
Knowledge of at least one MPV						
Yes	1	-		1	-	
No	29.9	12.8-69.9	**<0.001***	13.3	4.6-38.4	**<0.001***
Child's country of birth						
DRC	1	-		1	-	
Angola	11.6	5.7-23.6	**<0.001***	3.2	1.1-9.8	**0.046***
Place of delivery of the child						

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	Healthcare establishment	1	-		1	-	
	Residence	16.3	8.4-31.4	**<0.001***	5.2	2.1-12.5	**<0.001***
Rank in the child's siblings							
	1-2nd	1	-				
	3rd and above	0.8	0.5-1.4	0.456			

n = number of subjects in the sample; OR = Odd Ratio; AOR = Adjusted Odd Ratio; 95% CI = 95% Confidence Interval.

III.2. Qualitative results

Group discussions with revealed that mothers' perceptions influence children's vaccination. According to the mothers of full immunized children, the majority of mothers vaccinate their children but they do not follow the vaccination schedule. On the other hand, a tiny minority confirmed that many who refuse to have their children vaccinated because of fever and incessant crying they experience vaccination. A mother declared: "*No, they all vaccinate, but it is just that many stop vaccinating their children*". Another mother put it another way: "*Yes, many refuse because of the children's crying and the pain caused by vaccines. They say vaccines make children sick.* »

Fathers also play an important role in the vaccination of their children. There are husbands who, because of their negative perception of vaccination, refuse to allow their wives to come to the health center for ANC and for the vaccination of their children, and this is a barrier to vaccination of children. One mother said: "*They tell you that since the time of our grandparents and great-grandparents, they did not get vaccinated, were they not growing up well? They grew up without problems.* Another mother added: "*Others say that they have children so that the nurses can start taking money from their children, while they don't benefit from anything. Nurses and community health workers are paid when their children are vaccinated while the parents are not. Therefore, to avoid enriching nurses on their children's backs, it is better not to bring children for vaccination. Therefore, we work in vain to make the nurses and community health workers rich. We only remember the community health workers and the nurses without remembering those who make these children. You who waste this money should vaccinate your children*".

For mothers of ZD and under vaccinated children, the following reasons were given for not respecting the vaccination schedule, noting the problems the children suffered after receiving the vaccines. These include fear of side effects (crying and pain at the injection site), the child's mother's illness, lack of vaccines at the health center, AEFI (swelling in the right thigh, fever), expensive care after vaccination, the distance between at home and the health center, the absence of the child's father and the lack of moral support. A mother of an under vaccinated child declared that: "*Because every time we vaccinated him, he got sick until he was taken to the health center again for treatment. And every time I took him to the health center, they demanded to pay for the treatment. So, I had to give up, because it was a lot of work*". A mother of a ZD child added: "*I was afraid because of my child who comes immediately before this one. He had fallen seriously ill after receiving the vaccines. We left with his eldest and after receiving the vaccines, he suffered a lot. therefore, we were afraid that this one would also fall ill like his predecessor"*.

When asked what would happen to a child who is not vaccinated, most mothers of ZD children believe that neither humans nor vaccines have any power over a child's life. It is God who decides on the lives of humans because illness does not choose children to catch. Whether he is vaccinated or not, he will catch the disease. All the children get sick. As one mother put it: "*Everything depends on God. Whether the child is vaccinated or not, if God decides he's going to die, he'll die even if he's vaccinated. Even if he is not vaccinated, nothing can happen to him without God's will*.

With regard to the importance of childhood vaccination, the majority of ZD mothers noted that they were unaware of the importance of vaccination because since they were pregnant, they had not heard about the necessity and the importance of vaccinating children given that they lived in Angola, they did not receive this information. A tiny minority recognized the importance of vaccination. One mother declared: "*I too don't know the importance of vaccinating children. In Angola where I was, I had never heard of it*". Another mother added: "*I never knew the importance of vaccination. Moreover, I'm not interested in vaccinating children.*

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With regard to the perception of vaccination by those around them, mothers of children noted that people's opinions are divided. A mother of an under vaccinated child said : "*There are those who appreciate vaccinating children. Sometimes, you can be in a state of lethargy and you see someone who comes to make you aware to tell you: "but we shouted that there is vaccination of children today but why are you dragging to bring the child to the vaccination? Because vaccines are effective and help children a lot"*. Another added in these terms: "*When they see that the child is sick after having been vaccinated, they tell you: "that we told you that vaccines cause illnesses in children but you did not stubborn to bring your child. I cannot bring my child for vaccination. Now, you will have to go and pay the costs of care at the health center*". A mother of a ZD child commented: "*In my neighborhood, a lot of people say it's not a good idea to have children vaccinated. Vaccines cause many illnesses in children. Others also agreed that is good to send children for vaccination. Opinions differ between people*".

4. Discussion

The present study was carried out to analyze the factors associated with the ZD status of children aged 12-23 months in the Luambo health district in Kasai Central. This study showed that accessibility to adequate prenatal care services for the mothers was a factor influencing the ZD status of children aged 12-23 months. The study observed that mothers who had not used the ANC services were more likely to not fully vaccinate their children compared to mothers who had completed the recommended ANC visits (≥4). These results are in line with those found in previous studies which showed a statistically significant association between the number of ANC attended and childhood immunization [14–17]. ANCs are opportunity for the future mothers to receive advice from health personnel on the consequences of pregnancy, childbirth and care for the newborn, including vaccination. Mothers who do not attend these services are deprived of this advice, which may explain why they are more likely to have ZD children.

Mothers unaware of any vaccine-preventable diseases were more likely not to vaccinate their children. This result is similar to that of Udessa G et al. in Ethiopia [18]. This strong association can be explained by the fact that childhood vaccination is a practice and one of the determinants of good practice is having knowledge [18]. Not having knowledge about vaccination and vaccine-preventable diseases can decrease or inhibit the practice of childhood vaccination. A lack of knowledge about vaccination and vaccine-preventable diseases can also reduce or inhibit the fear that the absence of vaccines may put children at risk of different diseases, therefore, mothers cannot be induced to vaccinate their children.

The study also showed that being born at home increases the likelihood of child of being ZD, compared with being born in a health care facility. Similar results were published in previous studies in the DRC [19], in East Africa [20], Guinea [14], Cameroon [21], India [22] and Turkey [23]. This can be explained by the fact that mothers who give birth at home are mainly those who do not attend ANC during their pregnancies. In addition, giving birth at home deprives children of the vaccination card, which is a tool for planning future appointments. This would lead mothers not to appreciate the benefits of vaccination and not to have their children vaccinated. On the other hand, in addition to having a safe delivery by health professionals, the fact of being born in a healthcare establishment would present an additional advantage in postdelivery follow-up and vaccination related information provided by health professionals. The information included maternal education on vaccination and other maternal and child health care, which could increase mothers' practice of vaccinating their children [19]. This finding highlights the need to inform and sensitize pregnant women about the importance of ANC, institutional delivery for maternal and child health and its impact on child immunization. Nevertheless, as long as some women continue to give birth at home, it will be necessary to pay special attention to these children and administer the necessary vaccines. In these communities, a context-specific approach, such as using mobile clinics and working with traditional birth attendants to identify and vaccinate children at birth, will significantly improve immunization coverage.

The study also showed that children born in Angola were more likely to be ZD. This may be due to the fact that most mothers who go to Angola give birth at home because the majority live in mining

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camps, which does not allow them to easily access maternal and child care. Moreover, it has been proven that the place of residence of the mother plays a large role in the complete vaccination of children [24]. It was shown in a study conducted in Ethiopia that children of mothers living in rural areas were more likely to be unvaccinated than those living in urban areas. Particular attention should be paid to disadvantaged mothers by raising awareness about the importance of childhood vaccination [24].

Unlike other studies that have demonstrated a significant association between maternal education and child vaccination status [17,25–27], our study found no significant association between maternal education and the ZD status of the children. This finding is consistent with a study conducted in Uganda that found no significant association between maternal education and child vaccination status [28]. This could be due to the fact that the study participants although they were in school, they retained negative beliefs and perceptions about childhood vaccination.

The study also showed that mother's perceptions of child vaccination differ from each other. Some mothers have a good perception and believe that through vaccination, children are immunized against vaccine-preventable diseases and have fewer health problems that can weaken their growth. However, mothers of ZD children believe that vaccines do not help children but instead put families at risk by causing fevers and other illnesses that deprive families and lead them to pay for medical care. They even think that neither men nor vaccines have any power over the life of a child. It is God who decides on the lives of humans because illness does not choose children to catch. Whether the individual is vaccinated or not, catching the disease or not depends on God. These results show that mothers and fathers of children have a negative perception of childhood vaccination which is linked to habits and customs. This leads them to stop vaccinating their children or not to vaccinate them at all. On the other hand, this negative perception is also linked to a deficit of communication between vaccination service providers and mothers and/or babysitters. Health professionals may not communicate sufficiently with mothers, especially regarding AEFI. This insufficiency leads parents to stop vaccinating their children. In addition, given that some mothers do not attend ANC, educational talks focused on vaccination should be organized in the community with the mothers and fathers of children to help them understand the merits of vaccination and thus improve coverage vaccination in the Luambo HD.

Strengths and limitations

The greatest strength of our study is the design used and combination of mixed methods (quantitative and qualitative). However, the case-control design does not make it possible to establish a causal relationship. Additionally, this study did not assess supply-side factors such as type of nearby health facility, type of health professional providing vaccination services, availability of vaccines and supply shortage periods. in the HD, which are likely to influence child immunization. Finally, the study did not investigate the causes of birth at home.

5. Conclusions and recommandations

The results showed that the missing ANC services during pregnancy leads to home delivery with consequences being a lack of knowledge about childhood vaccine preventable diseases and subsequently children not being vaccinated. This study highlights the need to strengthen maternal and child health services through the creation of health posts, and mobile clinics and collaboration with traditional birth attendants. Furthermore, interventions to increase vaccination uptake should target not only mothers but also fathers of children. Finally, the introduction of a free vaccine-preventable disease support package in routine EPI as suggested some mothers will significantly reduce the proportion of under vaccinated children.

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Informed Consent Statement: Written informed consent was obtained from the study participants. The research team provided the respondent with information on the nature of the study, its objectives, the risks and benefits involved, the freedom to participate or not without any prejudice.

Data Availability Statement: The datasets used and/or analyzed during the current study available from the corresponding author on reasonable request.

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References

1. WHO. Regional Office for Africa. Immunization. Available online: https://www.who.int/healt-topics/immunization (accessed 10/20/2022 at 10:32 a.m.)
2. Kurayi Mahachi, Joss Kessels, Kofi Boateng, Anne Eudes Jean Baptiste, Pamela Mitula, Ebru Ekeman, Laura Nic Lochlainn, Alexander Rosewell, Samir V. Sodha, Bernadette Abela-Ridder, Albis Francesco Gabrielli, Zero- or missed-dose children in Nigeria: Contributing factors and interventions to overcome immunization service delivery challenges, Vaccine, Volume 40, Issue 37, 2022, Pages 5433-5444, ISSN 0264-410X, https://doi.org/10.1016/j.vaccine.2022.07.058.
3. Division I. Global routine vaccination coverage, 2018 – Global routine immunization coverage, 2018. Wkly Epidemiol Rec = Weekly epidemiological record. 2019; 94(43):498–504.
4. Second Demographic and Health Survey 2013-2014 p. 141-142
5. The multiple indicator cluster survey with malaria component (MICS6-Palu, DRC, 2017-2018) p. 162-166.
6. Ishoso DK, Danovaro -Holliday MC, Cikomola AM-W, Lungayo CL, Mukendi JC, Mwamba D, Ngandu C, Oil E, Lusamba Dikassa PS, Lulebo A et al. "Zero dose" children in the Democratic Republic of the Congo: how many and who are they? *Vaccines*. 2023; 11(5): 900. https://doi.org/10.3390/vaccines11050900).
7. ESP. Study Report ECV2021.
8. Ministry of Public Health of the DRC. *Emergency Plan for the Relaunch of Routine Vaccination Known as the "Marshall Plan on Routine Vaccination" (MASHAKO Plan). Expanded Vaccination Program*; Ministry of Public Health of the DRC: Kinshasa, Democratic Republic of Congo, July 2018. [Google Scholar]
9. Kirkby K, Bergen N, Schlotheuber A, Sodha S V., Danovaro -Holliday MC, Hosseinpoor AR. Subnational inequalities in diphtheria–tetanus–pertussis immunization in 24 countries in the African region. Bull World Health Organ. 2021;99(9):627–39;
10. PAO, Consolidated Operational Action Plan of the Luambo Health district 2023
11. PEV, comprehensive multi-year plan of the PEV of the Democratic Republic of Congo 2015-2019
12. Atnafu A, Andargie G, Yitayal M, Ayele TA, Alemu K, Demissie GD, et al. Prevalence and determinants of incomplete or not at all vaccination among children aged 12 – 36 months in Dabat and Gondar districts, northwest of Ethiopia: findings from the primary health care project. 2020 1–6.
13. Dupont, William D. "Power Calculations for Matched Case-Control Studies." *Biometrics* 44, no. 4 (1988): 1157–68. https://doi.org/10.2307/2531743 .
14. Diallo MD. Factors Associated with Complete Vaccination in Children 12 to 23 Months in Guinea. 2021;80–97.
15. Gualu T, Dilie A. Vaccination Coverage and Associated Factors among Children Aged 12 – 23 Months in Debre Markos Town, Amhara Regional State, Ethiopia. 2017; 2017:1–7.

16. Fatiregun AA, Etukiren EE. Determinants of uptake of third doses of oral polio and DTP vaccines in the Ibadan North Local Government Area of Nigeria. 2014;(May) :213–24.
17. Ozigbu CE, Olatosi B, Li Z, Hardin JW, Hair NL. Correlates of Zero-Dose Vaccination Status among Children Aged 12–59 Months in Sub-Saharan Africa: A Multilevel Analysis of Individual and Contextual Factors. Vaccines. 2022 ;10(7) :1–16.
18. Udessa G, Sena L, Berhanu S. Health Care : Current Reviews Vaccination Status and Factors Associated With It among Children Aged 12- 23 Months in Wadera District, South East Ethiopia. 2018 ;6(2).
19. Acharya P, Kismul H, Mapatano MA, Hatl A. Individual- and community-level determinants of child immunization in the United States: A multilevel analysis. 2018 ;1–17.
20. Tesema GA, Tessema ZT, Tamirat KS, Teshale AB. Complete basic childhood vaccination and associated factors among children aged 12 – 23 months in East Africa: a multilevel analysis of recent demographic and health surveys. 2020 ;1–1
21. Nchinjoh SC, Saidu Y, Agbor VN, Mbanga CM, Muteh NJ, Njoh AA, et al. Factors Associated with Zero-Dose Childhood Vaccination Status in a Remote Fishing Community in Cameroon: A Cross-Sectional Analytical Study. 2022; 1–11.
22. Shrivastwa N, Gillespie BW, Kolenic GE, Lepkowski JM, Boulton ML. Predictors of Vaccination in India for Children Aged 12-36 Months. Am J Prev Med [Internet]. 2015;49(6): S435–44. Available from: http://dx.doi.org/10.1016/j.amepre.2015.05.008.
23. Eryurt MA, Yalçin SS. Zero - dose children in Turkey: regional comparison of pooled data for the period 1990 to 2018. BMC Infect Dis [Internet]. 2022 ;1–14. Available from: https://doi.org/10.1186/s12879-022-07416-0
24. Chikako TU, Seidu A, Hagan JE, Aboagye RG. Bayesian Analysis of Predictors of Incomplete Vaccination against Polio among Children Aged 12 – 23 Months in Ethiopia. 2021;1–12.
25. Tesema, G.A.; Tessema, Z.T.; Tamirat, K.S.; Teshale, A.B. Complete basic childhood vaccination and associated factors among children aged 12–23 months in East Africa: A multilevel analysis of recent demographic and health surveys. BMC Public Health 2020, 20, 1–14.
26. Oleribe, O.; Kumar, V.; Awosika-Olumo, A.; Taylor, S.D. Individual and socioeconomic factors associated with childhood immunization coverage in Nigeria. Pan Afr. Med. J. 2017, 26, 220.
27. Feyisetan, B.J.; Asa, S.; Ebigbola, J.A. Mothers' management of childhood diseases in Yorubaland: The influence of cultural beliefs. Health Transit. Rev. Cult. Social. Behav. Determ. Health 1997, 7, 221–234.
28. Herliana P, Douiri A. Determinants of immunization coverage of children aged 12–59 months in Indonesia: a cross-sectional study. BMJ Open 2017; 7: e015790 https://doi.org/10.1136/bmjopen-2016-015790 PMID: 29275336