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Determinants of Missed Vaccination Opportunities for Children Aged 0 - 23 Months in the City of Garoua under the Expanded Program on Immunization

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Abstract

Introduction: To enhance vaccination coverage, a study was conducted to identify the determinants of missed Expanded Program on Immunization (EPI) vaccination opportunities among children aged 0 to 23 months in the city of Garoua, Cameroon. **Methodology:** This was a cross-sectional analytical study carried out from October 2023 to May 2024 in the Garoua 2 health district of Cameroon. A three-stage sampling method was employed: selection of the health area (first stage), health facility (second stage), and infants (third stage) whose mothers/guardians were interviewed. A total of 390 children attended the various health facilities, and 300 mothers agreed to respond to the questionnaire. Data were recorded in a pre-prepared form and analyzed using SPSS version 25.0. Qualitative data were compared using the chi-square test, with $p < 0.05$ considered statistically significant. Ethical considerations were observed. **Results:** The prevalence of Missed Vaccination Opportunities (MVOs) in the city of Garoua was 44.1%. Among the 300 children, 79.3% had an incorrect vaccination status and 83% had incomplete vaccination status. Vaccination completeness was 17%, with BCG and the third dose of pentavalent vaccine being the most frequently missed. Zero-dose children accounted for 13.3%. Factors associated with incorrect vaccination status included: mother's age between 21 and 30 years, uneducated mothers, household monthly income below 50,000 CFA, and nomadism. Factors related to mothers' knowledge about the importance of vaccination, lack of awareness of EPI target diseases, and fear of adverse events factors related to the health facility such as non-functional or absent cold chain and health center location and factors related to health

personnel such as lack of education on management of adverse events and multi-dose vaccine packaging were all statistically associated with incorrect vaccination status. **Conclusion:** Specialization of vaccination services with separation of care units is necessary to optimally improve vaccination coverage in this population.

Keywords

Determinants, Missed Vaccination Opportunity, EPI, Children, Cameroon

1. Introduction

Missed Vaccination Opportunities (MVOs) are defined as any visit to a healthcare facility by a child or adult eligible for vaccination—whether unvaccinated, partially vaccinated, not up to date, and with no contraindications—that does not result in the administration of all vaccine doses for which the individual is eligible [1]. MVOs serve as a key indicator of the quality of immunization services and provide insight into overall vaccination coverage [2].

The Expanded Program on Immunization (EPI) aims to prevent the occurrence of vaccine-preventable diseases, particularly among children aged 0 - 23 months, pregnant women, and girls aged 9 to 13 years; MVOs need to be addressed in all districts, and promising areas could be implemented with research strategies [3]. According to the World Health Organization (WHO), global immunization coverage has shown improvement; by 2022, coverage for the third dose of the diphtheria, tetanus, and pertussis vaccine (DTP3) increased from 81% in 2021 to 84% [4].

A cross-sectional study conducted in West Africa identified several factors contributing to MVOs among children aged 12 - 59 months, including home births, parental illiteracy, and adherence to traditional beliefs such as animism [5]. Failure to meet EPI targets among children under five is largely attributed to missed vaccination opportunities [6]. Despite substantial efforts by governments and international partners, immunization coverage in children under five remains suboptimal in low-income countries [7].

The primary objective of this study was to determine the prevalence and associated factors of missed EPI vaccination opportunities among children aged 0 - 23 months in Garoua, Cameroon. The findings aim to inform strategies to enhance immunization coverage and guide targeted interventions to reduce missed opportunities for vaccination in this age group.

2. Methodology

This was a cross-sectional, analytical study with prospective data collection conducted from October 2023 to May 2024 in the Garoua 2 Health District, Cameroon.

A three-stage sampling method was employed:

1) First stage—Health Area Selection: Health areas were selected through simple random sampling. The name of each area was written on a slip of paper, and the selected areas were drawn at random.

2) Second stage—Health Facility Selection: Within each selected health area, a list of health facilities was compiled and numbered. The facility corresponding to the randomly drawn number was selected first.

3) Third stage—Participant Selection: At each health facility, the exit interview method, recommended by the World Health Organization (WHO) [1], was used. All mothers leaving the facility with a child aged 0 - 23 months were invited to participate. The study objectives were explained to them, and informed consent was obtained before the interview.

The interviewers consisted of trained vaccinators and medical students who were already present in the health facilities. They were selected based on prior experience in immunization services and fluency in the local language.

The study population included infants aged 0 to 23 months residing in the Garoua 2 Health District for at least one year. Information was provided by the mother or, in her absence, an adult (≥15 years) with sufficient knowledge of the child's vaccination history. Informed consent was obtained from all participants.

4) Sample size determination

The minimum sample size was calculated using Lorenz's formula:

$$N = \frac{t^2 * p(1-p)}{m^2}$$

N = Required sample size.

t = 95% confidence level (standard value 1.96).

p = Estimated prevalence of Missed Opportunities for Vaccination (MOV) = 23, 83% obtained from the work of Dombou Zeufack *et al.* (2023) in the Dschang health district, West Cameroon region [2].

m = Margin of error at 5% (standard value of 0.05). Numerical application:

$N = [(1.96)^2 * 0.2383\ (1 - 0.2383)]/(0.05)^2 = 278.92$. A total of 300 infants were selected.

5) Immunization status assessment

Vaccination status was determined using either the child's vaccination booklet or the health facility's immunization register. An infant under one year of age is regarded as fully immunized when all antigens included in the national immunization schedule have been administered at the recommended ages and intervals, in accordance with WHO guidelines [8] [9]:

- Bacillus Calmette-Guérin (BCG).
- Three doses of Pentavalent vaccine (DTP-HepB-Hib).
- Three doses of Oral Polio Vaccine (OPV).
- One dose of Inactivated Polio Vaccine (IPV).
- Pneumococcal Conjugate Vaccine (PCV13).
- Measles vaccine.
- Yellow fever vaccine.

Children were also considered fully vaccinated if they received all scheduled vaccines with appropriate minimum intervals between doses. Those who do not comply with this principle are considered "incomplete vaccination status", and those who did not follow the vaccination schedule are considered "incorrect vaccination status".

Missed vaccination opportunities were assessed using the total number of children who attended the facility during the survey period (390 infants). Determinants or factors associated, however, were analyzed based on the responses of participants who completed the full questionnaire (300 infants).

Data Analysis and Ethics

Data were recorded on a predesigned collection form and analyzed using SPSS version 25.0. Qualitative variables were compared using the chi-square test, with $p < 0.05$ considered statistically significant.

All ethical standards for research involving human subjects were followed. The study was approved by the National Ethics Committee (Clearance No. 0071/CERSH/NO/2024).

3. Result

3.1. Study Population

During the study period, a total of 390 mother-child pairs were in contact with the selected health facilities. Among them, 300 mothers agreed to participate and completed the questionnaire. The remaining 90 children were excluded due to the unavailability of vaccination records, absence from the center's immunization register, or refusal to participate.

3.2. Maternal Characteristics

The mean age of mothers was 23.1 ± 0.75 years. The majority (56%) were aged between 21 and 30 years, while 7.3% were over 35. In terms of education, 42.3% had attained secondary education, 34.7% primary, 18.7% were uneducated, and 4.3% had university-level education. Most mothers were Muslim (63%), with Christians accounting for 32.7%. The majority were married (78%) and housewives (69.3%). Monthly household income was less than 50,000 CFA francs for 82.7% of participants.

3.3. Infant Characteristics

The most represented age group among infants was 3.5 months (18.66%), while the least represented was 11 months (1.7%). Girls accounted for 55.33% of the sample, resulting in a sex ratio of 0.81 (male/female). The majority of infants (70.67%) had their vaccination record booklets at the time of the survey; for the remaining 29.33%, data were obtained from the health facility's immunization registers due to forgotten or lost booklets.

Prevalence of Missed Vaccination Opportunities

Missed Vaccination Opportunities (MVOs) were assessed for all 390 children

attending the health facilities, regardless of participation. Of these, 172 children (44.1%) were not vaccinated during their visit. The prevalence of MVOs for children aged 0 - 23 months in this population was 44.1% for all vaccines combined.

High vaccination coverage was observed for BCG/VPO-0 (86.7%) and Penta 1 (81.6%), while the lowest coverage was for the third dose of vitamin A (3.7%) and the second dose of RR (9.4%). The most frequently missed vaccines were BCG/VPO-0 (13.3%) and Penta 3 (13%), while Penta 1 (6%) and Vit A dose 3 (3.7%) were the least missed.

A total of 13.3% of children were classified as zero-dose, having never received any vaccine. Incorrect vaccination status was found in 79.3% of children, and incomplete vaccination in 83%.

3.4. Factors Associated with Incomplete Vaccination

Among the 300 mothers surveyed, 41% considered vaccination days to be convenient, while 59% preferred not to have fixed vaccination days at health facilities. Most mothers (82.7%) lived less than 5 km from the health facility; only 4.7% travelled more than 10 km. Few mothers (2.7%) reported poor reception by health staff, but a large majority (68%) complained of long waiting times (more than 2 hours) (Table 1).

Table 1. Socio-demographic characteristics of mothers and children (n = 300).

Variables	Modalities	n	%
Mother's age	15 - 20 years old	30	10.0
	21 - 30 years old	168	56.0
	31 - 35 years	80	26.7
	>35	22	7.3
Education level	Primary	104	34.7
	Secondary	127	42.3
	University	13	4.3
	Uneducated	56	18.7
Religion	Muslim	189	63.0
	Christian	98	32.7
	Other	13	4.3
Marital status	Married	234	78.0
	Single	50	16.7
	Divorced	15	5.0
	Widowed	1	0.3
Profession	Housewife	208	69.3
	Tradeswoman	35	13.3
	Civil servant	17	11.7
	Other	40	5.7

Continued

Household income (FCFA)	<50,000	248	82.7
	50,000 - 100,000	38	12.7
	>100,000	14	4.7
Child's age	0 - 1 month and a half	52	17.3
	2 months and a half	10	3.3
	3 months and a half	56	18.7
	6 months	49	16.3
	9 months	43	14.3
	11 months	5	1.7
	12 months	25	8.3
	15 months	32	10.7
	18 - 23 months	28	9.3
Gender of child	Male	134	44.7
	Female	166	55.3

Although 91% of mothers had received information on their next vaccination appointment, 98% reported not receiving any education about Adverse Events Following Immunizations (AEFIs) or the recommended response. Fear of side effects was cited by 9.7% of mothers as a reason for missed vaccination.

No statistically significant association was found between child vaccination status and religion, marital status, or maternal occupation. However, significant associations were observed between incorrect vaccination status and the following maternal factors:

- Age between 21 - 30 years (P = 0.011).
- Lack of education (P = 0.040).
- Monthly household income < 50,000 CFA (P = 0.000) (Table 2).

Table 2. Correlation between correct vaccination status and socio-demographic characteristics.

Variables	Modalities	Yes	No	P-value	OR (95% CI)
Mother's age	15 - 20 years	8	22	0.660	1.563 (0.213 - 11.439)
	21 - 30 years	22	146	0.011	0.155 (0.036 - 10656)
	31 - 35 years	18	62	0.065	0.258 (0.061 - 1.089)
	>35 years	14	8		
Education level	Primary	16	88	0.155	0.438 (0.140 - 1.366)
	Secondary	22	105	0.442	1.700 (0.440 - 6.573)
	University	3	10	0.417	0.402 (0.044 - 3.639)
	Uneducated	21	35	0.040	3.59 (1.02 - 12.42)
Religion	Muslim	42	147	0.991	0.000
	Christian	20	78	0.991	0.000
	Other	0	13	NA	NA

Continued

Marital status	Married	49	185	1.000	4.656 (0.000 - 0.001)
	Single	5	45	1.000	1.150 (0.000 - 0.012)
	Divorced	8	7	1.000	10.767 (0.000)
	Widowed	0	1	NA	NA
Monthly household Income (In CFA)	<50,000	40	161	0.000	1.562 (0.085 - 0.155)
	50,000 - 100,000	15	54	0.452	2.318 (0.340 - 1.085)
	>100,000	6	22	0.125	6.420 (0.276 - 0.642)
Profession	Housewife	41	167	0.768	1.365 (0.172 - 10.829)
	Shopkeeper	7	28	0.128	5.170 (0.625 - 42.771)
	Civil servant	4	13	0.214	10.282 (0.260 - 406.451)
	Other	10	30	NA	NA

Incorrect child immunization status was also significantly associated with:

- Lack of maternal knowledge about the importance of immunization (P = 0.024).
- Inability to name an EPI-target disease (P = 0.040).
- Insufficient health personnel to open a vaccine vial (P = 0.030).
- Fear of adverse events (P = 0.000).
- Nomadic lifestyle (P = 0.010).
- Vaccine unavailability due to cold chain failure (P = 0.050).

No association was found between vaccination status and mothers' perception of the facility's organizational structure. However, a statistically significant link existed between incorrect vaccination status and living at a distance of 5 - 10 km from the health facility (P = 0.0015) (Table 3).

Table 3. Association between incorrect vaccination status and reasons for non-continuation/non-vaccination of the child.

Variables	Modalities	Yes (n, %)	No (n, %)	OR	95% CI
Staff-related	Nurse said child could not be vaccinated	3 (1.7)	4 (2.3)	2.31	(1.05 - 4.98)
	Insufficient number of staff	8 (4.7)	7 (4.1)	1.16	(0.36 - 7.01)
	Waiting time too long	0 (0.0)	6 (3.5)	0	(0 - 40.42)
	Carnet not free of charge	2 (1.2)	0 (0.0)	8.71	(1.83 - 62.33)
Mother-related	Household activities	16 (9.3)	26 (15.1)	3.82	(1.29 - 11)
	Forgot to bring child	21 (12.2)	0 (0.0)	9.6	(1.01 - 19.46)
	Didn't have time	11 (6.4)	6 (3.5)	1.3	(0.4 - 3.2)
	Nomadic	11 (6.4)	0 (0.0)	NA	
Structure-related	Lack of cold chain	0 (0.0)	7 (4.1)	NA	
	No daily service	0 (0.0)	13 (7.6)	NA	
	Unavailability of staff	2 (1.2)	9 (5.2)	NA	

4. Discussion

Females represented 55.33% of the study population, consistent with the findings of Isabelle *et al*., who reported 53.6% in Yaoundé in 2024 [10]. The mean age of mothers was 23.1 ± 0.75 years, closely aligning with that found by Kaboré *et al*. (26.37 ± 0.35 years) [11].

The overall prevalence of Missed Opportunities for Vaccination (MVO) in this study was 44.1%. This rate exceeds the 23.83% reported by Dombou Zeufack *et al*. in 2023 in the Dschang health district (West Cameroon) [2], and closely approaches the 40.1% recorded by Ndwandwe *et al*. in South Africa in 2020 [12]. However, it remains lower than the 57.5% observed by Isabelle *et al*. in Yaoundé [10]. These variations highlight the persistent challenge of achieving optimal vaccination coverage, as MVOs significantly increase the risk of vaccine-preventable disease outbreaks. Strengthening the organization of vaccination services is therefore imperative.

Immunization services require special attention. They should be separated from general care activities, with dedicated and specifically trained personnel. Currently, vaccinators are often general nurses temporarily assigned to immunization duties. There is an urgent need to professionalize this cadre with appropriate training and to structurally separate vaccination units from curative services.

The immunization card retention rate in this study was 70.67%, higher than that reported by Baonga Ba Pouth *et al*. in Djoungolo in 2014 (66.7%) [13].

The most frequently missed vaccines in the present study were BCG/VPO-0 (13.3%) and the third dose of Penta (13%). Since BCG is a multi-dose vaccine, providers often wait for several children before opening a vial, this practice within the health system explains why BCG, a multi-dose vaccine, was among the most frequently missed doses. The strongest associations were found for no vaccinations and no BCG in relation to 4+ ANC visits, with a 51% lower coverage (P-value < 0.001) [14].

Vaccination completeness in our sample was only 17%, much lower than the 50.3% reported by Nguefack *et al*. in Yaoundé in 2018 [15]. The proportion of fully vaccinated children was 20.7%, below the 36% reported in the 2018 Demographic and Health Survey [16]. The percentage of zero-dose children (13.3%) was lower than the 18% reported by Dombou Zeufack *et al*. in 2023 [2].

Factors Associated with Vaccine Non-Adherence

Fear of adverse reactions was cited by 9.7% of mothers as a reason for non-vaccination. This concern, which can even exist among healthcare workers, contributes to vaccine hesitancy [17]. It reflects a lack of awareness about adverse events and how to manage them.

Additionally, 59% of mothers were opposed to vaccination being offered only on specific days. This is consistent with the findings of Ouédraogo *et al*. in Burkina Faso, where only 30.7% of centers offered daily immunization services [18]. Strengthening fixed-site services and increasing the number of national immunization days could help address this issue.

Cold chain disruption was cited by 4.3% of mothers as a reason for missed vaccination—lower than the 21.1% reported by Nguefack *et al*. [15]. This points to logistical weaknesses in some centers. While 60% of mothers were satisfied with reception at vaccination sites (lower than the 93.1% reported by Ouédraogo *et al*. [18]), only 4.7% complained about long waiting times. This contrasts with the 17% reported by Ouédraogo *et al*. [18], respectively. These differences may be due to vaccinators being overextended, often managing consultations and other tasks in addition to immunization.

Although 91% of mothers reported being given a follow-up appointment, 98.3% said they had received no information regarding Adverse Events Following Immunization (AEFIs), unlike in Ouédraogo's study, where 63.8% had been informed [18]. This gap could be due to staff overload.

Regarding staff-related issues, 10.7% of mothers reported that vaccination was missed because there were not enough personnel to open a multi-dose vial. This practice—delaying vaccination to avoid wasting doses—is a known contributor to MVOs [19]. The introduction of single-dose vials could help overcome this constraint.

Study Limitations

A total of 90 children were excluded due to parental refusal to participate in the study or the absence of a vaccination card. This may have affected, in this study, the prevalence of missed vaccination opportunities and their determinants, as complete data were not available for a full analysis While this study provides important insights into barriers to vaccination coverage, several limitations must be acknowledged: According to WHO guidelines, a complete assessment of MVOs requires the administration of two questionnaires—one for caregivers and one for healthcare providers [20]. This study included only caregiver responses. The study period coincided with a national vaccination campaign, which may have reduced the number of MVOs and zero-dose children, potentially biasing results. In cases where vaccination booklets were unavailable, missing data from facility registers may have led to omitted variable bias.

5. Conclusions

The prevalence of Missed Opportunities for Vaccination (MVOs) among children aged 0 to 23 months in the Garoua 2 health district was 44.1%. MVOs were associated with socio-demographic factors such as young maternal age, low educational attainment, and household income below 50,000 FCFA. Additional determinants included a lack of maternal knowledge about vaccination, fear of adverse events, nomadic lifestyle, vaccine stockouts due to cold chain issues, and insufficient qualified personnel.

These findings highlight the urgent need for targeted interventions, including:

- Strengthening health education and community awareness.
- Professionalizing and dedicating vaccination personnel.
- Expanding fixed and outreach vaccination strategies.

- Enhancing cold chain logistics and introducing single-dose vials.
- The separation of curative and vaccination services would enable vaccination staff to dedicate more time to educating parents about potential vaccine side effects, as well as coordinating multi-dose vaccinations and setting precise follow-up appointment dates.

Such measures could significantly improve immunization coverage and sustainably reduce MVOs in the region.

Conflicts of Interest

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

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