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Missed Opportunities for Vaccination in Médecins Sans Frontières supported health facilities: eldest children urge for a second chance.

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Title Page

Title: Missed Opportunities for Vaccination in Médecins Sans Frontières supported health facilities: eldest children urge for a second chance.

Running Title: MOV in MSF supported health facilities

Key words: MOV, vaccination, children, immunization program, survey, low-income countries, Expanded Program of Immunization, missed opportunities

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2
3 **Title: Missed Opportunities for Vaccination in Médecins Sans Frontières supported**
4
5 **health facilities: eldest children urge for a second chance.**
6
7

8 **Abstract**
9

10 **Objective**
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12
13 To describe Missed Opportunities for Vaccination (MOV) among children visiting MSF-
14 supported facilities and its related factors, and to identify reasons for non-vaccination.
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16

17 **Methods**
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19
20 We conducted a cross-sectional survey in 19 MSF-supported facilities between 2011 and 2015
21 in Mauritania, Niger, South Sudan, Democratic Republic of Congo, Pakistan, and Afghanistan,
22 including children 0-59 months of age whose caregivers presented their vaccination card at
23 consultation exit. We describe MOV prevalence and assess the association of MOV with age,
24 type of facility and reason for visit.
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26
27
28

29 **Findings**
30

31
32 Among 5055 children's caregivers interviewed, 2738 presented a vaccination card. Of them,
33 62.8% were eligible for vaccination and of those, 64.6% had a MOV. Presence of MOV was
34 more likely in children visiting a hospital or visiting a health facility for a reason other than
35 vaccination. MOV occurrence was significantly higher among children aged 12-23 months
36 (84.4%) and 24-59 months (88.3%) compared with children below 12 months (56.2%),
37 $p \leq 0.001$. Main reasons reported by caregivers for MOV were lack of vaccines (40.3%), reason
38 unknown (31.2%), and not being informed (17.6%).
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43

44 **Conclusion**
45

46
47 MOV remains an important problem in low resource settings. Children beyond the Expanded
48 Program of Immunization target are particularly vulnerable for MOV; therefore, assessments
49 should include children above 23 months of age to better estimate MOV. We strongly
50 recommend assessment of eligibility for vaccination in all children in health care settings
51 regardless of the visit reason and strengthening implementation of "Second year of life" visits
52 to reduce MOV.
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Strengths and limitations of this study

- The major strength of the study is that only children with a valid vaccination card were included, so not relying on self-reported data helped to avoid potential recall bias
- Differences by gender on Missed Opportunities for Vaccination were not explored
- Reasons related with Missed Opportunities for Vaccination were limited to those included at the questionnaire and declared by caregivers.

For peer review only

1 **Introduction**

2 Since 1983, the Global Advisory Group of the Expanded Program of Immunization (EPI) has
3 recommended using every opportunity to immunize each eligible child, regardless of the reason
4 for consultation. If that occasion does not result in receiving all the vaccines for which the child
5 is eligible, it is defined as a Missed Opportunity for Vaccination (MOV). Among the causes for
6 under-vaccination in low and middle-income countries, 44% are for reasons related to health
7 systems, including MOV and lack of access to health care (1). In 1993, the first systematic
8 review, including 45 countries, found a median MOV prevalence of 67% (2). Since then, the
9 World Health Organization (WHO) has promoted the use of MOV surveys to measure the
10 performance of health services in vaccination (3),(4). In order to improve immunization
11 coverage, in 2017 WHO recommended a revised methodology to assess MOV, targeting
12 children aged 0-23 months (5). However, data is scarce on MOV prevalence in children above
13 23 months of age (6). Through its medical humanitarian programs in low and middle-income
14 countries, Médecins Sans Frontières (MSF) strengthens routine vaccination services regardless
15 the age of the child following WHO recommendations in order to reduce the number of under
16 and unvaccinated children. Therefore, we took the opportunity to systematically assess MOV
17 in children up to five years of age within MSF programs.

18 Our objective was to describe the MOV prevalence and characteristics, and to identify reasons
19 for non-vaccination among children up to five years of age visiting MSF-supported health
20 facilities in six different countries.

21 **Methods**

22 **Study design and settings**

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2
3 23 A cross-sectional exit survey of caregivers was performed in 19 health facilities (four hospitals
4
5 24 and 15 primary health care centers [PHCC]) between 2011 and 2015 in six countries:
6
7 25 Mauritania, Niger, South Sudan, Democratic Republic of Congo, Pakistan and Afghanistan.
8
9

10 26 **Patient and Public Involvement**

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12
13 27 Patients or the public were not involved in the design, or conduct, or reporting, or dissemination
14
15
16 28 plans of our research.
17

18 29 **Study population and participant selection**

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21
22 30 The study population consisted of children up to five years of age accompanied by a caregiver,
23
24 31 visiting an MSF-supported facility. Health facilities and time to perform the assessment were
25
26 32 selected on a convenience basis during the study period. A convenient sample of all caregivers
27
28 33 accompanying a child under five years of age on the specific day of the survey in each facility
29
30 34 were approached. Caregivers were invited to participate at the facility exit, regardless of the
31
32 35 reason for the visit, and those who provided oral consent were interviewed. If several children
33
34 36 were present per caregiver, the interviewer included them all. Children whose caregivers did
35
36 37 not present the respective vaccination card were excluded from the analysis.
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40 38 **Data collection**

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44 39 MSF developed a standardized methodology to assess MOV based on the 1988 WHO tool.
45
46 40 Interviews were conducted in local languages. In preparation for the survey, local staff received
47
48 41 a two-day training focusing on conducting the interview and identification of eligible children
49
50 42 for vaccination according to national vaccination schedules.
51

52
53
54 43 A structured questionnaire was used (Supplementary material). Information on type of facility
55
56 44 (hospital or primary health care center [PHCC]), age of the child, presentation of vaccination
57
58 45 card, reason for visiting the facility and vaccination history were collected. Surveyors
59
60

1
2
3 46 determined if the child was eligible that day for at least one vaccine dose according to age and
4
5 47 the national vaccination schedule, whether he/she had received all the recommended vaccines
6
7 48 during the visit, and the presence of a contraindication for vaccination (defined as fever above
8
9 49 38,5 °C). For those who had not received each of the recommended vaccines during the visit,
10
11 50 surveyors asked for reasons why the child was not vaccinated, caregivers' acceptance of
12
13 51 receiving the missing vaccines doses, and their awareness of next vaccination appointment.
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16 17 52 **Data analysis**

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19
20 53 We classified children as having a MOV as per standard WHO's definition (5) according to
21
22 54 each national vaccination schedule. A MOV occurs when a child eligible for vaccination
23
24 55 (without contraindication) remains unvaccinated or partially vaccinated (not up to date) at the
25
26 56 end of any visit to a health facility (Figure 1).
27
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29

30 57 We calculated the prevalence of MOV as the number of children with MOV divided by the
31
32 58 number of children eligible for a vaccination - which excluded those already up to date at the
33
34 59 start of the visit and those with a reported contraindication. Among children with MOV we
35
36 60 calculated 1. vaccination acceptance (as the proportion of caregivers who would have accepted
37
38 61 vaccination if it had been proposed on the day of the visit) and 2. vaccination appointments
39
40 62 given (as the proportion of caregivers who knew their date of next vaccination appointment).
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45 63 Proportions were used to describe the children and to estimate MOV. Significant differences in
46
47 64 the distribution were assessed using the Pearson's two-sided Chi-square test or Fisher exact
48
49 65 test. For the bivariate analysis, age was categorized in targeted by the EPI (below 12 months of
50
51 66 age) or not targeted (≥ 12 months). Reason for visit to the facility was grouped into either
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53 67 vaccination or other reasons. We assessed the association of MOV with age, type of facility and
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55 68 reason for visit by calculating Odds Ratios. A logistic regression model was adjusted for age
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69 (0-11,12-59 months), type of facility (hospital, PHCC), and reason for visit (vaccination, other
70 reason). The level of statistical significance was set at $p < 0.05$.

71 In each facility, data entry officers inputted the paper questionnaire data into an Excel database,
72 which was validated by two of the study investigators. The analysis was performed using
73 STATA (version 16, College Station, Texas).

74 **Ethic statement**

75 Prior to each evaluation authorization from the local health authorities and from the director of
76 each health facility was obtained. Oral consent was obtained from each caregiver. During the
77 survey, children identified with MOV were sent back to the vaccination unit to receive the
78 missing vaccine(s) if the caregiver agreed and if there was no shortage. All data from the
79 questionnaires were anonymous and entered into a dedicated password-protected electronic
80 database. This research fulfilled the exemption criteria set by the Médecins Sans Frontières
81 Ethics Review Board.

82 **Results**

83 From 2011 to 2015, the caregivers of 5055 children were interviewed in 19 facilities (four
84 hospitals and 15 PHCC). We report the results for the 2706 (53.5%) children who presented
85 their vaccination card on the day of the survey: 1888 from Niger, 447 from South Sudan, 244
86 from Mauritania, 79 from Democratic Republic of Congo, 33 from Afghanistan and 15 from
87 Pakistan.

88 **Characteristics of the study population**

89 Among the 2706 children included, 995 (36.7%) were already up to date before the visit, and
90 1711 (63.2%) were eligible for vaccination. Twenty three caregivers (1.3%) reported a
91 contraindication (Figure 1). Among eligible children, 609 (36.1%) were vaccinated during the
92 visit, whereas 1079 (63.9%) had a MOV at exit from the health facility.

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2
3 93 Children's baseline characteristics are presented in Table 1. Their mean age was 10.1 months
4
5 94 (Standard Deviation - 9). The majority (2213, 81.8%) were interviewed at exit of a PHCC. The
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7
8 95 most common reason for visiting the health facility was curative consultation (831, 30.7%).
9

10 96 **Characteristics of children with MOV**

11
12
13 97 Most of the children who were eligible for vaccination and consulting for a reason other than
14
15 98 vaccination, had a MOV (960, 71.9%), while a third of the children coming to the facility for
16
17 99 vaccination also had a MOV (119, 33.7%). More than 80% children aged 12-23 months and
18
19
20 100 almost 90% of children aged 23-59 had a MOV, compared to 55% of children below 12 months.
21
22
23 101 MOV occurrence was significantly more likely among older children than younger ones (Table
24
25 102 1).
26
27

28 103 Only four caregivers of children with MOV would have refused vaccination if it had been
29
30 104 proposed during the visit. About one fifth (21%) of caregivers of children with MOV were
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32
33 105 aware of the date of the next vaccination appointment.
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36 106 The most common reason declared for having a MOV was lack of vaccines (40.1%), followed
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38 107 by reason unknown (32%), not being informed (17.3%), lack of staff (3.3%), waiting time too
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40
41 108 long (1.7%) and other unclassified reasons (5.6%).
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43

44 109 **Factors related with presence of MOV**

45
46 110 Children above 12 months of age (not targeted by the EPI) and those accessing the health
47
48 111 facility for a reason other than vaccination, had an almost five times higher risk of having a
49
50 112 MOV (Table 2), compared to children below 12 months of age and those visiting for
51
52
53 113 vaccination. Those children visiting a hospital had 2.7 times higher risk for having a MOV than
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55 114 children visiting a PHCC. After adjusting by type of facility and reason for visit, children above
56
57
58 115 12 months still had a significantly higher risk of having a MOV (adjusted OR: 1.7, 95%CI 1.1-
59
60 116 2.5).

117 **Table 1. Characteristics of children who visited MSF-supported health facilities and the**
 118 **presence of Missed Opportunities for Vaccination (MOV), 2011-2015**

	Total children n=2706 n (%)	Eligible for vaccination ^a n=1688 n (%) ^b	MOV		<i>p</i> value
			No n (%) ^c	Yes n (%) ^c	
Age groups					
<12 m	1805 (66.7)	1203 (66.5)	540 (44.9)	663 (55.1)	<0,001 ^e
12-23 m	597 (22.1)	314 (52.6)	49 (15.6)	265 (84.4)	
24-59 m	304 (11.2)	171 (56.3)	20 (11.7)	151 (88.3)	
Facility type					
Hospital	493 (18.2)	336 (68.2)	67 (20)	269 (80.1)	<0,001 ^e
PHCC ^d	2213 (81.8)	1352 (61.1)	542 (40.1)	810 (59.9)	
Reason of the visit					
Curative	831 (30.7)	513 (61.7)	40 (7.8)	473 (92.2)	<0,001 ^f
Other	706 (26.1)	311 (44.1)	281 (90.4)	30 (9.7)	
Vaccination	436 (16.1)	353 (81.0)	234 (64.3)	119 (33.7)	
Nutrition	430 (15.9)	275 (64.0)	23 (8.4)	252 (91.6)	
Mother Child Health visit	265 (9.8)	214 (80.8)	29 (13.6)	185 (86.5)	
Accompanying	38 (1.4)	22 (57.9)	2 (9.0)	20 (90.9)	

119 ^a Without contraindication for vaccination

120 ^b Row percentage over the total children

121 ^c Row percentage over the eligible children without contraindication for vaccination

122 ^d PHCC: Primary Health Care Center

123 ^e Chi square test

124 ^f Fisher exact test

126 **Table 2. Factors related to Missed Opportunities for Vaccination (MOV) in eligible**
 127 **children who visited MSF-supported health facilities, 2011-2015**

	MOV children n= 1079 n (%)	Odds Ratio (95%CI)	Adjusted Odds Ratio (95%CI)
Age in months			
0-11 m	663 (55.1)		
12-59 m	416 (85.8)	4.91 (3.67-6.57)	3.79 (2.84-5.07)
Reason for visiting			
Vaccination	119 (33.7)		
Other	960 (89.0)	5.03 (3.86-6.56)	3.52 (2.70-4.58)
Facility type			
PHCC ^a	810 (59.9)		
Hospital	269 (80.1)	2.69 (2.00-3.60)	2.75 (2.02-3.73)

128 ^a PHCC: Primary Health Care Center

129 Odds ratio adjusted for age, reason for visiting, facility type (two categories each)

130

131 **Discussion**

132 This study summarizes MSF experience and lessons learned assessing MOV from 2011 to 2015
133 in six low-income countries. To our knowledge, this is one of the few studies that assess MOV
134 in children beyond the EPI target. Our results highlight that, despite MSF's efforts, most
135 children had a MOV after visiting one of the facilities. Of those children who specifically visited
136 for vaccination, one third still missed at least one dose of vaccine for which eligible during the
137 visit. The proportion of children with MOV increased with age, with children above one year
138 of age being at higher risk.

139 MOV prevalence in our study (63.9%) was higher than the last systematic review conducted in
140 low income countries in 2014, which found a prevalence of 32% (26.8–37.7) (6). An
141 explanation could be that the majority of studies in this meta-analysis only included children
142 below two years of age resulting in a lower estimation of MOV. As our data show, MOV was
143 nearly 90% in children above 23 months of age. One of the few studies including older children
144 also reported that MOV prevalence was higher in children aged 1-5 years (56.6%), compared
145 to those below one year (31.4%) (7). Thus, we believe that overall MOV prevalence is being
146 seriously underestimated, as assessments do not include children beyond the EPI target, that is,
147 above 23 months of age.

148 Consistent with recent studies in low income countries (8), we found a higher MOV prevalence
149 in children above 12 months. In a recent study that assessed MOV with WHO methodology in
150 Chad and Malawi (9), Ogbuano et al. found a MOV prevalence of 86% in Chad and 94% in
151 Malawi among children above one year of age, compared to 49% and 61% below one year
152 respectively.

153 Age as a risk for having MOV may be explained by older children having been perceived as
154 “too old” to be eligible (10), as most of EPI programs only target children below one year of

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2
3 155 age. In a WHO review about factors related with under-vaccination (11), false contraindications
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5 156 like age were found to be one of the main reasons for having a MOV. This was reflected in our
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8 157 study, where only 4% (n=14) of children visiting specifically for vaccination were above 12
9
10 158 months of age. A “second year of life healthy child visit” is already recommended by WHO
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12 159 (12) increasing the number of opportunities for vaccination in children above 12 months of age,
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14 160 especially in those who might have missed vaccination in their first year of life. This strategy,
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16
17 161 together with complementary catch-up activities to continue screening children at any contact
18
19 162 with health services should be strengthened in low-resource settings (13)(14)(15). The latest
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21 163 WHO update of recommendations for routine immunization (16) emphasizes that measles
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23 164 vaccine should not be limited only to children up to 12 months of age. We believe this approach
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26 165 must be extended to all vaccines included in the vaccination schedule, in order to increase
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28 166 individual protection and improve population vaccine coverage.

30
31 167 Our data draw attention to the high proportion of children missing the opportunity to get
32
33 168 vaccinated at hospital level. A similar proportion has been found in a recent study performed
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35
36 169 in northern Indian hospitals (17). This could be explained by the belief of false contraindications
37
38 170 for vaccination in a sick child, both among caregivers and health care workers. For example, a
39
40 171 study in Haiti reported that up to 13% of reasons for under vaccination was child illness, despite
41
42 172 the fact that mild infections should not prevent vaccination (18). In the last MOV assessments
43
44 173 using WHO methodology, Anyie J. Li et al. (10) found that only 24% of health care workers
45
46 174 were able to identify true contraindications, and L. Kaboré et al. (8) reported that 83% of health
47
48 175 workers failed to correctly identify valid contraindications for vaccination. Promoting training
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50 176 on true contraindications for vaccination among health care workers could be an effective
51
52 177 strategy to reduce MOV (19).

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57 178 We identified that one third of children actually visiting for vaccination were still not up to date
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59 179 at the end of the visit despite being vaccinated with one or more doses. Similar estimates were

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3 180 found in four recent MOV assessments in East Timor, Chad, Malawi, and Burkina Faso
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5 181 (8)(9)(10). This could be explained by supply shortages of specific vaccines, but also by health
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7 182 workers potentially failing to identify eligibility for certain vaccines. Failure to administer
8
9 183 simultaneous vaccines due to fear of wasting doses from multi-vial vaccines has been also
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11 184 suggested as an explanation for remaining MOV after vaccination visits (20)(21).
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15 185 Over three-quarters of eligible children consulting for reasons other than vaccination (mother-
16
17 186 and-child health visits, nutrition, curative) had a MOV. Integrating vaccination into other
18
19 187 preventive services could represent a significant reduction on MOV (22). Also, strengthening
20
21 188 routine screening of vaccination status irrespectively of reason visit, could be an opportunity to
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23 189 improve vaccine uptake (23).
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27 190 Our survey allowed us to identify and address the two main reasons related to MOV. More than
28
29 191 a third of caregivers reported lack of vaccines as the reason for MOV, and almost 20% reported
30
31 192 not been informed about the eligibility of the child. This is consistent with recent MOV
32
33 193 assessments (9), where approximately 30% of health care workers reported insufficient vaccine
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35 194 supply or logistics issues. Inadequate vaccine supply has already been pointed out as one of the
36
37 195 main reasons for under vaccination in low income countries (1). Ministries of Health and their
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39 196 partners must work to ensure adequate vaccine supply at facility level in order be able to
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41 197 vaccinate any children who had already accessed health care services (24). Lack of information
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43 198 on vaccine eligibility has also been reported elsewhere (25); therefore, promotion strategies
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45 199 should address the lack of information causing MOV.
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50
51 200 This study has three main limitations. First, gender was not collected, missing the opportunity
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53 201 to uncover gender differences. Nevertheless, no gender differences in the distribution of MOV
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55 202 have been reported in the latest studies (6)(9). Second, our survey didn't allow us to explore
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57 203 health care providers' practices and perceptions, identified as one of the main reasons related
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3 204 with MOV in the last systematic review (6). In 2015, WHO launched a revised MOV strategy
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5 205 which included Knowledge, Attitudes and Practices (KAP) questionnaires, to better guide the
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7 206 implementation of interventions to reduce MOV (9), which is generating new evidence (26).
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9
10 207 Third, we excluded from the analysis almost half of the children, as they were not able to present
11
12 208 a vaccination card. This may mean that we underestimated MOV prevalence in our target
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14 209 population, since not presenting a vaccination card has been associated with MOV (1)(6)(27).
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16
17 210 However, not relying on self-reported data helped avoid potential recall bias, which is a
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19 211 limitation in vaccine coverage studies in low resource settings(28).
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21

22 **Conclusions**

23
24 213 Despite progress in vaccine coverage through the Global Vaccine Action Plan, MOV remain
25
26 214 an important problem in low-resource settings. Avoiding MOV should remain a priority where
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28 215 access to health care is limited, especially considering also the negative impact COVID-19
29
30 216 pandemic is having on routine immunization programs, especially in low and middle income
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32 217 countries (29).
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36 218 We recommend integrating routine vaccination screening in health care settings regardless of
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38 219 visit reason as a main strategy to identify eligible children and reduce MOV, together with
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40 220 addressing caregiver's lack of information and knowledge gaps in health care workers.
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44 221 We identified that children above 23 months of age as particularly vulnerable for MOV. At the
45
46 222 moment of our report, WHO methodology for MOV assessments only targets children below
47
48 223 23 months, which according to our findings leads to underestimation of MOV. Therefore, we
49
50 224 recommend that MOV assessments should include children up to 5 years of age. Strengthening
51
52 225 the implementation of second year of life visits, as recommend by WHO, and catch-up
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54 226 vaccination activities would provide missed vaccine doses to those who urge for a second
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56 227 chance.
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230 workers who performed the surveys. Special thanks to Ibrahim Barrie and Marie-Eve Burny for
231 implementation of MOV studies in the field. Thanks to Tony Reid for language review and to
232 J.A. Rodrigo for its valuable inputs.

233 **Contributorship Statement**

234 Bachy C. and Panunzi I. designed the study and contributed to the development on the field.
235 Bachy C., Panunzi I., Gil-Cuesta J. and Borrás-Bermejo B. carried out the data analysis. Borrás-
236 Bermejo B. drafted the manuscript that was critically reviewed and approved by all authors.

237 **Competing interests**

238 None declared

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240 The study was carried out by MSF staff as part of their routine activities. No extra funding was
241 required.

242 **Data Availability Statement**

243 Questionnaire dataset is available in a public, open access repository.

244 [dataset] (30) Borrás-Bermejo B. Data from: Missed Opportunities for Vaccination in MSF-
245 Supported Health Facilities. Open Science Framework. December 6, 2021.

246 <https://doi.org/10.17605/OSF.IO/SFXDK>

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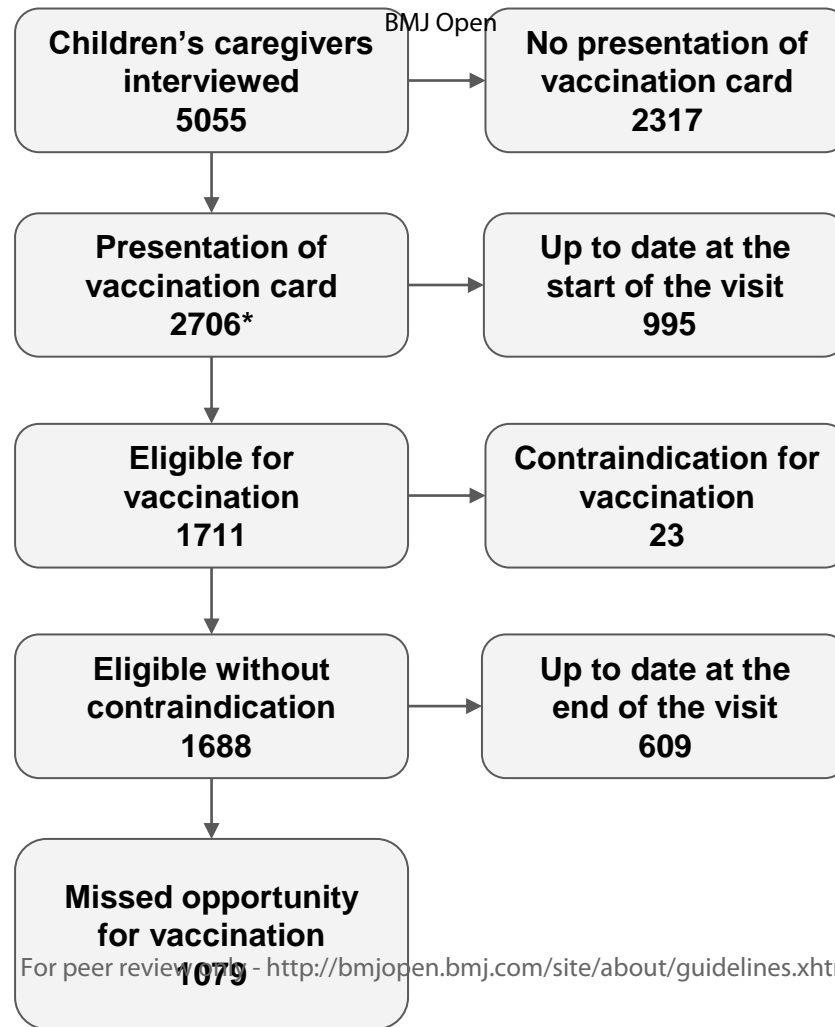
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21 380 **Figure 1. Flow chart of participants' inclusion and for determining Missed Opportunities**
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23 381 **for Vaccination (MOV), MSF-supported health facilities, 2011-2015**

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26 382 **32 children were not included due to data inconsistencies.*
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Evaluation of missed vaccination opportunities: child questionnaire

District:

Team:

N° child:

Center:

Date: / /

Age of the child: years months

1) Do you have a vaccination card or a health book for the child?

 No Yes → Did you bring it today? No Yes
2) What was the main purpose of your visit to the health center today? (One answer only)

<input type="checkbox"/> Curative consultation <input type="checkbox"/> MCH consultation <input type="checkbox"/> Accompanying an adult	<input type="checkbox"/> Vaccination <input type="checkbox"/> Feeding program <input type="checkbox"/> Other:
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3) Vaccination status:

Write the **dates** (dd/mm/yy) mentioned in the health book **and circle it** if vaccine given today.If the history of vaccination is only confirmed orally by the caretaker, write **H**.**Cross** the box (X) for the missing dose of vaccine that could have been given today.

	Dose 0	Dose 1	Dose 2	Dose 3
BCG	X		X	X
HepB birth dose		X	X	X
Polio				
DTP - HepB - Hib	X			
PCV 13	X			
Rota	X			X
Measles	X			X
Yellow fever	X		X	X

4) Was the child eligible for a vaccine today?

 No → Do you know the date of your next vaccination? No Yes → **END**
 Yes → Did the child present with a true contra-indication to the vaccination today?

 No Yes → **GO TO QUESTION 6**
5) Did the child receive all vaccines required today?
 Yes

(If X in box)

 No → Would you have accepted the vaccination today if proposed?

 Yes No → Why?

→ Reason(s) for not receiving all vaccines today? (One answer only)

<input type="checkbox"/> Out of stock <input type="checkbox"/> Waiting time too long <input type="checkbox"/> Don't know the reason	<input type="checkbox"/> No vaccinator <input type="checkbox"/> Not enough information <input type="checkbox"/> Other:
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6) Did you get an appointment for your next vaccination?

 No Yes

THANK YOU FOR YOUR PARTICIPATION!

STROBE Statement—Checklist of items that should be included in reports of *cross-sectional studies*

	Item No	Recommendation	Page No
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	2
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	4-5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4-5
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants	5
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	5-6
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	5-6
Bias	9	Describe any efforts to address potential sources of bias	5
Study size	10	Explain how the study size was arrived at	NA
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6-7
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	7
		(b) Describe any methods used to examine subgroups and interactions	7
		(c) Explain how missing data were addressed	6
		(d) If applicable, describe analytical methods taking account of sampling strategy	NA
		(e) Describe any sensitivity analyses	NA
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	6
		(b) Give reasons for non-participation at each stage	6
		(c) Consider use of a flow diagram	6
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8
		(b) Indicate number of participants with missing data for each variable of interest	NA
Outcome data	15*	Report numbers of outcome events or summary measures	8
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	9

		(b) Report category boundaries when continuous variables were categorized	10
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	NA
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	NA
Discussion			
Key results	18	Summarise key results with reference to study objectives	11
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	13-14
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	14
Generalisability	21	Discuss the generalisability (external validity) of the study results	NA
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	1

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

Missed Opportunities for Vaccination (MOV) in children up to 5 years old in 19 Médecins Sans Frontières-supported health facilities: a cross-sectional survey in six low resource countries.

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Primary Subject Heading:	Health policy
Secondary Subject Heading:	Epidemiology, Public health, Infectious diseases
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Title Page

Title: Missed Opportunities for Vaccination (MOV) in children up to 5 years old in 19 Médecins Sans Frontières-supported health facilities: a cross-sectional survey in six low resource countries.

Running Title: MOV in MSF supported health facilities

Key words: vaccine, vaccination, children, immunization program, health policy, process assessment, survey, low-income countries, Expanded Program of Immunization, missed opportunities, MOV, catch-up

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2
3 **Title: Missed Opportunities for Vaccination (MOV) in children up to 5 years old in 19**
4 **Médecins Sans Frontières-supported health facilities: a cross-sectional survey in six low**
5 **resource countries.**
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8
9 **Abstract**

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11 **Objective**

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14 To describe Missed Opportunities for Vaccination (MOV) among children visiting MSF-
15 supported facilities, their related factors, and to identify reasons for non-vaccination.
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18 **Design:** Cross-sectional surveys conducted between 2011 and 2015.
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21 **Setting and participants:** children up to 59 months of age visiting 19 MSF-supported
22 facilities (15 primary health care centers and 4 hospitals) in Afghanistan, Democratic
23 Republic of the Congo, Mauritania, Niger, Pakistan and South Sudan. Only children whose
24 caregivers presented their vaccination card were included.
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28 **Outcome measures:** We describe MOV prevalence and reasons for no vaccination. We also
29 assess the association of MOV with age, type of facility and reason for visit.
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32 **Results:** Among 5055 children's caregivers interviewed, 2738 presented a vaccination card of
33 whom 62.8% were eligible for vaccination and of those, 64.6% had a MOV. Presence of
34 MOV was more likely in children visiting a hospital or a health facility for a reason other than
35 vaccination. MOV occurrence was significantly higher among children aged 12-23 months
36 (84.4%) and 24-59 months (88.3%) compared with children below 12 months (56.2%,
37 $p \leq 0.001$). Main reasons reported by caregivers for MOV were lack of vaccines (40.3%),
38 reason unknown (31.2%), and not being informed (17.6%).
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45 **Conclusions**

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47 Avoiding MOV should remain a priority in low-resource settings, in line with the new 2030
48 Immunization Agenda. Children beyond the Expanded Program of Immunization are
49 particularly vulnerable for MOV. We strongly recommend assessment of eligibility for
50 vaccination as routine health care practice regardless of the reason for the visit by screening
51 vaccination card. Strengthening implementation of "Second year of life" visits and catch-up
52 activities are proposed strategies to reduce MOV.
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Strengths and limitations of this study

- The major strength of the study is that only children with a valid vaccination card were included, so not relying on self-reported data helped to avoid potential recall bias
- Differences by gender on Missed Opportunities for Vaccination were not explored
- Reasons related with Missed Opportunities for Vaccination were limited to those included at the questionnaire and declared by caregivers.

For peer review only

1 INTRODUCTION

2 Since 1983, the Expanded Program of Immunization (EPI) has recommended using every
3 health care visit as an opportunity to immunize each eligible child, regardless of the reason for
4 consultation. A Missed Opportunity for Vaccination (MOV) occurs when a child eligible for
5 vaccination (without contraindication) remains unvaccinated or partially vaccinated (not up-
6 to-date) at the end of the visit, so the consultation does not result in the children receiving all
7 the vaccine doses for which he or she was eligible. Among the causes for under-vaccination in
8 low and middle-income countries, 44% are for reasons related to health systems, including
9 MOV and lack of access to health care (1). In 1993, the first systematic review including 45
10 countries found a median MOV prevalence of 67% (2), and despite increases in routine
11 vaccination coverage since then, MOV remain as high as 32% in the last systematic review
12 performed in 2014 (3). Since then, the World Health Organization (WHO) has promoted the
13 use of MOV assessments to measure the performance of health services in vaccination (4)(5).
14 In order to improve immunization coverage, in 2017 WHO recommended a revised
15 methodology to assess MOV, targeting children aged 0-23 months (6). However, data is
16 scarce on MOV prevalence in children above 23 months of age (3). Through its medical
17 humanitarian programs in low and middle-income countries, Médecins Sans Frontières (MSF)
18 strengthens routine vaccination services regardless the age of the child, following WHO
19 recommendations (7), in order to reduce the number of under and unvaccinated children.
20 Therefore, we took the opportunity to systematically assess MOV in children up to five years
21 of age within MSF programs.

22 Our objective was to describe MOV prevalence and its characteristics, and to identify reasons
23 for non-vaccination among children up to five years of age visiting MSF-supported health
24 facilities in six different countries.

25 **METHODS**

26 **Study design and settings**

27 A cross-sectional exit survey of caregivers was performed in 19 health facilities. They
28 included four hospitals and 15 primary health care centers (PHCC) between 2011 and 2015 in
29 six countries: Afghanistan, Democratic Republic of the Congo, Mauritania, Niger, Pakistan
30 and South Sudan. Countries, health facilities and time of the assessments were chosen on a
31 convenient basis following operational reasons. Facilities included were chosen because MSF
32 was already supporting routine vaccination and where MOV training to local staff was
33 feasible in those health facilities.

34 **Patient and Public Involvement**

35 Patients or the public were not involved in the design, conduct, reporting or dissemination
36 plans of our research.

37 **Study population and participant selection**

38 The study population consisted of children up to five years of age accompanied by a
39 caregiver, visiting an MSF-supported facility. A convenience sample of all caregivers
40 accompanying a child under five years of age was approached on the day of the survey at each
41 facility. Caregivers were invited to participate when exiting the facility, regardless of the
42 reason for their visit, and those who provided oral consent were interviewed. If several
43 children were present with one caregiver, all were included. Children whose caregivers could
44 not present a vaccination card were excluded from the analysis.

45 **Data collection**

46 MSF developed a standardized methodology to assess MOV based on the 1988 WHO tool
47 (8). Interviews were conducted in local languages. In preparation for the survey, surveyors

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2
3 48 locally recruited received two days of training focusing on conducting the interview and
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5 49 identifying eligible children for vaccination according to national vaccination schedules, age
6
7 50 of the child and minimum interval between doses.
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10 51 A structured questionnaire was created (Annex 1) and used in all assessments. Information
11
12 52 on type of facility (hospital or PHCC), age of the child, presentation of a vaccination card,
13
14 53 reason for visiting the facility and vaccination history were collected, as well as whether there
15
16 54 was a contraindication for vaccination. We considered as contraindications, fever above 38,5
17
18 55 °C and a severe allergic reaction to a previous dose of DTP-containing or measles-containing
19
20 56 vaccines. For those who had not received any of the recommended vaccines during the visit,
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22 57 surveyors asked for reasons why the child was not vaccinated, whether caregivers accepted
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24 58 receiving the missing vaccines doses, and about their awareness of the next vaccination
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26 59 appointment.
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32 60 We classified children as having a MOV as per standard WHO's definition (6): a MOV
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34 61 occurs when a child eligible for vaccination (without contraindication) remains unvaccinated
35
36 62 or partially vaccinated (not up to date) at the end of any visit to a health facility (Figure 1).
37
38

39 63 Surveyors determined if the child was eligible that day of the assessment for at least one
40
41 64 vaccine dose according to age and National immunization schedules (Figure 2), and whether
42
43 65 the child had received all the recommended vaccines during that visit. Most of National
44
45 66 immunization programs allowed vaccination until 12 months of age by the time of the
46
47 67 assessments. Nevertheless, MSF supported vaccination of children up to 5 years of age in
48
49 68 each of these facilities. In our study, surveyors considered a MOV if a child did not receive
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51 69 the indicated vaccines even if they were above the recommended age to receive them
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53 70 according to the country policy, to the exception of BCG and Rotavirus (Figure 2). Only
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3 71 widely introduced vaccines in each country were considered to ascertain MOV. Year of
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5 72 vaccine introduction in each country can be consulted here (9).
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8 73 For those having a MOV, surveyors asked for reasons why the child was not vaccinated,
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10 74 whether caregivers would have accepted receiving the missing vaccines doses, and about their
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13 75 awareness of the next vaccination appointment.
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16 76 **Data analysis**

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19 77 We calculated the prevalence of MOV among children eligible for a vaccination, excluding
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21 78 those with a reported contraindication. Among children with a MOV we calculated the
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23 79 proportion of caregivers who would have accepted vaccination if it had been proposed on the
24
25
26 80 day of the visit and the proportion of caregivers who knew their date of next vaccination
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28 81 appointment.
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30

31 82 Proportions were used to describe the children and to estimate MOV. Significant differences
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33 83 in the distribution were assessed using the Pearson's two-sided Chi-square test or Fisher exact
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35
36 84 test. For the bivariate analysis, age was categorized as below and above 12 months of age as
37
38 85 this was the main target of the National program schedules in countries included at the time
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40
41 86 the survey was performed. Reasons for visit to the facility were grouped into either
42
43 87 vaccination or others. We assessed the association of MOV with age, type of facility and
44
45 88 reason for visit by calculating Odds Ratios. A logistic regression model was adjusted for age
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47 89 (0-11,12-59 months), type of facility (hospital, PHCC), and reason for visit (vaccination,
48
49 90 other reason). The level of statistical significance was set at $p < 0.05$.

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52 91 In each facility, data entry officers inputted the paper questionnaire data into an Excel
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54 92 database, which was validated by two of the study investigators. The analysis was performed
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56
57 93 using STATA (version 16, College Station, Texas).
58

59 94 **Ethics issues**

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3 95 Prior to each evaluation, authorization from the local health authorities and from the director
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5 96 of each health facility was obtained. Oral consent was received from each caregiver. During
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7 97 the survey, children <12 months identified with MOV were sent back to the vaccination unit
8
9 98 to receive the missing vaccine(s) if the caregiver agreed and if there was no shortage. All data
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11 99 from the questionnaires were anonymous and entered into a dedicated password-protected
12
13 100 electronic database. This research fulfilled the exemption criteria by Médecins sans Frontières
14
15 101 Ethics Review Board (MSF ERB) for a posteriori analysis of routinely collected clinical data
16
17 102 and thus did not require MSF ERB review. It was conducted with permission from the
18
19 103 Medical Director, Operational Centre Brussels Médecins sans Frontières.
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24 104 **RESULTS**

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27 105 From 2011 to 2015, the caregivers of 5055 children were interviewed in 19 facilities (four
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29 106 hospitals and 15 PHCCs). We report the results for the 2706 (53.5%) children who presented
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31 107 their vaccination card on the day of the survey: 33 from Afghanistan, 79 from Democratic
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33 108 Republic of the Congo, 244 from Mauritania, 1888 from Niger, 15 from Pakistan and 447
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35 109 from South Sudan. Characteristics of children not presenting vaccination cards can be
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37 110 consulted at Supplementary table 1.
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42 111 **Characteristics of the study population**

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45 112 Among the 2706 children included, 995 (36.7%) were already up to date before the visit, and
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47 113 1711 (63.2%) were eligible for vaccination. Twenty-three caregivers (1.3%) reported a
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49 114 contraindication (Figure 1). Among eligible children, 609 (36.1%) were vaccinated during the
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51 115 visit, whereas 1079 (63.9%) experienced a MOV during their health facility visit.
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55 116 Children's baseline characteristics are presented in Table 1. Their mean age was 10.1 months
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57 117 (Standard Deviation - 9). The majority (2213, 81.8%) were interviewed at exit of a PHCC.
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59 118 Reasons for visiting the health facility were distributed among curative consultation (31%),
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3 119 followed by unspecified reason (26%), vaccination (16%), nutrition (16%), mother and child
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5 120 health visit (10%) and accompanying an adult (1%).
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8 121 **Characteristics of children with MOV**

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11 122 Most children who were eligible for vaccination and consulting for a reason other than
12
13 123 vaccination, had a MOV (n=960, 71.9%), while a third of the children coming to the facility
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15 124 for vaccination also had a MOV (n=119, 33.7%). More than 80% of children aged 12-23
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17 125 months (265/314) and almost 90% of children aged 23-59 (151/171) had a MOV, compared
18
19 126 to 55% of children below 12 months (663/1203). MOV occurrence was significantly more
20
21 127 likely among older children than younger ones (Table 1). Differences in MOV by country can
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23 128 be consulted at Supplementary table 3.
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28 129 Only four caregivers of children with MOV would have refused vaccination if it had been
29
30 130 proposed during the visit. About one fifth (21%) of caregivers of children with MOV were
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32 131 aware of the date of the next vaccination appointment.
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36 132 The commonest reason declared for having a MOV was lack of vaccines (40.1%), followed
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38 133 by reason unknown (32%), not being informed (17.3%), lack of staff (3.3%), waiting time too
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40 134 long (1.7%) and other unclassified reasons (5.6%).
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43 135 **Factors related with presence of MOV**

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46 136 Children above 12 months of age and those accessing the health facility for a reason other
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48 137 than vaccination, had an almost five times higher risk of having a MOV (Table 2), compared
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50 138 to children below 12 months of age and those visiting for vaccination. Children visiting a
51
52 139 hospital had a 2.7 times higher risk of having a MOV compared to children visiting a PHCC.
53
54 140 After adjusting by type of facility and reason for visit, children above 12 months still had a
55
56 141 significantly higher risk of having a MOV (adjusted OR: 1.7, 95% CI 1.1-2.5).
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Table 1. Characteristics of children who visited MSF-supported health facilities and the presence of Missed Opportunities for Vaccination (MOV), 2011-2015

	Total children n=2706 n (%)	Eligible for vaccination ^a n=1688 n (%) ^b	MOV		p value
			No n (%) ^c	Yes n (%) ^c	
Age groups					
<12 m	1805 (66.7)	1203 (66.5)	540 (44.9)	663 (55.1)	<0,001 ^e
12-23 m	597 (22.1)	314 (52.6)	49 (15.6)	265 (84.4)	
24-59 m	304 (11.2)	171 (56.3)	20 (11.7)	151 (88.3)	
Facility type					
Hospital	493 (18.2)	336 (68.2)	67 (20)	269 (80.1)	<0,001 ^e
PHCC ^d	2213 (81.8)	1352 (61.1)	542 (40.1)	810 (59.9)	
Reason of the visit					
Curative	831 (30.7)	513 (61.7)	40 (7.8)	473 (92.2)	<0,001 ^f
Other	706 (26.1)	311 (44.1)	281 (90.4)	30 (9.7)	
Vaccination	436 (16.1)	353 (81.0)	234 (64.3)	119 (33.7)	
Nutrition	430 (15.9)	275 (64.0)	23 (8,4)	252 (91.6)	
Mother Child Health visit	265 (9.8)	214 (80.8)	29 (13.6)	185 (86.5)	
Accompanying	38 (1.4)	22 (57.9)	2 (9.0)	20 (90.9)	

^a Without contraindication for vaccination

^b Row percentage over the total children

^c Row percentage over the eligible children without contraindication for vaccination

^d PHCC: Primary Health Care Center

^e Chi square test

^f Fisher exact test

Table 2. Factors related to Missed Opportunities for Vaccination (MOV) in eligible children who visited MSF-supported health facilities, 2011-2015

	MOV children n= 1079 n (%)	Odds Ratio (95%CI)	Adjusted Odds Ratio (95%CI)
Age in months			
0-11 m	663 (55.1)		
12-59 m	416 (85.8)	4.91 (3.67-6.57)	3.79 (2.84-5.07)
Reason for visiting			
Vaccination	119 (33.7)		
Other	960 (89.0)	5.03 (3.86-6.56)	3.52 (2.70-4.58)
Facility type			
PHCC ^a	810 (59.9)		
Hospital	269 (80.1)	2.69 (2.00-3.60)	2.75 (2.02-3.73)

^a PHCC: Primary Health Care Center

Odds ratio adjusted for age, reason for visiting, facility type (two categories each)

157 **DISCUSSION**

158 This study summarizes the MSF experience and lessons learned assessing MOV from 2011 to
159 2015 in six low-income countries. To our knowledge, this is one of the few studies that
160 assessed MOV in children beyond 23 months of age. Our results highlight that, despite MSF's
161 efforts, most children had a MOV after visiting one of the facilities. Even among those
162 children who specifically visited for vaccination, one third still missed at least one dose of a
163 vaccine for which they were eligible during the visit. The proportion of children with MOV
164 increased with age, with children above one year of age being at higher risk.

165 MOV prevalence in our study (64%) was higher than the last systematic review conducted in
166 low income countries in 2014, which found a prevalence of 32% (26.8–37.7) (3). An
167 explanation could be that the majority of studies in this meta-analysis only included children
168 below two years of age resulting in a lower estimation of MOV. As our data show, MOV was
169 nearly 90% in children above 23 months of age. One of the few studies to include older
170 children also reported that MOV prevalence was higher in children aged 1-5 years (56.6%),
171 compared to those below one year (31.4%) (10). Thus, we believe that overall MOV
172 prevalence is being seriously underestimated, as assessments do not include children beyond
173 the EPI age target for most vaccines, that is, above 23 months of age.

174 Consistent with recent studies in low-income countries (11), we found a higher MOV
175 prevalence in children above 12 months. In a recent study that assessed MOV with WHO
176 methodology in Chad and Malawi (12), Ogbuano et al. found a MOV prevalence of 86% in
177 Chad and 94% in Malawi among children above one year of age, compared to 49% and 61%
178 below one year, respectively.

179 Age as a risk for having MOV may be explained by older children having been perceived as
180 “too old” to be eligible (13), as most National immunization programs only target children

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3 181 below one year of age. Age as a false contraindication was found to be one of the main
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5 182 reasons for having a MOV in a WHO review about factors related with under-vaccination
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7 183 (14). But efforts are being made to ‘Leave No One Behind’ (15): the latest WHO update of
8
9 184 recommendations for routine immunization (16) emphasizes that measles vaccine should not
10
11 185 be limited to children up to 12 months of age. Actually, there are no age limits to vaccinate
12
13 186 children (with rotavirus exception). In line with that, a “second year of life healthy child visit”
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15 187 is already recommended by WHO (17)(7) increasing the opportunity to vaccinate children,
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17 188 especially in those who might have missed vaccination in their first year of life. This strategy,
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19 189 together with complementary catch-up activities to continue screening children at any contact
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21 190 with health services, should be strengthened in low-resource settings (7)(18)(19)(20). We
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23 191 believe this ‘never too old’ policy should be adopted by all national immunization programs
24
25 192 in order to ensure children do not miss the opportunity to be fully vaccinated at any age.
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32 193 Our data draw attention to the high proportion of children missing an opportunity to get
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34 194 vaccinated at hospital level. A similar proportion has been found in a recent study performed
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36 195 in northern Indian hospitals (21). This could be explained by vaccine shortage at hospital
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38 196 level but also by the belief in the false contraindication for vaccination in a sick child among
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40 197 caregivers and health care workers. For example, a study in Haiti reported that up to 13% of
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42 198 reasons for under-vaccination was child illness, despite the fact that mild infections should not
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44 199 prevent vaccination (22). A similar finding is highlighted in a MOV assessment in East Timor
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46 200 (13) were Anyie J. Li et al. found that only 24% of health care workers were able to identify
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48 201 true contraindications, and L. Kaboré et al. (11) reported that 83% of health workers failed to
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50 202 correctly identify valid contraindications for vaccination. This could be avoided through the
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52 203 proper adherence to the Integrated Management of Newborn and Childhood Illnesses
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54 204 (IMNCI) guidelines (19), already in place in these countries (23).
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3 205 We identified that one third of children actually visiting for vaccination were still not up to
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5 206 date at the end of the visit despite being vaccinated with one or more doses. Similar estimates
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7 207 were found in four recent MOV assessments in East Timor, Chad, Malawi, and Burkina Faso
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9 208 (11)(12)(13). This could be explained by supply shortages of specific vaccines, but also by
10
11 209 health workers potentially failing to identify eligibility for certain vaccines. Failure to
12
13 210 administer simultaneous vaccines due to fear of wasting doses from multi-vial vaccines has
14
15 211 been also suggested as an explanation for remaining MOV after vaccination visits (24)(25).
16
17 212 Among reasons for MOV in our study, almost 20% reported not being informed by health
18
19 213 care workers about the eligibility of the child for vaccination. This lack of information on
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21 214 vaccine eligibility has also been reported elsewhere (26). Therefore, promoting training on
22
23 215 eligibility assessment and true contraindications for vaccination among health care workers
24
25 216 could be an effective strategy to reduce MOV (27).

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31 217 Over three-quarters of eligible children consulting for reasons other than vaccination (mother-
32
33 218 and-child health visits, nutrition, curative) had a MOV. This highlights the need of
34
35 219 strengthening routine screening of vaccination status that must be done irrespective of reason
36
37 220 visit. Caregivers should be encouraged to bring the vaccination card to every contact with
38
39 221 health services, to facilitate and ensure that the child can be properly screened for vaccination
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41 222 eligibility. So, integrating vaccination into other preventive or curative services at hospital
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43 223 and at primary health care level, could facilitate a significant reduction on MOV (28)(29).

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48 224 In our study, caregivers reported lack of vaccines as the main reason for MOV. This is
49
50 225 consistent with recent MOV assessments (12), where approximately 30% of health care
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52 226 workers reported insufficient vaccine supply or logistics issues. Inadequate vaccine supply
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54 227 has already been pointed out as one of the main reasons for under vaccination in low income
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56 228 countries (1). Ministries of Health and their partners must work to ensure adequate vaccine
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3 229 supply at facility level in order be able to vaccinate any children who have accessed health
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5 230 care services (30).
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8 231 This study has three main limitations. First, gender was not collected, losing the opportunity
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10 232 to uncover gender differences. Nevertheless, no gender differences in the distribution of MOV
11
12 233 have been reported in the latest studies (3)(12). Second, our survey didn't allow us to explore
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14 234 health care providers' practices and perceptions, identified as one of the main reasons related
15
16 235 to MOV in the last systematic review (3). In 2015, WHO launched a revised MOV strategy,
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18 236 which included Knowledge, Attitudes and Practices (KAP) questionnaires, to better guide the
19
20 237 implementation of interventions to reduce MOV (12); it is generating new evidence (31).
21
22 238 Also, we could not explore other factors that have been previously related to MOV such as
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24 239 maternal education, living in rural areas, number of children and other economic inequalities
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26 240 (32).
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32 241 Third, we excluded from the analysis almost half of the children whose caregivers could not
33
34 242 present a vaccination card. This may mean that we underestimated MOV prevalence in our
35
36 243 target population, since not presenting a vaccination card has shown to be associated with
37
38 244 MOV (1)(3)(33). On one hand, not relying on self-reported data helped avoid potential recall
39
40 245 bias, which is a limitation in vaccine coverage studies in low-resource settings (34). On the
41
42 246 other hand, possession of vaccination card declines with age (10) (a relation also observed in
43
44 247 our study, Supplementary table 1); what could result in an overestimated prevalence of MOV
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46 248 in older children. Nevertheless, when assessing the relation between MOV and age including
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48 249 those with and without vaccination card, we obtain similar results (Supplementary table 2).
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53 250 Finally, as children with identified MOV were sent back for vaccination when possible, it
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55 251 could have introduced a bias in MOV prevalence if these children were inadvertently
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3 252 interviewed again. Also, MOV prevalence estimates may have improved over the last ten
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5 253 years, as WHO has lately reinforced EPI vaccination during the second year of life.
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8 254 **CONCLUSIONS**

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10 255 Despite progress in vaccine coverage, MOV remains an important problem in low-resource
11
12 256 settings. Avoiding MOV should remain a priority where access to health care is limited, in
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14 257 line with the new 2030 Immunization Agenda (15). This is particularly important considering
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16 258 the negative impact COVID-19 pandemic is having on routine immunization programs in low
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18 259 and middle-income countries (35)(36).
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23 260 We recommend integrating systematic vaccination screening into routine health care services,
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25 261 regardless of the reason for the visit, the type of facility and the age of the child. To promote
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27 262 maintaining and providing vaccination cards at every health care visit will help to reinforce
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29 263 vaccination screening and better identification of eligible children.
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32
33 264 We identified that children above 23 months of age are particularly vulnerable for MOV.
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35 265 Thus, we would recommend including children beyond 23 months of age in the current WHO
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37 266 methodology for MOV assessments in order to avoid underestimation of MOV. National
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39 267 immunization programs should allow to administer missing doses regardless the age of the
40
41 268 child, as the EPI has expanded its vaccination recommendations during second year of life
42
43 269 and beyond. Strengthening the implementation of second-year-of-life visits, as recommended
44
45 270 by WHO, with catch-up vaccination strategies (7) would provide additional opportunities to
46
47 271 receive missed vaccine doses and *leave no one behind*.
48
49

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51
52
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54
55 274 workers who performed the assessments. Special thanks to Ibrahim Barrie and Marie-Eve
56
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2
3 275 Burny for implementation of MOV studies in the field. Thanks to Tony Reid for language
4
5 276 review and to J.A. Rodrigo for his valuable input.
6

277 **Contributorship Statement**

278 Bachy C. and Panunzi I. designed the study and contributed to conduct it in the six countries.
279 Bachy C., Panunzi I., Gil-Cuesta J. and Borrás-Bermejo B. carried out the data analysis.
280 Borrás-Bermejo B. drafted the manuscript that was critically reviewed and approved by all
281 authors.

282 **Competing interests**

283 None declared

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285 The study was carried out by MSF staff as part of their routine activities. No extra funding
286 was required.

287 **Data Availability Statement**

288 Questionnaire dataset is available in a public, open access repository.

289 [dataset] Borrás-Bermejo B. Data from: Missed Opportunities for Vaccination in MSF-
290 Supported Health Facilities. Open Science Framework. December 6, 2021.

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17 **Figure 1. Flow chart of participants' inclusion and for determining Missed Opportunities for**
18 **Vaccination (MOV), MSF-supported health facilities, 2011-2015.**

19 **32 children were not included due to data inconsistencies.**
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24 **Figure 2. Immunization schedule to ascertain MOV**
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26 **BCG: Bacille Calmette-Guerin vaccine.**

27 **OPV: Oral Polio vaccine. Inactivated Polio Vaccine was not considered for MOV.**

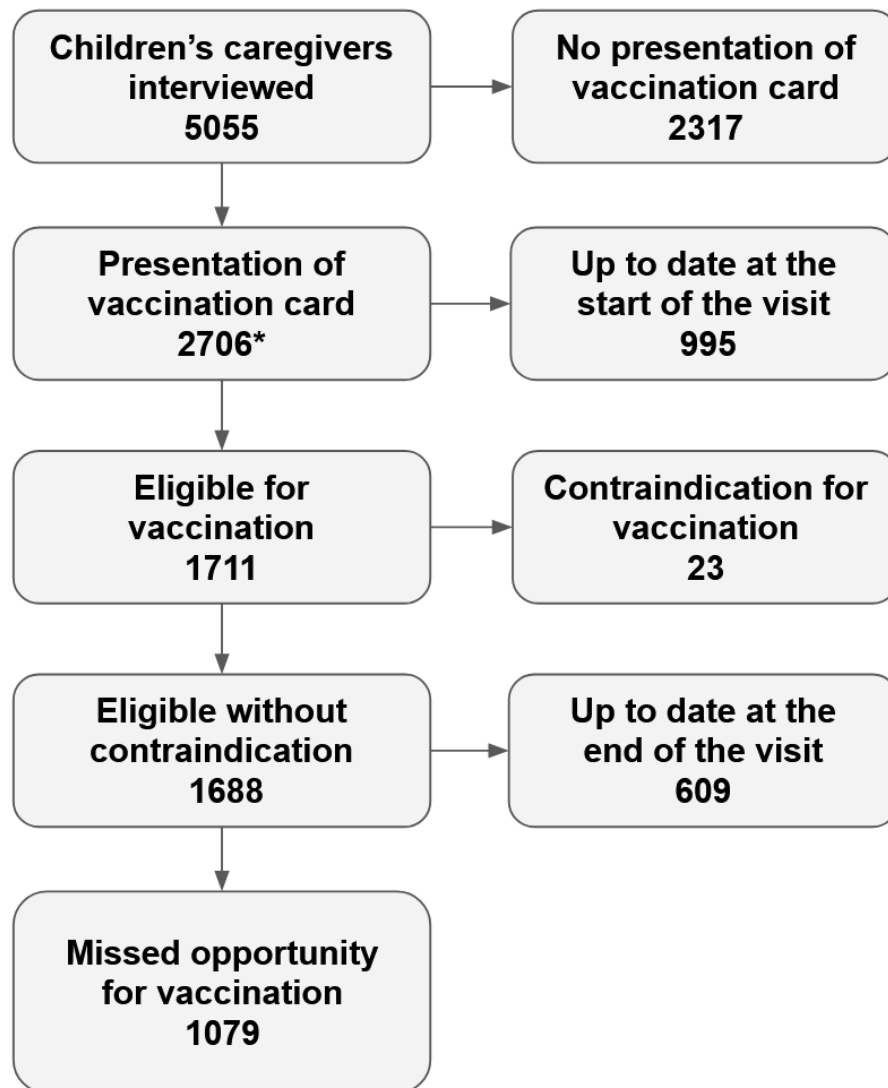
28 **Pentavalent vaccine: Diphtheria-tetanus-pertussis-hepatitis B- Haemophilus influenza type b.**

29 **PCV: Pneumococcal conjugate vaccine. Only considered for MOV in countries where it was**
30 **introduced.**
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32 **Measles containing vaccine: only one dose was considered for MOV.**

33 **Yellow Fever: it was considered for MOV only in endemic countries.**
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Figure 1. Flow chart of participants' inclusion and for determining Missed Opportunities for Vaccination (MOV), MSF-supported health facilities, 2011-2015



*32 children were not included due to data inconsistencies.

Figure 2. Immunization schedule to ascertain MOV

Vaccine	Recommended age
Birth dose	
BCG	At birth – up to 12 months
OPV	At birth – up to 2 weeks
Hepatitis B vaccine	At birth – up to 2 weeks
First dose	
OPV	From 6 weeks - up to 12 months
Pentavalent vaccine	From 6 weeks
PCV	From 6 weeks
Rotavirus	From 6 weeks - up to 12 months
Minimum interval of 4 weeks between First and Second dose	
Second dose	
OPV	From 10 weeks - up to 12 months
Pentavalent vaccine	From 10 weeks
PCV	From 10 weeks
Rotavirus	From 10 weeks - up to 12 months
Minimum interval of 4 weeks between Second and Third dose	
Third dose	
OPV	From 14 weeks - up to 12 months
Pentavalent vaccine	From 14 weeks
PCV	From 14 weeks
Measles-containing vaccine	From 9 months
Yellow Fever	From 9 months

BCG: Bacille Calmette-Guerin vaccine.

OPV: Oral Polio vaccine. Inactivated Polio Vaccine was not considered for MOV.

Pentavalent vaccine: Diphtheria-tetanus-pertussis-hepatitis B- Haemophilus influenza type b.

PCV: Pneumococcal conjugate vaccine. Only considered for MOV in countries where it was introduced.

Measles containing vaccine: only one dose was considered for MOV.

Yellow Fever: it was considered for MOV only in endemic countries.

Supplementary Table 1. Characteristics of interviewed children by presentation of vaccination card. MSF-supported health facilities (2011-2015)

	Total N	Presentation of vaccination card				<i>p</i> value
		No		Yes		
	N	N	%	N	%	
Age groups						
<12 m	2742	906	33.0	1836	67.0	
12-23 m	1263	665	52.7	598	47.4	
24-59 m	1050	746	71.1	304	29.0	<0.001 ^a
Eligible						
No	2276	1258	55.3	1018	44.7	
Yes	2779	1059	38.1	1720	61.9	<0.001 ^b
MOV^c						
No	2985	1358	45.5	1627	54.5	
Yes	2070	959	46.3	1111	53.7	0.558 ^b
Total	5055	2317	45.8	2738	54.2	

% Row percentages

^a Fisher exact test

^b Chi square test

^c MOV over the eligible children without contraindication for vaccination

Supplementary Table 2. Characteristics of children with MOV irrespective of the possession of vaccination card. MSF-supported health facilities (2011-2015)

	MOV ^a				<i>p</i> value
	No		Yes		
	N	%	N	%	
Age groups					
<12 m	588	33.2	1182	66.8	
12-23 m	66	11.6	504	88.4	
24-59 m	55	12.5	384	87.5	0.001 ^b
Total	709	25.5	2070	74.5	

^a MOV over the eligible children without contraindication for vaccination

^b Fisher exact test

Supplementary Table 3. Children who visited MSF-supported health facilities by country (2011-2015)

Country	Children with vaccination card		Eligible with no contraindication		MOV	
	n	% ^a	n	% ^b	n	% ^c
Afghanistan	33	1.2	11	33.3	8	72.7
Democratic Republic of the Congo	79	2.9	41	51.9	26	63.4
Mauritania	244	9.0	158	64.8	118	74.7
Niger	1888	69.8	1073	56.8	851	79.3
Pakistan	15	0.6	8	53.3	1	12.5
South Sudan	447	16.5	397	88.8	75	18.9
Total	2706	100.0	1688	62.4	1079	63.9

^a Column percentage

^b Row percentage among children with vaccination card

^c Row percentage among eligible children without contraindication

Evaluation of missed vaccination opportunities: child questionnaire

District: Team: N° child:

Center: Date: / / Age of the child: years months

1) Do you have a vaccination card or a health book for the child?

No Yes → Did you bring it today? No Yes

2) What was the main purpose of your visit to the health center today? (One answer only)

- | | |
|--|--|
| <input type="checkbox"/> Curative consultation | <input type="checkbox"/> Vaccination |
| <input type="checkbox"/> MCH consultation | <input type="checkbox"/> Feeding program |
| <input type="checkbox"/> Accompanying an adult | <input type="checkbox"/> Other: |

3) Vaccination status:

Write the **dates** (dd/mm/yy) mentioned in the health book **and circle it** if vaccine given today. If the history of vaccination is only confirmed orally by the caretaker, write **H**. **Cross** the box (X) for the missing dose of vaccine that could have been given today.

	Dose 0	Dose 1	Dose 2	Dose 3
BCG	X		X	X
HepB birth dose		X	X	X
Polio				
DTP - HepB - Hib	X			
PCV 13	X			
Rota	X			X
Measles	X			X
Yellow fever	X		X	X

4) Was the child eligible for a vaccine today?

No → Do you know the date of your next vaccination? No Yes → **END**

Yes → Did the child present with a true contra-indication to the vaccination today?
 No Yes → **GO TO QUESTION 6**

5) Did the child receive all vaccines required today?

Yes
 (If X in box) No → Would you have accepted the vaccination today if proposed?
 Yes No → Why?

→ Reason(s) for not receiving all vaccines today? (One answer only)

- | | |
|--|---|
| <input type="checkbox"/> Out of stock | <input type="checkbox"/> No vaccinator |
| <input type="checkbox"/> Waiting time too long | <input type="checkbox"/> Not enough information |
| <input type="checkbox"/> Don't know the reason | <input type="checkbox"/> Other: |

6) Did you get an appointment for your next vaccination? No Yes

THANK YOU FOR YOUR PARTICIPATION!

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60STROBE Statement—Checklist of items that should be included in reports of *cross-sectional studies*

	Item No	Recommendation	Page No
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	2
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants	5
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	5-7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	5-7
Bias	9	Describe any efforts to address potential sources of bias	6-7
Study size	10	Explain how the study size was arrived at	NA
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6-7
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	7
		(b) Describe any methods used to examine subgroups and interactions	7
		(c) Explain how missing data were addressed	6
		(d) If applicable, describe analytical methods taking account of sampling strategy	NA
		(e) Describe any sensitivity analyses	NA
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	8
		(b) Give reasons for non-participation at each stage	8
		(c) Consider use of a flow diagram	6
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8
		(b) Indicate number of participants with missing data for each variable of interest	NA
Outcome data	15*	Report numbers of outcome events or summary measures	8
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	9-10

		(b) Report category boundaries when continuous variables were categorized	10
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	NA
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	NA
Discussion			
Key results	18	Summarise key results with reference to study objectives	11
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	14
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	14
Generalisability	21	Discuss the generalisability (external validity) of the study results	NA
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	16

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

Missed Opportunities for Vaccination (MOV) in children up to 5 years old in 19 Médecins Sans Frontières-supported health facilities: a cross-sectional survey in six low resource countries.

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Manuscript ID	bmjopen-2021-059900.R2
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Primary Subject Heading:	Health policy
Secondary Subject Heading:	Epidemiology, Public health, Infectious diseases
Keywords:	Public health < INFECTIOUS DISEASES, Epidemiology < INFECTIOUS DISEASES, Organisation of health services < HEALTH SERVICES ADMINISTRATION & MANAGEMENT, Paediatric infectious disease & immunisation < PAEDIATRICS, Community child health < PAEDIATRICS

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Title Page

Title: Missed Opportunities for Vaccination (MOV) in children up to 5 years old in 19 Médecins Sans Frontières-supported health facilities: a cross-sectional survey in six low resource countries.

Running Title: MOV in MSF supported health facilities

Key words: vaccine, vaccination, children, immunization program, health policy, process assessment, survey, low-income countries, Expanded Program of Immunization, missed opportunities, MOV, catch-up

Authors

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2
3 **Title: Missed Opportunities for Vaccination (MOV) in children up to 5 years old in 19**
4 **Médecins Sans Frontières-supported health facilities: a cross-sectional survey in six low**
5 **resource countries.**
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8
9 **Abstract**

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11 **Objective**

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13 To describe Missed Opportunities for Vaccination (MOV) among children visiting MSF-
14 supported facilities, their related factors, and to identify reasons for non-vaccination.
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18 **Design:** Cross-sectional surveys conducted between 2011 and 2015.
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21 **Setting and participants:** children up to 59 months of age visiting 19 MSF-supported
22 facilities (15 primary health care centers and 4 hospitals) in Afghanistan, Democratic
23 Republic of the Congo, Mauritania, Niger, Pakistan and South Sudan. Only children whose
24 caregivers presented their vaccination card were included.
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28 **Outcome measures:** We describe MOV prevalence and reasons for no vaccination. We also
29 assess the association of MOV with age, type of facility and reason for visit.
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33 **Results:** Among 5055 children's caregivers interviewed, 2738 presented a vaccination card of
34 whom 62.8% were eligible for vaccination and of those, 64.6% had a MOV. Presence of
35 MOV was more likely in children visiting a hospital or a health facility for a reason other than
36 vaccination. MOV occurrence was significantly higher among children aged 12-23 months
37 (84.4%) and 24-59 months (88.3%) compared with children below 12 months (56.2%,
38 $p \leq 0.001$). Main reasons reported by caregivers for MOV were lack of vaccines (40.3%),
39 reason unknown (31.2%), and not being informed (17.6%).
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45 **Conclusions**

46
47 Avoiding MOV should remain a priority in low-resource settings, in line with the new
48 "Immunization Agenda 2030". Children beyond their second year of life are particularly
49 vulnerable for MOV. We strongly recommend assessment of eligibility for vaccination as
50 routine health care practice regardless of the reason for the visit by screening vaccination
51 card. Strengthening implementation of "Second year of life" visits and catch-up activities are
52 proposed strategies to reduce MOV.
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Strengths and limitations of this study

- The major strength of the study is that only children with a valid vaccination card were included, so not relying on self-reported data helped to avoid potential recall bias
- Differences by gender on Missed Opportunities for Vaccination were not explored
- Reasons related with Missed Opportunities for Vaccination were limited to those included at the questionnaire and declared by caregivers.

For peer review only

1 INTRODUCTION

2 Since 1983, the Expanded Program of Immunization (EPI) has recommended using every
3 health care visit as an opportunity to immunize each eligible child, regardless of the reason for
4 consultation. A Missed Opportunity for Vaccination (MOV) occurs when a child eligible for
5 vaccination (without contraindication) remains unvaccinated or partially vaccinated (not up-
6 to-date) at the end of the visit, so the consultation does not result in the children receiving all
7 the vaccine doses for which he or she was eligible. Among the causes for under-vaccination in
8 low and middle-income countries, 44% are for reasons related to health systems, including
9 MOV and lack of access to health care (1). In 1993, the first systematic review including 45
10 countries found a median MOV prevalence of 67% (2), and despite increases in routine
11 vaccination coverage since then, MOV remain as high as 32% in the last systematic review
12 performed in 2014 (3). Since then, the World Health Organization (WHO) has promoted the
13 use of MOV assessments to measure the performance of health services in vaccination (4)(5).
14 In order to improve immunization coverage, in 2017 WHO recommended a revised
15 methodology to assess MOV, targeting children aged 0-23 months (6). However, data is
16 scarce on MOV prevalence in children above 23 months of age (3). Through its medical
17 humanitarian programs in low and middle-income countries, Médecins Sans Frontières (MSF)
18 strengthens routine vaccination services regardless the age of the child, following WHO
19 recommendations (7), in order to reduce the number of under and unvaccinated children.
20 Therefore, we took the opportunity to systematically assess MOV in children up to five years
21 of age within MSF programs.

22 Our objective was to describe MOV prevalence and its characteristics, and to identify reasons
23 for non-vaccination among children up to five years of age visiting MSF-supported health
24 facilities in six different countries.

25 **METHODS**

26 **Study design and settings**

27 A cross-sectional exit survey of caregivers was performed in 19 health facilities. They
28 included four hospitals and 15 primary health care centers (PHCC) between 2011 and 2015 in
29 six countries: Afghanistan, Democratic Republic of the Congo, Mauritania, Niger, Pakistan
30 and South Sudan. Countries, health facilities and time of the assessments were chosen on a
31 convenient basis following operational reasons. Facilities included were chosen because MSF
32 was already supporting routine vaccination and where MOV training to local staff was
33 feasible in those health facilities.

34 **Patient and Public Involvement**

35 Patients or the public were not involved in the design, conduct, reporting or dissemination
36 plans of our research.

37 **Study population and participant selection**

38 The study population consisted of children up to five years of age accompanied by a
39 caregiver, visiting an MSF-supported facility. A convenience sample of all caregivers
40 accompanying a child under five years of age was approached on the day of the survey at each
41 facility. Caregivers were invited to participate when exiting the facility, regardless of the
42 reason for their visit, and those who provided oral consent were interviewed. If several
43 children were present with one caregiver, all were included. Children whose caregivers could
44 not present a vaccination card were excluded from the analysis.

45 **Data collection**

46 MSF developed a standardized methodology to assess MOV based on the 1988 WHO tool
47 (8). Interviews were conducted in local languages. In preparation for the survey, surveyors

1
2
3 48 locally recruited received two days of training focusing on conducting the interview and
4
5 49 identifying eligible children for vaccination according to national vaccination schedules, age
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7 50 of the child and minimum interval between doses.
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10 51 A structured questionnaire was created (Annex 1) and used in all assessments. Information
11
12 52 on type of facility (hospital or PHCC), age of the child, presentation of a vaccination card,
13
14 53 reason for visiting the facility and vaccination history were collected, as well as whether there
15
16 54 was a contraindication for vaccination. We considered as contraindications, fever above 38,5
17
18 55 °C and a severe allergic reaction to a previous dose of DTP-containing or measles-containing
19
20 56 vaccines. For those who had not received any of the recommended vaccines during the visit,
21
22 57 surveyors asked for reasons why the child was not vaccinated, whether caregivers accepted
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24 58 receiving the missing vaccines doses, and about their awareness of the next vaccination
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26 59 appointment.
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32 60 We classified children as having a MOV as per standard WHO's definition (6): a MOV
33
34 61 occurs when a child eligible for vaccination (without contraindication) remains unvaccinated
35
36 62 or partially vaccinated (not up to date) at the end of any visit to a health facility (Figure 1).
37
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39 63 Surveyors determined if the child was eligible that day of the assessment for at least one
40
41 64 vaccine dose according to age and National immunization schedules (Figure 2), and whether
42
43 65 the child had received all the recommended vaccines during that visit. Most of National
44
45 66 immunization programs allowed vaccination until 12 months of age by the time of the
46
47 67 assessments. Nevertheless, MSF supported vaccination of children up to 5 years of age in
48
49 68 each of these facilities. In our study, surveyors considered a MOV if a child did not receive
50
51 69 the indicated vaccines even if they were above the recommended age to receive them
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53 70 according to the country policy, to the exception of BCG and Rotavirus (Figure 2). Only
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3 71 widely introduced vaccines in each country were considered to ascertain MOV. Year of
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5 72 vaccine introduction in each country can be consulted here (9).
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8 73 For those having a MOV, surveyors asked for reasons why the child was not vaccinated,
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10 74 whether caregivers would have accepted receiving the missing vaccines doses, and about their
11
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13 75 awareness of the next vaccination appointment.
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16 76 **Data analysis**

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18
19 77 We calculated the prevalence of MOV among children eligible for a vaccination, excluding
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21 78 those with a reported contraindication. Among children with a MOV we calculated the
22
23 79 proportion of caregivers who would have accepted vaccination if it had been proposed on the
24
25
26 80 day of the visit and the proportion of caregivers who knew their date of next vaccination
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28 81 appointment.
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31 82 Proportions were used to describe the children and to estimate MOV. Significant differences
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33 83 in the distribution were assessed using the Pearson's two-sided Chi-square test or Fisher exact
34
35
36 84 test. For the bivariate analysis, age was categorized as below and above 12 months of age as
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38 85 this was the main target of the National program schedules in countries included at the time
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40
41 86 the survey was performed. Reasons for visit to the facility were grouped into either
42
43 87 vaccination or others. We assessed the association of MOV with age, type of facility and
44
45 88 reason for visit by calculating Odds Ratios. A logistic regression model was adjusted for age
46
47 89 (0-11,12-59 months), type of facility (hospital, PHCC), and reason for visit (vaccination,
48
49 90 other reason). The level of statistical significance was set at $p < 0.05$.

50
51
52 91 In each facility, data entry officers inputted the paper questionnaire data into an Excel
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54 92 database, which was validated by two of the study investigators (10). The analysis was
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56
57 93 performed using STATA (version 16, College Station, Texas).
58

59 94 **Ethics issues**

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3 95 Prior to each evaluation, authorization from the local health authorities and from the director
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5 96 of each health facility was obtained. Oral consent was received from each caregiver. During
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7 97 the survey, children identified with MOV were sent back to the vaccination unit to receive the
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9 98 missing vaccine(s) if the caregiver agreed and if there was no shortage. All data from the
10
11 99 questionnaires were anonymous and entered into a dedicated password-protected electronic
12
13 100 database. This research fulfilled the exemption criteria by Médecins sans Frontières Ethics
14
15 101 Review Board (MSF ERB) for a posteriori analysis of routinely collected clinical data and
16
17 102 thus did not require MSF ERB review. It was conducted with permission from the Medical
18
19 103 Director, Operational Centre Brussels Médecins sans Frontières.

104 **RESULTS**

105 From 2011 to 2015, the caregivers of 5055 children were interviewed in 19 facilities (four
106 hospitals and 15 PHCCs). We report the results for the 2706 (53.5%) children who presented
107 their vaccination card on the day of the survey: 33 from Afghanistan, 79 from Democratic
108 Republic of the Congo, 244 from Mauritania, 1888 from Niger, 15 from Pakistan and 447
109 from South Sudan. Characteristics of children not presenting vaccination cards can be
110 consulted at Supplementary table 1.

111 **Characteristics of the study population**

112 Among the 2706 children included, 995 (36.7%) were already up to date before the visit, and
113 1711 (63.2%) were eligible for vaccination. Twenty-three caregivers (1.3%) reported a
114 contraindication (Figure 1). Among eligible children, 609 (36.1%) were vaccinated during the
115 visit, whereas 1079 (63.9%) experienced a MOV during their health facility visit.

116 Children's baseline characteristics are presented in Table 1. Their mean age was 10.1 months
117 (Standard Deviation - 9). The majority (2213, 81.8%) were interviewed at exit of a PHCC.
118 Reasons for visiting the health facility were distributed among curative consultation (31%),

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3 119 followed by unspecified reason (26%), vaccination (16%), nutrition (16%), mother and child
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5 120 health visit (10%) and accompanying an adult (1%).
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8 121 **Characteristics of children with MOV**

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11 122 Most children who were eligible for vaccination and consulting for a reason other than
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13 123 vaccination, had a MOV (n=960, 71.9%), while a third of the children coming to the facility
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15 124 for vaccination also had a MOV (n=119, 33.7%). More than 80% of children aged 12-23
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17 125 months (265/314) and almost 90% of children aged 23-59 (151/171) had a MOV, compared
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19 126 to 55% of children below 12 months (663/1203). MOV occurrence was significantly more
20
21 127 likely among older children than younger ones (Table 1). Differences in MOV by country can
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23 128 be consulted at Supplementary table 2.
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28 129 Only four caregivers of children with MOV would have refused vaccination if it had been
29
30 130 proposed during the visit. About one fifth (21%) of caregivers of children with MOV were
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32 131 aware of the date of the next vaccination appointment.
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36 132 The commonest reason declared for having a MOV was lack of vaccines (40.1%), followed
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38 133 by reason unknown (32%), not being informed (17.3%), lack of staff (3.3%), waiting time too
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40 134 long (1.7%) and other unclassified reasons (5.6%).
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44 135 **Factors related with presence of MOV**

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46 136 Children above 12 months of age and those accessing the health facility for a reason other
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48 137 than vaccination, had an almost five times higher risk of having a MOV (Table 2), compared
49
50 138 to children below 12 months of age and those visiting for vaccination. Children visiting a
51
52 139 hospital had a 2.7 times higher risk of having a MOV compared to children visiting a PHCC.
53
54 140 After adjusting by type of facility and reason for visit, children above 12 months still had a
55
56 141 significantly higher risk of having a MOV (adjusted OR: 1.7, 95% CI 1.1-2.5).
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Table 1. Characteristics of children who visited MSF-supported health facilities and the presence of Missed Opportunities for Vaccination (MOV), 2011-2015

	Total children n=2706 n (%)	Eligible for vaccination ^a n=1688 n (%) ^b	MOV		p value
			No n (%) ^c	Yes n (%) ^c	
Age groups					
<12 m	1805 (66.7)	1203 (66.5)	540 (44.9)	663 (55.1)	<0,001 ^e
12-23 m	597 (22.1)	314 (52.6)	49 (15.6)	265 (84.4)	
24-59 m	304 (11.2)	171 (56.3)	20 (11.7)	151 (88.3)	
Facility type					
Hospital	493 (18.2)	336 (68.2)	67 (20)	269 (80.1)	<0,001 ^e
PHCC ^d	2213 (81.8)	1352 (61.1)	542 (40.1)	810 (59.9)	
Reason of the visit					
Curative	831 (30.7)	513 (61.7)	40 (7.8)	473 (92.2)	<0,001 ^f
Other	706 (26.1)	311 (44.1)	281 (90.4)	30 (9.7)	
Vaccination	436 (16.1)	353 (81.0)	234 (64.3)	119 (33.7)	
Nutrition	430 (15.9)	275 (64.0)	23 (8.4)	252 (91.6)	
Mother Child Health visit	265 (9.8)	214 (80.8)	29 (13.6)	185 (86.5)	
Accompanying	38 (1.4)	22 (57.9)	2 (9.0)	20 (90.9)	

^a Without contraindication for vaccination

^b Row percentage over the total children

^c Row percentage over the eligible children without contraindication for vaccination

^d PHCC: Primary Health Care Center

^e Chi square test

^f Fisher exact test

Table 2. Factors related to Missed Opportunities for Vaccination (MOV) in eligible children who visited MSF-supported health facilities, 2011-2015

	MOV children n= 1079 n (%)	Odds Ratio (95%CI)	Adjusted Odds Ratio (95%CI)
Age in months			
0-11 m	663 (55.1)		
12-59 m	416 (85.8)	4.91 (3.67-6.57)	3.79 (2.84-5.07)
Reason for visiting			
Vaccination	119 (33.7)		
Other	960 (89.0)	5.03 (3.86-6.56)	3.52 (2.70-4.58)
Facility type			
PHCC ^a	810 (59.9)		
Hospital	269 (80.1)	2.69 (2.00-3.60)	2.75 (2.02-3.73)

^a PHCC: Primary Health Care Center

Odds ratio adjusted for age, reason for visiting, facility type (two categories each)

157 **DISCUSSION**

158 This study summarizes the MSF experience and lessons learned assessing MOV from 2011 to
159 2015 in six low-income countries. To our knowledge, this is one of the few studies that
160 assessed MOV in children beyond 23 months of age. Our results highlight that, despite MSF's
161 efforts, most children had a MOV after visiting one of the facilities. Even among those
162 children who specifically visited for vaccination, one third still missed at least one dose of a
163 vaccine for which they were eligible during the visit. The proportion of children with MOV
164 increased with age, with children above one year of age being at higher risk.

165 MOV prevalence in our study (64%) was higher than the last systematic review conducted in
166 low income countries in 2014, which found a prevalence of 32% (26.8–37.7) (3). An
167 explanation could be that the majority of studies in this meta-analysis only included children
168 below two years of age resulting in a lower estimation of MOV. As our data show, MOV was
169 nearly 90% in children above 23 months of age. One of the few studies to include older
170 children also reported that MOV prevalence was higher in children aged 1-5 years (56.6%),
171 compared to those below one year (31.4%) (11). Thus, we believe that overall MOV
172 prevalence is being seriously underestimated, as assessments do not include children beyond
173 the EPI age target for most vaccines, that is, above 23 months of age.

174 Consistent with recent studies in low-income countries (12), we found a higher MOV
175 prevalence in children above 12 months. In a recent study that assessed MOV with WHO
176 methodology in Chad and Malawi (13), Ogbuano et al. found a MOV prevalence of 86% in
177 Chad and 94% in Malawi among children above one year of age, compared to 49% and 61%
178 below one year, respectively.

179 Age as a risk for having MOV may be explained by older children having been perceived as
180 “too old” to be eligible (14), as many National immunization programs only target children

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3 181 below one year of age. Age as a false contraindication was found to be one of the main
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5 182 reasons for having a MOV in a WHO review about factors related with under-vaccination
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8 183 (15). For example, even if 2013 WHO removed age restriction for rotavirus vaccine in the
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10 184 WHO African region, nevertheless it is not implemented in many countries (16)(17). But
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12 185 efforts are being made to ‘Leave No One Behind’ (18): the latest WHO update of
13
14 186 recommendations for routine immunization (19) emphasizes that measles vaccine should not
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17 187 be limited to children up to 12 months of age. In line with that, a “second year of life healthy
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19 188 child visit” is already recommended by WHO (20)(7) increasing the opportunity to vaccinate
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21 189 children, especially in those who might have missed vaccination in their first year of life. This
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24 190 strategy, together with complementary catch-up activities to continue screening children at
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26 191 any contact with health services, should be strengthened in low-resource settings
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28 192 (7)(21)(22)(23). We believe this ‘never too old’ policy should be adopted by all national
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30 193 immunization programs in order to ensure children do not miss the opportunity to be fully
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33 194 vaccinated at any age.

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36 195 Our data draw attention to the high proportion of children missing an opportunity to get
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38 196 vaccinated at hospital level. A similar proportion has been found in a recent study performed
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40 197 in northern Indian hospitals (24). This could be explained by vaccine shortage at hospital
41
42 198 level but also by the belief in the false contraindication for vaccination in a sick child among
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44 199 caregivers and health care workers. For example, a study in Haiti reported that up to 13% of
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46 200 reasons for under-vaccination was child illness, despite the fact that mild infections should not
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48 201 prevent vaccination (25). A similar finding is highlighted in a MOV assessment in Timor
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50 202 Leste (14) were Li et al. found that only 24% of health care workers were able to identify true
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52 203 contraindications, and Kaboré et al. (12) reported that 83% of health workers failed to
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54 204 correctly identify valid contraindications for vaccination. This could be avoided through the
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3 205 proper adherence to the Integrated Management of Newborn and Childhood Illnesses
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5 206 (IMNCI) guidelines (22), already in place in these countries (26).
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8 207 We identified that one third of children actually visiting for vaccination were still not up to
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10 208 date at the end of the visit despite being vaccinated with one or more doses. Similar estimates
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12 209 were found in four recent MOV assessments in Timor Leste, Chad, Malawi, and Burkina Faso
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14 210 (12)(13)(14). This could be explained by supply shortages of specific vaccines, but also by
15
16 211 health workers potentially failing to identify eligibility for certain vaccines. Failure to
17
18 212 administer simultaneous vaccines due to fear of wasting doses from multi-vial vaccines has
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20 213 been also suggested as an explanation for remaining MOV after vaccination visits (27)(28).
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22 214 Among reasons for MOV in our study, almost 20% reported not being informed by health
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24 215 care workers about the eligibility of the child for vaccination. This lack of information on
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26 216 vaccine eligibility has also been reported elsewhere (29). Therefore, promoting training on
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28 217 eligibility assessment and true contraindications for vaccination among health care workers
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30 218 could be an effective strategy to reduce MOV (30).
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36 219 Over three-quarters of eligible children consulting for reasons other than vaccination (mother-
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38 220 and-child health visits, nutrition, curative) had a MOV. This highlights the need of
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40 221 strengthening routine screening of vaccination status that must be done irrespective of reason
41
42 222 visit. Caregivers should be encouraged to bring the vaccination card to every contact with
43
44 223 health services, to facilitate and ensure that the child can be properly screened for vaccination
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46 224 eligibility. So, integrating vaccination into other preventive or curative services at hospital
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48 225 and at primary health care level, could facilitate a significant reduction on MOV (31)(32).
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53 226 In our study, caregivers reported lack of vaccines as the main reason for MOV. This is
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55 227 consistent with recent MOV assessments (13), where approximately 30% of health care
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57 228 workers reported insufficient vaccine supply or logistics issues. Inadequate vaccine supply
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3 229 has already been pointed out as one of the main reasons for under vaccination in low income
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5 230 countries (1). Ministries of Health and their partners must work to ensure adequate vaccine
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7 231 supply at facility level in order be able to vaccinate any children who have accessed health
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10 232 care services (33).

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12
13 233 This study is not from a representative sample, and very few children were eligible in two of
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15 234 the six countries included (Supplementary table 2). It has three main limitations. First, gender
16
17 235 was not collected, losing the opportunity to uncover gender differences. Nevertheless, no
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19 236 gender differences in the distribution of MOV have been reported in the latest studies (3)(13).
20
21 237 Second, our survey didn't allow us to explore health care providers' practices and
22
23 238 perceptions, identified as one of the main reasons related to MOV in the last systematic
24
25 239 review (3). In 2015, WHO launched a revised MOV strategy, which included Knowledge,
26
27 240 Attitudes and Practices (KAP) questionnaires, to better guide the implementation of
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29 241 interventions to reduce MOV (13) which is generating new evidence (34). Also, we could not
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31 242 explore other factors that have been previously related to MOV such as maternal education,
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33 243 living in rural areas, number of children and other economic inequalities, as information on
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35 244 contacted caregivers was not kept(35) and unfortunately, we do not have information to
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37 245 estimate the participation rate.

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43 246 Third, we excluded from the analysis almost half of the children whose caregivers could not
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45 247 present a vaccination card. This may mean that we underestimated MOV prevalence in our
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47 248 target population, since not presenting a vaccination card has shown to be associated with
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49 249 MOV (1)(3)(36). On one hand, not relying on self-reported data helped avoid potential recall
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51 250 bias, which is a limitation in vaccine coverage studies in low-resource settings (37). On the
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53 251 other hand, possession of vaccination card declines with age (11) (a relation also observed in
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55 252 our study, Supplementary table 1); what could result in an overestimated prevalence of MOV
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3 253 in older children. Nevertheless, when assessing the relation between MOV and age including
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5 254 those with and without vaccination card, we obtain similar results (Supplementary table 3).
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8 255 Finally, as children with identified MOV were sent back for vaccination when possible, it
9
10 256 could have introduced a bias in MOV prevalence if these children were inadvertently
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12 257 interviewed again. Also, MOV prevalence estimates may have improved over the last ten
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14 258 years, as WHO has lately reinforced EPI vaccination during the second year of life.
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18 259 **CONCLUSIONS**

20 260 Despite progress in vaccine coverage, MOV remains an important problem in low-resource
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22 261 settings. Avoiding MOV should remain a priority where access to health care is limited, in
23
24 262 line with the new “Immunization Agenda 2030” (18). This is particularly important
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26 263 considering the negative impact COVID-19 pandemic is having on routine immunization
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28 264 programs in low and middle-income countries (38)(39).
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32 265 We recommend integrating systematic vaccination screening into routine health care services,
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34 266 regardless of the reason for the visit, the type of facility and the age of the child. To promote
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36 267 maintaining and providing vaccination cards at every health care visit will help to reinforce
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38 268 vaccination screening and better identification of eligible children.
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42 269 We identified that children above 23 months of age are particularly vulnerable for MOV.
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44 270 Thus, we would recommend including children beyond 23 months of age in the current WHO
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46 271 methodology for MOV assessments in order to avoid underestimation of MOV. National
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48 272 immunization programs should allow administration of missing doses, regardless of the age of
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50 273 the child, as the EPI has expanded its vaccination recommendations during the second year of
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52 274 life and beyond.
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3 275 Strengthening the implementation of second-year-of-life visits, as recommended by WHO,
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5 276 with catch-up vaccination strategies (7) would provide additional opportunities to receive
6
7 277 missed vaccine doses and *leave no one behind*.

278 **Data Availability Statement**

279 Questionnaire dataset is available in a public, open access repository.

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284 review and to J.A. Rodrigo for his valuable input.

285 **Contributorship Statement**

286 Bachy C. and Panunzi I. designed the study and contributed to conduct it in the six countries.
287 Bachy C., Panunzi I., Gil-Cuesta J. and Borrás-Bermejo B. carried out the data analysis.
288 Borrás-Bermejo B. drafted the manuscript that was critically reviewed and approved by all
289 authors.

290 **Competing interests**

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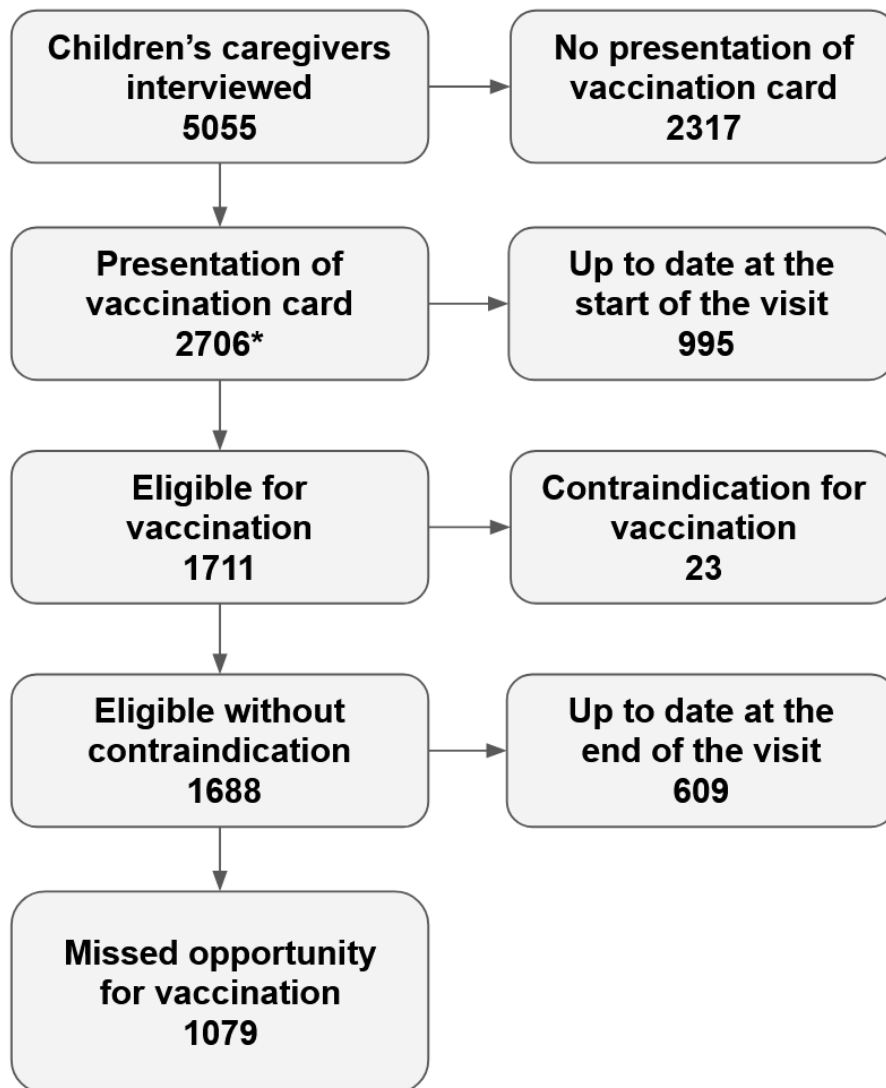
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8 434 Figure 1. Flow chart of participants' inclusion and for determining Missed Opportunities for
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10 435 Vaccination (MOV), MSF-supported health facilities, 2011-2015
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12 436 Figure 2. Immunization schedule to ascertain MOV
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For peer review only

Figure 1. Flow chart of participants' inclusion and for determining Missed Opportunities for Vaccination (MOV), MSF-supported health facilities, 2011-2015



*32 children were not included due to data inconsistencies.

Figure 2. Immunization schedule to ascertain MOV

Vaccine	Recommended age
Birth dose	
BCG ¹	At birth – up to 12 months
OPV ²	At birth – up to 2 weeks
Hepatitis B vaccine	At birth – up to 2 weeks
First dose	
OPV	From 6 weeks
Pentavalent vaccine ³	From 6 weeks
PCV ⁴	From 6 weeks
Rotavirus	From 6 weeks - up to 12 months
Minimum interval of 4 weeks between First and Second dose	
Second dose	
OPV	From 10 weeks
Pentavalent vaccine	From 10 weeks
PCV	From 10 weeks
Rotavirus	From 10 weeks - up to 12 months
Minimum interval of 4 weeks between Second and Third dose	
Third dose	
OPV	From 14 weeks
Pentavalent vaccine	From 14 weeks
PCV	From 14 weeks
Measles-containing vaccine ⁵	From 9 months
Yellow Fever ⁶	From 9 months

¹BCG: bacille Calmette-Guerin vaccine.

²OPV: Oral poliovirus vaccine. Inactivated poliovirus vaccine was not considered for MOV.

³Pentavalent vaccine: Diphtheria-tetanus-pertussis-hepatitis B- *Haemophilus influenzae* type b vaccine.

⁴PCV: Pneumococcal conjugate vaccine.

⁵Only one dose of Measles containing vaccine was considered for MOV.

⁶Yellow Fever was considered for MOV only in endemic countries.

Rec :

Evaluation of missed vaccination opportunities: child questionnaire

District: Team: N° child:

Center: Date: / / Age of the child: years months

1) Do you have a vaccination card or a health book for the child?

No Yes → Did you bring it today? No Yes

2) What was the main purpose of your visit to the health center today? (One answer only)

- Curative consultation
- Vaccination
- MCH consultation
- Feeding program
- Accompanying an adult
- Other:

3) Vaccination status:

Write the **dates** (dd/mm/yy) mentioned in the health book **and circle it** if vaccine given today.
If the history of vaccination is only confirmed orally by the caretaker, write **H**.
Cross the box (X) for the missing dose of vaccine that could have been given today.

	Dose 0	Dose 1	Dose 2	Dose 3
BCG				
HepB birth dose				
Polio				
DTP - HepB - Hib				
PCV 13				
Rota				
Measles				
Yellow fever				

4) Was the child eligible for a vaccine today?

No → Do you know the date of your next vaccination? No Yes → **END**

Yes → Did the child present with a true contra-indication to the vaccination today?
 No Yes → **GO TO QUESTION 6**

5) Did the child receive all vaccines required today?

Yes
(If X in box) No → Would you have accepted the vaccination today if proposed?
 Yes No → Why?

→ Reason(s) for not receiving all vaccines today? (One answer only)

- Out of stock
- No vaccinator
- Waiting time too long
- Not enough information
- Don't know the reason
- Other:

6) Did you get an appointment for your next vaccination? No Yes

THANK YOU FOR YOUR PARTICIPATION!

Supplementary Table 1. Characteristics of interviewed children by presentation of vaccination card. MSF-supported health facilities (2011-2015)

	Total N	Presentation of vaccination card ^d				<i>p</i> value
		No		Yes		
	N	N	%	N	%	
Age groups						
<12 m	2742	906	33.0	1836	67.0	
12-23 m	1263	665	52.7	598	47.4	
24-59 m	1050	746	71.1	304	29.0	<0.001 ^a
Eligible						
No	2276	1258	55.3	1018	44.7	
Yes	2779	1059	38.1	1720	61.9	<0.001 ^b
MOV^c						
No	2985	1358	45.5	1627	54.5	
Yes	2070	959	46.3	1111	53.7	0.558 ^b
Total	5055	2317	45.8	2738	54.2	

% Row percentages

^a Fisher exact test

^b Chi square test

^c MOV over the eligible children without contraindication for vaccination

^d Vaccination history was obtained by presentation of vaccination card or oral history.

Supplementary Table 2. Children who visited MSF-supported health facilities by country (2011-2015)

Country	Children with vaccination card		Eligible with no contraindication		MOV	
	n	% ^a	n	% ^b	n	% ^c
Afghanistan	33	1.2	11	33.3	8	72.7
Democratic Republic of the Congo	79	2.9	41	51.9	26	63.4
Mauritania	244	9.0	158	64.8	118	74.7
Niger	1888	69.8	1073	56.8	851	79.3
Pakistan	15	0.6	8	53.3	1	12.5
South Sudan	447	16.5	397	88.8	75	18.9
Total	2706	100.0	1688	62.4	1079	63.9

^a Column percentage

^b Row percentage among children with vaccination card

^c Row percentage among eligible children without contraindication

Supplementary Table 3. Characteristics of children with MOV irrespective of the possession of vaccination card. MSF-supported health facilities (2011-2015)

	MOV ^a				p value
	No		Yes		
	N	%	N	%	
Age groups					
<12 m	588	33.2	1182	66.8	
12-23 m	66	11.6	504	88.4	
24-59 m	55	12.5	384	87.5	0.001 ^b
Total	709	25.5	2070	74.5	

^a MOV over the eligible children without contraindication for vaccination

^b Fisher

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60STROBE Statement—Checklist of items that should be included in reports of *cross-sectional studies*

	Item No	Recommendation	Page No
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	2
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants	5
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	5-7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	5-7
Bias	9	Describe any efforts to address potential sources of bias	6-7
Study size	10	Explain how the study size was arrived at	NA
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6-7
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	7
		(b) Describe any methods used to examine subgroups and interactions	7
		(c) Explain how missing data were addressed	6
		(d) If applicable, describe analytical methods taking account of sampling strategy	NA
		(e) Describe any sensitivity analyses	NA
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	8
		(b) Give reasons for non-participation at each stage	8
		(c) Consider use of a flow diagram	6
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8
		(b) Indicate number of participants with missing data for each variable of interest	NA
Outcome data	15*	Report numbers of outcome events or summary measures	8
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	9-10

		(b) Report category boundaries when continuous variables were categorized	10
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	NA
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	NA
Discussion			
Key results	18	Summarise key results with reference to study objectives	11
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	14
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	14
Generalisability	21	Discuss the generalisability (external validity) of the study results	NA
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	16

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at <http://www.plosmedicine.org/>, Annals of Internal Medicine at <http://www.annals.org/>, and Epidemiology at <http://www.epidem.com/>). Information on the STROBE Initiative is available at www.strobe-statement.org.