

ORIGINAL ARTICLE

Innovative approach in assessing the children's immunization status when it cannot be documented

JEROME ATEUDJIEU¹⁻³, KETINA HIRMA TCHIO-NIGHIE¹, MARTIN NDINAKIE YAKUM¹,
ANDRÉ PASCAL GOURA¹, LAPIA AMADA¹, ISAAC SONKOUA¹,
BLAISE WAKAM NKONTCHOU^{4,5} and BRUNO KENFACK^{6,7}

¹Department of Health Research, Meilleur Accès aux soins de Santé (M.A. SANTE), Yaoundé;

²Division of Health Operations Research, Ministry of Public Health; ³Department of Public Health, Faculty of Medicine and Pharmaceutical Sciences, University of Dschang, Dschang;

⁴Expanded Program of Immunization, Ministry of Public Health, Yaounde; ⁵Bill and Melinda Gates Foundation; ⁶Department of Gynecology and Obstetrics, Faculty of Medicine and Pharmaceutical Sciences, University of Dschang; ⁷Department of Gynecology and Obstetrics, Dschang District Hospital, Dschang, Cameroon

DOI: 10.4081/jphia.2023.2450

Abstract. During surveys, it is recommended that children immunization status should be based on immunization documents. It has been noted that in some communities, a number of children are claimed to be vaccinated but have no evidence of vaccination. This work is proposed to estimate routine immunization coverage in children based on both documented vaccination and the tracking of undocumented immunization. It was a community-based survey targeting children aged 0-59 months in which the immunization status of children was assessed based on vaccination documents and based on a questionnaire tracking immunization sites and period for children with undocumented vaccination. The vaccination coverage and completeness were estimated from data collected in immunization cards and re-estimated after tracking the immunization status of children with no immunization cards. Of 1435 children reached in households, 1430 (99.7%) were included. Of 1072 children aged 12-59 months, 194 (18.1%) received DPT-Hi+Hb 3 with evidence and 399 (37.2%) with evidence and tracking. In the same age group, the dropout rate from DPT-Hi+Hb 1 (157 doses administered) to DPT-Hi+Hb 3 (127 doses administered) with evidence was 19.1% and 42.4% with evidence and tracking. The tracking of immunization status in children with no evidence of

vaccination allows to determine their immunization status and to improve the reliability of the estimated vaccination coverage. This strategy could be adopted to be part of the planning and implementation of vaccination coverage surveys of EPI vaccines.

Introduction

The Expanded Program on Immunization (EPI) offers every child cohort, a chance to be protected against infectious diseases that contribute to high infant mortality and morbidity. The monitoring of each child's immunization status and vaccination coverage makes it possible to identify and catch up with the gaps in order to limit the circulation of most of EPI preventable diseases (1). Conducting community-based surveys is a common approach in accurately assessing children immunization coverage (1,2). During these surveys, the immunization status of each child is determined from an immunization card expected to be provided by the vaccination team during the immunization session in which the child received vaccines (3). For reasons that, to the best of our knowledge are still to be assessed, many parents of vaccinated children are unable to provide evidence of the child vaccination (4). Most of the time, caregivers who cannot present any proof of vaccines declare that the child received vaccines but are unable to remember names of different vaccines administered during each child contacts with vaccination teams (5). Routinely, vaccination doses administered during immunization sessions are documented only on tally sheets that give count number of vaccine doses administered during the session but does not record which vaccine type and dose administered to each child (6). Thus, these sheets can't be used to assess the vaccination status of individual children in communities. Future studies and interventions should be tested and identified to ensure

Correspondence to: Ketina Hirma Tchio-Nighie, Department of Health Research, M.A. SANTE, 33490 Yaounde, Cameroon
E-mail: ktchio@masante-cam.org

Key words: immunization coverage documentation, coverage surveys, Cameroon, tracking immunization status

1 the documentation of each vaccine dose administered with a
2 traceability for each child.

3 Given the actual lack of methods to ensure the fully docu-
4 mentation of each vaccine dose regarding every child, we
5 suggested to test an innovative method of tracking vaccina-
6 tion status of children from children guardians that failed
7 to provide evidence of vaccination. This was implemented
8 assuming that vaccination teams administer vaccines in the
9 good order and appropriate sites, that they are trained and
10 that children parents recall the approximate age and site to
11 which a child was vaccinated. This was done during a survey
12 on immunization coverage conducted in the Fouban health
13 district (based in West Cameroon Health region) in July 2018.

15 **Material and methods**

16
17 *Ethical considerations.* This study involved collecting data
18 from children immunization records and from parents or
19 guardians. Personal identification variables were not collected.
20 Caregivers were informed on study objectives and procedures
21 and their consent obtained prior to the children inclusion. The
22 study protocol was evaluated and approved by the Cameroon
23 National Ethics Committee for Human Health Research with
24 reference 2018/07/1058/CE/CNERSH/SP.

25
26 *Study design.* This was a community based two-stage cluster
27 survey conducted in July 2018 in Fouban health district
28 in which the immunization status of children was assessed
29 based on vaccination documents and based on a questionnaire
30 tracking immunization sites and period for children with
31 undocumented vaccination. The vaccination coverage and
32 completeness were estimated from data collected in immuni-
33 zation cards and re-estimated after tracking the immunization
34 status of children with no immunization cards.

35
36 *Setting and period.* The study was conducted in Fouban
37 health district which is one of the 20 health districts of the West
38 region of Cameroon. Data were collected in selected house-
39 holds of selected communities during the month of July 2018.
40 This is one of the health districts of the West region-Cameroon
41 characterized by high numbers of caregivers reporting vacci-
42 nated children without proof of vaccination (unpublished
43 source).

44
45 *Participants.* Children aged 0-59 months born or living in
46 the selected households for at least the past seven days before
47 the survey were eligible. The age of each child was asked
48 from consenting mother or the child guardian (caregivers) or
49 checked from any available vaccination document if the care-
50 giver was unable to give the child's age. In case the age of a
51 child could not be provided from each of these sources, it was
52 tracked based on local events.

53
54 *Variable and data sources.* After obtaining the permission of
55 the head of the household, eligible children and their caregivers
56 were identified. Consenting caregivers were administered a
57 questionnaire to confirm the child age and collect data on the
58 availability of child's immunization card or any related docu-
59 mentation. For children with immunization documents, data
60 on the child's name, date of vaccination and age was collected

61 using a grid. For children with no vaccination card, a ques-
62 tionnaire was administered to the child's caregiver to assess
63 and record whether the child has ever been vaccinated or not,
64 the number of contacts of the child with vaccines and per
65 vaccination site. The tracking was done using key questions
66 such as: did the child receive an injection at the anterior site
67 of the left forearm? at the exterior site of the any thigh? at the
68 outer shoulder? For each time that a child was declared to have
69 been taken to vaccination, his age in month was requested and
70 recorded. For caregivers who could not respond to the ques-
71 tionnaire, the modality 'I do not know' was recorded.

72 These variables were developed based on the vaccination
73 guidelines of the Expanded Program on Immunization on
74 which the training of vaccination teams is based. According to
75 these guidelines each vaccine is meant to be administered at
76 a standard site (7). In the purpose of the study, the child who
77 had received a vaccine injection on the anterior site of the left
78 forearm was considered to have received vaccines of the first
79 contact, the one who had received it during one vaccination
80 visit at the thigh was recorded to have received the vaccines
81 of the second contact, the one who had received the vaccine
82 on the second visit on the thigh was recorded to have received
83 vaccines of the third contact, the one who declared to have
84 received vaccines on the thigh three times visit was considered
85 to have received vaccines of the fourth contact, the one who
86 declared to have received the vaccine fourth on the thigh was
87 recorded to have received vaccines of the fifth contact and
88 have been vaccinated at the out left shoulder was an argument
89 supporting that the child had received vaccines of the fifth
90 contact.

91
92 *Data collection tools.* Data collection tools were developed by
93 the research team and pretested in one of the district's health
94 area and validated before data collection. Data collection
95 tool was designed on ODK forms, data collected with smart-
96 phones in face to face by trained and supervised surveyors
97 and uploaded daily on a password-secured data base. GPS
98 coordinates of selected households was recorded.

99
100 *Sample size estimate and sampling process.* We planned to
101 enroll at least 504 children aged 0-59 months to estimate
102 the proportion of children immunized in this age group in
103 Fouban Health District. This was obtained assuming a
104 84.5% vaccination coverage (8), and planning in this study to
105 estimate immunization coverage with 95% confidence interval
106 and 5% precision; assuming a cluster design effect of 2 and a
107 80% response rate.

108 The estimated number of children was enrolled from
109 80 clusters of about 30 buildings each, expecting to have
110 eight children aged 12-59 months per cluster. These clusters
111 were proportionately assigned to 14 health areas (HA). This
112 selection covered 2/3 of urban, rural and transhumant health
113 areas. In each HA, clusters were randomly assigned to
114 quarters by systematic random sampling. Each quarter was
115 mapped using the 'my position' function of Google earth
116 smartphone application. The screen print image of the map
117 was divided in cluster of about 30 buildings. One of these
118 blocks was randomly selected and included to be visited
119 for data collection. Each building that had a roof, door and
120 window was visited as well as all HH (group of people

Table I. Coverage of clusters, buildings and households per health area.

Health areas (HA)	Clusters coverage n (%)	Identified households n	Interviewed households n (%)	CI 95% (L-U)
Bafole	2 (100.0)	49	40 (81.6)	(68.0-91.2)
Foumban Nord	3 (100.0)	75	64 (85.3)	(75.3-92.4)
Foumban Ouest	7 (100.0)	195	157 (80.5)	(74.2-85.8)
Foumban Sud	10 (100.0)	246	219 (89.0)	(84.4-92.6)
Kouchankap	3 (100.0)	71	55 (77.5)	(66.0-86.5)
Kouffen	5 (100.0)	88	69 (78.4)	(68.3-86.5)
Koupa Kagnam	7 (100.0)	230	178 (77.4)	(71.4-82.6)
Koupa matapit	9 (100.0)	203	170 (83.7)	(77.9-88.5)
Koutie	5 (100.0)	90	81 (90.0)	(81.9-95.3)
Makouetvu	3 (100.0)	46	42 (91.3)	(79.2-97.6)
Mancha	3 (100.0)	62	56 (90.3)	(80.1-96.4)
Mataket	10 (100.0)	247	214 (86.6)	(81.5-90.6)
Matoumbain	3 (100.0)	91	61 (67.0)	(56.4-76.5)
Njimom	10 (100.0)	214	179 (83.6)	(78.0-88.3)
Total	80 (100.0)	1,907	1585 (83.1)	(81.4-84.8)

Table II. Distribution of children per age group and sex.

	Number of included		
	Male n (%)	Female n (%)	Total n (%)
Aged 0-11	189 (52.8)	169 (47.2)	358 (25.0)
Aged 12-23	149 (50.7)	145 (49.3)	294 (20.6)
Aged 12-59	513 (47.9)	559 (52.1)	1072 (75.0)
Total (Aged 0-59)	702 (49.1)	728 (50.9)	1,430 (100.0)

Table III. Mean number of children per cluster, household and age group.

Age of children (in months)	n	Mean number per cluster	Mean number per Household
0-11	358	4.48	0.23
12-23	294	3.68	0.19
24-59	778	9.73	0.50
Total (0-59)	1,430	17.88	0.92

living under the same roof for at least one week, under the authority of a head and usually sharing the same meal) in the building. Each household with at least one child under five was included and questions administered on the immunization status of all children aged 0-59 who had been living in the household for at least a week. Closed households or those with no available respondents were revisited twice and only those that remained closed or with no respondent were excluded.

Data analysis. The transmission, quality and completeness of collected data were monitored daily. These data were downloaded on Microsoft Excel 2013 worksheet, cleaned and imported in Epi info7.2.2.6 software for analysis. BCG, DPT-Hi+Hb dose 3 and Measles/Mumps-Rubella (MR) vaccination coverages were estimated among children aged 0-59 from data collected using immunization card and tracking. The coverage was estimated with as numerator, the number of children with evidence of immunization and re-estimated with as numerator, the number of children vaccinated with evidence plus the number of children declared to have been vaccinated from the tracking. For these two estimates, the denominator was all included participants aged 0-59 months. General vaccination dropout rate (BCG-MR) was assessed by estimating the proportion of children not vaccinated with MR among those that received BCG. Specific vaccination dropout rate (DPT-Hi+Hb 1 to DPT-Hi+Hb 3) was assessed by estimating the proportion of children not vaccinated with DPT-Hi+Hb 3 among those that were vaccinated with DPT-Hi+Hb 1. The numerator of the dropout rate among children vaccinated with evidence was the number of children with no evidence of vaccination. The numerator of the dropout rate among all children vaccinated including those with evidence and those vaccinated from tracking will be the number of neither vaccinated with evidence nor from tracking.

Results

Coverage of clusters, buildings and households. Of 1907 identified households, 1549 (83.1%) were included. Other households were excluded for the following reasons; 322 (16.9%) households were closed even after 03 visits of the surveyors and 36 (2.8%) refused to participate. From the 1549 surveyed households, 687 (44.3%) households had no child aged between 0-59 months. Table I presents the distribution of the targeted clusters and coverage of households interviewed

Table IV. Distribution per age group of routine Immunization coverage per vaccine.

Antigens	Age group in months																
	0-2 N=99			06-11 N=179			0-11 N=358			12-23 N=294			12-59 N=1072			0-59 N=1430	
	n (%)	95% CI	n (%)	95% CI	n (%)	95% CI	n (%)	95% CI	n (%)	95% CI	n (%)	95% CI	n (%)	95% CI	n (%)	95% CI	
BCG with evidence	51 (51.5)	(41.2-61.4)	84 (46.9)	(39.3-53.8)	174 (48.6)	(43.3-53.7)	84 (28.6)	(23.4-33.9)	242 (22.6)	(20.2-25.0)	416 (29.1)	(26.9-31.5)					
BCG (evidence + tracking)	63 (63.6)	(53.4-73.1)	158 (88.3)	(82.6-92.6)	287 (80.2)	(75.7-84.0)	244 (83.0)	(78.0-87.1)	872 (81.3)	(78.9-83.6)	1159 (81.0)	(78.9-83.0)					
DPT-Hi+Hb (DPT-Hi+Hb) 1 with evidence	26 (26.3)	(18.3-35.6)	81 (45.3)	(37.4-51.9)	143 (39.9)	(34.7-45.0)	78 (26.5)	(21.6-31.6)	235 (21.9)	(19.6-24.2)	378 (26.4)	(24.2-28.6)					
DPT-Hi+Hb 1 (evidence + tracking)	29 (29.3)	(20.6-39.3)	149 (83.2)	(76.9-88.4)	236 (65.9)	(60.9-70.6)	201 (68.4)	(62.7-73.6)	693 (64.6)	(61.7-67.4)	929 (65.0)	(62.5-67.4)					
DPT-Hi+Hb 3 with evidence	0 (0.0)	0	67 (37.4)	(30.1-44.1)	85 (23.7)	(19.1-28.6)	67 (22.8)	(18.1-27.6)	194 (18.1)	(15.7-20.4)	279 (19.5)	(17.4-21.6)					
DPT-Hi+Hb 3 coverage (evidence + tracking)	0 (0.0)	0	92 (51.4)	(43.8-58.9)	113 (31.6)	(27.0-36.5)	119 (40.5)	(34.8-46.3)	399 (37.2)	(34.4-40.1)	512 (35.8)	(33.4-38.3)					
RR (Measles and Rubella vaccine) with evidence	0 (0.0)	0	12 (6.7)	(3.3-10.8)	12 (3.4)	(1.6-5.4)	42 (14.3)	(10.3-18.1)	148 (13.8)	(11.8-15.9)	160 (11.2)	(9.5-12.9)					
RR (Measles and Rubella vaccine) (evidence + tracking)	0 (0.0)	0	32 (17.9)	(12.6-24.3)	42 (11.7)	(8.8-15.5)	106 (36.0)	(30.6-41.8)	396 (36.9)	(34.1-39.9)	438 (30.6)	(28.3-33.1)					

61
62
63
64
65
66
67
68
69
70
71
72
73
74
75
76
77
78
79
80
81
82
83
84
85
86
87
88
89
90
91
92
93
94
95
96
97
98
99
100
101
102
103
104
105
106
107
108
109
110
111
112
113
114
115
116
117
118
119
120

Table V. Specific dropout rates (DPT-Hi+Hb 1 to DPT-Hi+Hb 3) per age groups.

	Age groups			
	12-23 months		12-59 months	
	Vaccination with evidence	Vaccination with evidence and from tracking	Vaccination with evidence	Vaccination with evidence and from tracking
Number of DPT-Hi+Hb 1 doses administered	78	201	157	693
Number of DPT-Hi+Hb 3 doses administered	67	119	127	399
Dropout rate (%)	14.1	40.8	19.1	42.4

Table VI. General dropout rate (BCG to Measles-rubella) per age group.

	Age groups			
	12-23 months		12-59 months	
	Vaccination with evidence	Vaccination with evidence and from tracking	Vaccination with evidence	Vaccination with evidence and from tracking
Number of BCG doses administered	84	244	158	872
Number of Measles-Rubella doses administered	42	106	106	396
Dropout rate (%)	50.0	56.6	32.9	54.6

per health area. The coverage of households interviewed differed per health area but not significantly.

Distribution of children per cluster, household, age and sex. In total, 1430 children aged 0-59 months were identified in the reached households. Table II gives the distribution of registered children per age and sex and Table III presents the mean number of children per cluster, HH and age groups. The most represented age group was 12-59 months (75.0%) and more were female children (50.9%).

Immunization coverage. Table IV presents the documented and tracked immunization coverage of children regarding main EPI vaccines. It is noted that for almost all antigens and age group, the estimate of immunization coverage increases when the immunization status of children with no immunization card (tracked) is taken into account. Also, the coverage of children documented immunization decreases as their age increase.

Dropout rate of EPI vaccination among children. Tables V and VI present specific and general vaccination dropout rates among children aged 12-23 months and 12-59 months. We note that for both age groups, the DPT-Hi+Hb 1 to DPT-Hi+Hb 3 dropout rates estimated from immunization

documents were higher when estimated with data collected from both immunization cards and tracking. The trend is similar for BCG-Measles/rubella vaccine as noted in Table VI.

Discussion

This study was conducted to assess an innovative method to record children's immunization coverage when no documented proof is available. Results presented in this paper indicate that EPI vaccines coverage in children estimated from a vaccination document was lower than that estimated when the tracking of the immunization status in children with no vaccination document. The vaccination drop-out rate was lower when the children immunization status was assessed only from evidence than when it was assessed from evidence and tracking of immunization status among children with no evidence of immunization.

Surveys are described as the best source of information regarding the estimation of immunization coverage in communities (2,9). The reliability of these data depends on the ability of the survey designer on one hand to plan and implement the sampling and coverage of homes, households and targeted children; and on the other hand, the ability to ensure the assessment and recording of the eligibility and immunization status of each child. The assessment of the eligibility and immunization

1 status of the child is relatively easy when the child care giver
 2 can present a document indicating the child date of birth as well
 3 as the doses and dates of vaccines administration to the child.
 4 Several surveys conducted to estimate vaccination coverage
 5 determined the immunization status of the child based on
 6 immunization documents and/or on questionnaire administered
 7 to guardians (10-13). Survey methods based on questionnaire
 8 administration to caregivers may provide relatively reliable
 9 vaccine coverage if the survey is conducted in a relatively
 10 short time (sufficiently short to allow caregiver to recall) after
 11 vaccination and/or when it follows a single dose of vaccine
 12 administered. For surveys that are planned to estimate EPI
 13 immunization coverage and/or completeness which regularly
 14 target children under age 12 months and above, with certain
 15 vaccination doses administered a year earlier, it seems less reli-
 16 able to assess children immunization status from the guardian
 17 declaration. WHO recommends a number of questions to track
 18 the immunization status of the children with no immunization
 19 card, but to the best of our knowledge, no published study has
 20 taken this into account (13). The present survey included a
 21 series of standardized questions to determine the vaccination
 22 status of one of the planned vaccine doses for five immunization
 23 appointments in children whose parents do not hold a vaccina-
 24 tion document. The results reveal that the vaccination coverage
 25 estimated by taking into account the tracking of vaccination
 26 status in children without vaccination documents was higher
 27 than that estimated on the basis of immunization documents for
 28 almost all antigens and for each age group targeted. To the best
 29 of our knowledge, this double estimate has not yet been made in
 30 a previous study. The immunization coverage gap from the two
 31 estimates can be explained by the fact that these children were
 32 vaccinated but did not receive a document certifying it, or they
 33 received a document and lost it, or the document was received
 34 but kept by one of the child's previous caregiver or parents may
 35 be mistakenly taking injection received by the child as vaccina-
 36 tion. We did not collect the data to assess the weight of each of
 37 these hypotheses, but the latter is unlikely since the data collec-
 38 tion process involved identifying and excluding these cases
 39 (by asking of the injection was done because the child was ill).

40 The estimate of the general and specific dropout rate of
 41 EPI vaccines based on data from vaccination documents
 42 and, taking into account the tracking of vaccination status in
 43 children who do not have immunization document shows a
 44 higher drop-out rate in the latter case indicating that children
 45 with documented vaccination are more likely to complete
 46 and that the tracking allow to detect more children that need
 47 to complete their vaccination. It can also mean that care-
 48 givers who keep securely keep vaccination cards are more
 49 likely to ensure that each child complete his vaccination.
 50 The observed difference supports the argument that tracking
 51 should be used in addition to immunization card when
 52 assessing children population in need of EPI vaccination
 53 completion rate.

54 Immunization status tracking is limited because it is based
 55 on data collected by questionnaire from the caregiver and
 56 can be conducted in some cases long after the administration
 57 of certain vaccination doses. It may also be limited because
 58 immunization status data are collected by assuming that the
 59 vaccinator respected the recommended vaccination site but
 60 nothing ensures that all of them will respect the recommended

sites. Despite these limitations, it is the only alternative currently
 available to collect information on the immunization status of
 children with no documentation. The reduction of the limita-
 tions of this method would require the establishment of a source
 of documentation of immunization status in health facilities
 accessible during follow-up or immunization coverage survey
 activities that may permit to trace children status.

Conclusions

Results of the present study indicate that EPI vaccines coverage
 in children estimated from a vaccination document was lower
 than that estimated taking into account the tracked immuni-
 zation status in children with no vaccination document. The
 results of the present may imply that EPI vaccination coverage
 is underestimated when it is based only on the documentation
 of vaccination as well as the number of children needing to
 complete their vaccination. If the immunization status of chil-
 dren who do not have evidence of vaccination is not tackled,
 there is a risk that more doses will be given than expected in
 the immunization schedule, leading to unexplained stockouts
 and higher expected cost.

We recommend that during surveys and immunization
 coverage monitoring activities, the immunization status of
 children be determined from vaccination cards and from
 tracking among children with no vaccination documents.
 From this status, immunization coverage with documented
 status and that taking the tracking into account should be
 reported. Studies should be conducted to identify and respond
 to reasons contributing to the unavailability of vaccination
 cards among some vaccinated children and secondly to assess
 the feasibility of setting up an alternative accessible source of
 data to the vaccination card to determine the immunization
 status of children during vaccination surveys and monitoring.

Contributions

JA, design, coordination of the project, and draft of the
 manuscript; JA, NMY, APG, data collection monitoring;
 KHTN, NMY, APG, LA, IF, BK, writing, and revision of the
 manuscript. All the authors approved the final version to be
 published.

Funding

This study is funded by the Bill & Melinda Gates Foundation
 under the Grand Challenges Explorations (Round 21). The
 funding body was not involved in the design of the study and
 was not involved in the implementation and exploitation of the
 results.

Ethical approval and consent to participate

The protocol has received ethical approval from the Cameroon
 National Ethics Committee (2018/07/1058/CE/CNERSH/SP)
 and administrative authorization from the Cameroon Ministry
 of Public Health (631-19-18). Prior to participation in this
 study, all heads of households were informed of the survey,
 and their consent was required before any data was collected
 in the household. No personal data were collected.

Availability of data and material

Not applicable.

Informed consent

The manuscript does not contain any individual person's data in any form.

Conflict of interest

The authors declare no potential conflict of interest.

Accepted: 21, January 2023; submitted: 30, December 2022.

References

1. Cutts FT, *et al.* -2016-Monitoring vaccination coverage defining the role.pdf [Internet]. [cité 9 mars 2019]. Disponible sur: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4967442/pdf/main.pdf>.
2. Cutts FT, Claquin P, Danovaro-Holliday MC and Rhoda DA: Monitoring vaccination coverage: Defining the role of surveys. *Vaccine* 34: 4103-4109, 2016.
3. Danovaro-Holliday MC, Dansereau E, Rhoda DA, Brown DW, Cutts FT and Gacic-Dobo M: Collecting and using reliable vaccination coverage survey estimates: Summary and recommendations from the 'Meeting to share lessons learnt from the roll-out of the updated WHO Vaccination Coverage Cluster Survey Reference Manual and to set an operational research agenda around vaccination coverage surveys', Geneva, 18-21 April 2017. *Vaccine* 36: 5150-5159, 2018.
4. Sally ET and Kenu E: Evaluation of access and utilization of EPI services amongst children 12-23 months in Kwahu Afram Plains, Eastern region, Ghana. *Pan Afr Med J* 28: 238, 2017.
5. Siddiqi N, Siddiqi A, Nisar N and Khan A: Mothers' knowledge about EPI and its relation with age-appropriate vaccination of infants in Peri-urban Karachi. *JPMA J Pak Med Assoc* 60: 940-944, 2010.
6. Torun SD and Bakırcı N: Vaccination coverage and reasons for non-vaccination in a district of Istanbul. *BMC Public Health* 6: 125, 2006.
7. Ministère de la Santé Publique Cameroun. Normes Et Standards Du Programme Elargi De Vaccination du Cameroun [Internet]. [cité 15 févr 2022]. Disponible sur: <https://docplayer.fr/7296942-Normes-et-standards-du-programme-elargi-de-vaccination-du-cameroun.html>.
8. Russo G, Miglietta A, Pezzotti P, Biguioh RM, Bouting Mayaka G, Sobze MS, Stefanelli P, Vullo V and Rezza G: Vaccine coverage and determinants of incomplete vaccination in children aged 12-23 months in Dschang, West Region, Cameroon: A cross-sectional survey during a polio outbreak. *BMC Public Health* 15: 630, 2015.
9. Dietz V, Venczel L, Izurieta H, Stroh G, Zell ER, Monterroso E and Tambini G: Assessing and monitoring vaccination coverage levels: Lessons from the Americas. *Rev Panam Salud Pública* 16: 432-442, 2004.
10. Waters HR, Dougherty L, Tegang SP, Tran N, Wiysonge CS, Long K, Wolfe ND and Burke DS: Coverage and costs of childhood immunizations in Cameroon. *Bull World Health Organ* 82: 668-675, 2004.
11. Baguune B, Ndago JA and Adokiya MN: Immunization dropout rate and data quality among children 12-23 months of age in Ghana. *Arch Public Health* 75: 18, 2017.
12. Ngomba AV, Kollo B, Bitá AF, Djouma FN, Edengue JM, Elongue MJ and Adiogo D: Immunization programme in urban areas in Cameroon: A case study of the Djoungolo Health District. *Pan Afr Med J* 25: 213, 2016 (In French).
13. Olorunsaiye CZ, Langhamer MS, Wallace AS and Watkins ML: Missed opportunities and barriers for vaccination: A descriptive analysis of private and public health facilities in four African countries. *Pan Afr Med J* 27 (Suppl 3): 6, 2017.
14. Vaccination_coverage_cluster_survey_with_annexes.pdf [Internet]. [cité 4 avr 2019]. Disponible sur: https://www.who.int/immunization/monitoring_surveillance/Vaccination_coverage_cluster_survey_with_annexes.pdf.