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Factors associated with missed opportunities for vaccination in children under five in Oaxaca, Mexico, 2018

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Abstract

Introduction. We estimated the frequency of missed opportunities for vaccination and the factors associated with them in children under five as they exited the health facilities in two health districts of Oaxaca, Mexico in 2018.

Population and Methods. We conducted a cross-sectional study out of an exit survey of public health facilities with low immunization coverage. The study population was comprised of 837 children and their caregivers who had visited those health facilities. Crude and adjusted odds ratios were calculated to analyze factors associated with missed opportunities for vaccination.

Results. A total of 502 children were eligible to receive 1338 doses of missing vaccines; 986 missed opportunities for vaccination were observed. The factors related to missing opportunities were related to health facilities (810, 82.2%); mainly due to total or partial vaccine shortages (789, 97.4%), followed by health personnel (108, 10.9%) and child caregivers (68, 6.9%).

Discussion. The main variable associated with missed vaccination opportunities was partial or complete vaccine shortages.

Keywords: Vaccination; Health Services; Immunization; Missed Opportunities; Vaccine Shortage.

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Introduction

In 2017, Mexico's Universal Vaccination Program (UVP) schedule included nine vaccines targeting, children under five, during seven contacts with the health system [1]. Mexico had partial shortages of pentavalent, BCG, rotavirus, and pneumococcal vaccines, and complete shortages of hepatitis B, diphtheria-pertussis-tetanus (DPT), and measles, mumps, and rubella (MMR) vaccines in early 2018, the year in which this survey was carried out.

Availability of vaccines and supplies for immunization in the world market, frequently is not enough to satisfy requirements of the immunization program in the countries. Occasionally, these difficulties are related to political conditions in a given the country; however, we did not find evidence in the peer-reviewed literature that partial or total shortages occur with every transition of each change of government in Mexico.

Administrative coverage levels and national surveys show variations at the sub-national level [2-4] that do not meet the goals ≥95% coverage by individual vaccine and ≥90% coverage for the complete immunization schedule [1,5]. In 2016, the administrative vaccination coverage level among infants in the state of Oaxaca was 80.7%, but varied from 74.6% in the district of Tuxtepec, 79.4% in Valles Centrales, 89.1% in Mixteca, and 91.1% in Costa district. The districts with the lowest coverages in the state —Istmo, Valles Centrales and Tuxtepec—also had the highest number of births [6]. En enero de 2021 llega a República Dominicana el primer lote de vacunas Oxford-AstraZeneca y Sinovac destinadas principalmente al personal de salud de primera línea y grupos de riesgos. La vacunación se inició en febrero de 2021.

The World Health Organization recommends taking advantage of all contacts of the population with health services. Failing to administer one or more doses of vaccine to an eligible child without contraindications, has been defined as a missed opportunity for vaccination (MOV) [7]. MOVs are one of the main causes of incomplete vaccination scheme and of non-follow-up of the missing doses of vaccine increase the incidence of immunopreventable diseases.

Studies in the Americas have shown variable rates of MOV, ranging from 32% to 77% [8], 40-45% in Mexico [8-13], and 44% in the Dominican Republic [14]. In these studies, the main causes of MOVs were false contraindications and special vaccination days [8-14].

To estimate the frequency of MOVs and the factors associated with these, we conducted an exit survey to accompanied adults by a child under five visiting state health facilities in two districts of Oaxaca.

Population and Methods

We conducted a cross-sectional study in primary and secondary state-run health facilities. We assumed that the proportion of MOV could be50%, to estimate such proportion with a precision 3.4% with a confidence level of 95% and a projected non-response rate of 5% it required a sample size was 837 children [15].

We selected two districts, Valles Centrales and Tuxtepec, with the low levels of administrative vaccination coverage among infants in the state, and high number of births [6]. Of those, we choosed 3 of 23 municipalities in Tuxtepec and 14 of 190 in Valles Centrales as a convenience sample.

All public healthcare facilities offering routine vaccination services were included in the sample. These included 43 health centers and 1 hospital in Valles Centrales and 21 health centers and 1 hospital in Tuxtepec.

Study participants were exiting adults accompanying a child under five in two health districts of Oaxaca, Mexico. Participants had to provide the child's vaccination card to be including, and we request their voluntary participation in the study. We estimated the number of children who would visit a health facility each day based on population projections for 2017 [16], demographic data provided by health facilities [6], and reported annual visits to the State Health Services in Oaxaca [17]. Using probability proportional to size sampling, determined how many interviews should be conducted in each health center, recruiting 542 adults accompanying children aged <5 years in Valles Centrales and 295 in Tuxtepec. When the adult to be interviewed was accompanied by two or more children under five, all of them were included, if they had the vaccination card.

In April - May of 2018, we used a structured, pre-codified questionnaire designed and validated by the Pan American Health Organization (PAHO), modifying questions based on vaccination schedule in Mexico [7] to interview adults accompanying children under five. The questionnaire included sections about participant´s demographics, the reasons for visiting the health facility, collected data from the vaccination card if present, asked about the vaccines administered during the visit, and other operational and logistical aspects of the Universal Vaccine Program (UVP).

After recording and cleaning collected information in a secure database, we analyzed data in STATA 14 and EPIINFO 7.2.2.6 based on the following operational definitions:

Total vaccine stockout. Absolute absence of vaccine vials, the day of visiting the health unit.

Partial vaccine stockout. Existence of some vaccine vials, but not enough to meet the demand of the population, the day of visiting the health unit.

True contraindications for vaccination. Presence of fever over 38°C, pneumonia, diarrhea with dehydration, or other

serious illness. Contraindications for different reasons were considered "not true".

Eligible child. Child who missed one or more doses of a vaccine included in the immunization schedule, who did not have true contraindications, and who"according to the date of application of the previous doses", was eligible to receive the required dose(s) on the day of the interview.

Fully vaccinated child. Child who had received all doses of all vaccines in the immunization schedule, according to their age:

0-1 month: 1 BCG + 1 Hepatitis B (HB)

2-3 months: 1 BCG + 2 HB + 1 Pentavalent (PV)* + 1 pneumococcal + 1 rotavirus (RV)

4-5 months: 1 BCG + 2 HB + 2 PV + 2 pneumococcal + 2 RV

6-11 months: 1 BCG + 3 HB + 3 PV + 2 pneumococcal + 3 RV + influenza

1-4 years: 1 BCG + 3 HB + 3 PV + 3 pneumococcal + 3 RV + 1 MMR + influenza

*Pentavalent vaccine includes diphtheria-tetanus-pertussis (DPT) antigens, trivalent inactivated poliovirus (IPV), and Haemophilus influenza type b (Hib) vaccine.

Booster doses

18 months to 3 years: 1 PV (4th dose)

6 months to 4 years 1 bOPV in two annual campaigns

4 years: 1 PV (4th dose) + 1 DPT

Undervaccinated child. Child who missed ≥1 doses of vaccines in the immunization schedule, according to their age. Unvaccinated child. Child who had not all doses of all vaccines in the immunization schedule.

Data analysis

We considered vaccines not applied to eligible children to be MOVs and evaluated the occurrence of MOVs by age, sex, vaccine type, caregiver characteristics, and variables related to health services and personnel. To evaluate true and false contraindications for vaccination, we analyzed the responses related to reasons for non-vaccination, in children who were sick the day of interview. The answers provided by the children´s caregivers were compared with a list of true and false contraindications, according to national and international vaccination guidelines. We estimated the frequency of vaccine stockout by reasons given of not vaccinating eligible children to receive a specific vaccine.

Conditions of variables which had the highest proportion of MOVs, were selected as reference for odds ratios (ORs) estimation, including the 95% confidence intervals (95% CI), estimated with software STATA 14 and EPIINFO 7.2.2.6. We adjusted via logistic regression analysis; the effect of factors associated in simple analysis by those variables that changed the crude estimate of the ORs for MOVs. Differences were analyzed using chi square tests. P-values of <0.05 were considered statistically significant [18, 19].

Protection of human subjects

The Institutional Review Board of Mexico's National Institute of Public Health authorized this study. We obtained informed consent from all study participants, providing them with information about the study's objectives and content and notifying them that all information was anonymous and would be maintained in a secure database to be viewed only by the study team.

Results

A total of 1011 exiting accompanied adults by a child aged <5 years were contacted. Exclusion criteria included participant refusal (n=28), child aged >5 years (n=90), and lack of vaccination card (n=56). Overall, 837 adults (82.8%) agreed their children to participate in the study. Of these, 502 (60.0%) were eligible for 1338 vaccine doses, having 372 (74.1%) MOVs, of which 209 (56.2%) had just 1 MOV, and 163 (43.8%) had 2 or more MOVs. Together these children accumulated 986 MOVs.

Descriptive analysis of participants and MOV´s

Most participants had a secondary or higher level of education (72.9%) and lived in urban areas (87.8%). Of 837 children, 421 were male (50.3%) and 416 were female (49.7%), with 425 (50.8%) aged <1 year and 412 (49.2%) aged 1-4 years (Table 1).

A total of 502 children (60%) were eligible to receive 1,338 missing vaccine doses. As shown in Table 1, children aged <1 year (66.1%) were more likely to be eligible to receive vaccines than those aged 1-4 years (53.6%) ($P = 0.0003$).

Of the 502 eligible children, 372 experienced at least one MOV (Table 2); 91% of eligible children aged 1-4 years had a MOV, compared to 60.9% of infants ($P < 0.0001$). However, among infants, the highest rates of MOVs occurred in children aged <2 months (n=42/49, 85.7%), and were even higher among those 2-3 years (n=29/30, 96.7%), and was universal among those 4 years of age (n=55/55, 100.0%).

MOVs related to health services, to health personnel, or to caregivers of children

A total of 986 MOVs were observed: 625 in children aged <1 year and 361 in children aged 1-4 years (Table 3). There were 986 accumulated MOVs in 372 eligible children (74.1%). Factors related to MOVs were attributable to health facilities (n=810, 82.2%), followed by health personnel (n=108, 10.9%) and caregivers of children (n=68, 6.9%).

Due to complete shortages of HB, DTP, and MMR vaccines, a total of 608 vaccine doses could not be administered, 355 in children aged <1 year and 253 in children aged 1-4 years. Consequently, MOV proportion for these vaccines were 100.0% (Table 3).

Table 1. Characteristics of children under five in the Study, Oaxaca, Mexico. 2018

Characteristics		n (%)	Children eligible for vaccine		
			Eligible	Percent eligible*	(95% CI)
Sex	Male	421 (50.3)	248	59.9	(55.0 - 64.7)
	Female	416 (49.7)	246	60.1	(55.2 - 64.9)
	Total	837 (100)	494	60.0§	(56.6 - 63.4)
Age	<2 months	110 (25.9)	49	44.5	(35.1 - 54.3)
	2-3 months	77 (18.1)	57	74.0	(62.8 - 83.4)
	4-5 months	70 (16.5)	66	94.3	(86.0 - 98.4)
	6-11 months	168 (39.5)	109	64.9	(57.2 - 72.1)
	Subtotal <1 year	425 (100)	281	66.1	(61.4 - 70.6)
	1 year	173 (42.0)	136	78.6	(71.7 - 84.5)
	2-3 years	160 (38.8)	30	18.8	(13.0 - 25.7)
	4 years	79 (19.2)	55	69.6	(58.2 - 79.5)
	Subtotal 1-4 years	412 (100)	221	53.6	(48.7 - 58.5)
	Total <5 years	837 (100)	502**	60.0	(56.6 - 63.3)

* Per 100 children included in the study

** Information about sex was not available in database for eight children

*** Eligible for 1338 vaccine doses

§The difference between eligible children <1 year and 1-4 years was statistically significant ($P < 0.001$)

Table 2. Missed Opportunities for Vaccination in children under five by Age Group, Oaxaca, Mexico, 2018

Age Group	Children eligible for vaccination n	Missed opportunities for vaccination		
		Missed	Percent of the eligible*	(95% CI)
<2 months	49	42	85.7	(72.8 - 94.1)
2-3 months	57	27	47.4	(34.0 - 61.0)
4-5 months	66	37	56.1	(43.3 - 68.3)
6-11 months	109	65	59.6	(49.8 - 68.9)
Subtotal <1 year	281	171	60.9§	(54.9 - 66.6)
1 year	136	117	86.0	(79.0 - 91.4)
2-3 years	30	29	96.7	(82.8 - 99.9)
4 years	55	55	100.0	(93.5 - 100.0)
Subtotal 1-4 years	221	201	91.0§	(86.4 - 94.4)
Total <5 years	502	372	74.1	(70.0 - 77.9)

* Per 100 children included in the study and whose were eligible for vaccination. §The difference in MOVs between eligible children aged <1 year and children aged 1-4 years was statistically significant ($P < 0.0001$).

Table 3. Missed opportunities for vaccination among children under five by age and vaccine type, Oaxaca, Mexico, 2018.

Vaccines	Children eligible for vaccine N	Missed opportunities for vaccination		
		Missed	Percent of the eligible *	(95% CI)
Children aged <1 year**				
BCG	59	49	83.1	(71.0 - 91.6)
Hepatitis B	355	355	100.0	(99.0 - 100.0)
Pentavalent	217	116	53.5	(46.6 - 60.2)
Rotavirus	144	62	43.1	(34.8 - 51.6)
Neumoccocal	137	43	31.4	(23.7 - 39.9)
Children 1-4 years***				
BCG	6	6	100.0	(61.0 - 100.0)
Hepatitis B	80	80	100.0	(95.4 - 100.0)
Pentavalent	103	65	63.1	(53.0 - 72.4)
Neumoccocal	64	37	57.8	(44.8 - 70.1)
DTP	55	55	100.0	(93.5 - 100.0)
MMR	118	118	100.0	(97.0 – 100.0)

* Per 100 children included in the study and whose were eligible by vaccine type

**n=625 MOVs
***n=361 MOVs

For vaccines of pentavalent, BCG, rotavirus, and pneumococcal, 181 MOVs were due stockout, while 197 resulted from other reasons related to health services, health workers, or caregivers. The MOV proportion in children aged <1 year for BCG vaccine was 83.1% (95% CI = 71.0-91.6) and 100% in children aged 1-4 years.

Factors associated with MOVs attributable to health services, to health personnel, or to caregivers of children

Health services

The most frequent factors related to health facilities were vaccines shortages (n=789, 97.4%), followed by logistical considerations, such as scheduling the vaccination on certain dates (resulting in "today [was] not a vaccination day") (n=7, 0.9%), closure of the vaccination clinics (n=6, 0.7%) or missing other supplies (e.g., syringes) for vaccination (n=8, 1.0%).

Health personnel

Some health personnel incorrectly believed that the children's immunization schedule was complete or that they were not due for the next vaccine dose (n=70, 64.8%). Some workers did not review the vaccination card or inquire about the vaccination status of the children (n=21, 19.4%). Others thought that children could not be vaccinated due to illness based on false contraindications (n=17, 15.7%).

Beliefs of the caregivers of children

Parents and caregivers incorrectly believed that their children were not vaccinated because they had received all vaccines for their age (n=9, 13.2%), because they were companions (n=47, 69.2%), or because they visited the health facility for other reasons (n=12, 17.6%).

Factors associated with MOVs

Bivariate analysis showed higher odds of MOVs in children of caregivers who lived in rural areas (92.9%), who had less than a secondary education (82.6%), and whose children had previously been denied a vaccine (80.7%). Simultaneously adjusted ORs confirmed these associations, with residence in rural areas (OR=0.6, P =0.024) and a history of previous vaccine refusal (OR=0.7, P =0.023) associated with greater odds of MOVs (Table 4).

Children aged 1-4 years had higher odds of MOVs (91.0%) than children aged <1 year (60.9%), with an OR=0.1, this difference was statically significant *(P*=0.001). On the other hand, among infant children, the highest frequency of MOVs was among children aged <2 months (85.7%). (Table 4).

Eligible children who came to health facilities as companions or for other reasons had greater likelihoods of MOVs (98.2%) than children who went to the health facilities for vaccination (61.7%, OR=0.4, *P* =0.0001) (Table 4).

Table 4. Factors associated with missed opportunities for vaccination, Oaxaca, Mexico, 2018.

Factors	Children eligible for vaccination n	Missed opportunities for vaccination					
		Missed	Frequency (%)*	OR (95% CI)	*P*	Adjusted§ OR (95% CI)	*P*
Education of children's caregivers							
Less than secondary school	132	109	82.6	1		1	
Secondary school or more	370	263	71.1	0.5 (0.6-1.3)	0.0096	0.8 (0.6-1.3)	0.399
Place of residence							
Rural	56	52	92.9	1		1	
Urban	446	320	71.7	0.2 (0.07-0.5)	0.0007	0.6 (0.4-0.9)	0.024
History of having been denied vaccination to any of their children							
Yes	161	130	80.7	1		1	
No	303	204	67.3	0.5 (0.3-0.8)	0.0022	0.7 (0.5-0.9)	0.023
No response	38	---	---	---	---	---	---
Age group							
<2 months	49	42	85.7	1	---	1	---
2-3 months	57	27	47.4	0.1 (0.05-0.4)	0.0001	0.3 (0.1-0.7)	0.005
4-5 months	66	37	56.1	0.2 (0.08-0.5)	0.0007	0.1 (0.06-0.3)	0.0001
6-11 months	109	65	59.6	0.2 (0.1-0.6)	0.0012	0.2 (0.09-0.5)	0.0001
1-4 years	221	201	91	1	---	1	---
<1 year	281	171	60.9	0.2 (0.09-0.3)	0.001	0.1 (0.05-0.3)	0.001
Reason for visiting the health facility							
Accompanying child / other*	166	163	98.2	1	---	1	---
Vaccination	332	205	61.7	0.02 (0.009-0.09)	0.0001	0.4 (0.6-0.3)	0.0001

*Well-child visits, consultations for illness without real contraindications for vaccination, dentist appointments, or nutrition consultations.

§ All independent variables listed were simultaneously entered in the model

Discussion

In addition to contributing to MOVs literature, our study provides an analysis in the context of vaccine shortages. It has been documented that the shortage of vaccines affects different countries regardless of their economic situation, vaccines most affected by shortages in an international review were BCG and vaccines containing DPT, HB and Hib, in our study the vaccines most affected by the stockout were HB, DPT, MMR and BCG [20]. As previously mentioned, 372 eligible children accumulated 986 MOVs; of these (Table 4), 332 children who attended to health facilities for vaccination, 205 accumulated 789 MOVs which were attributable to partial or complete shortages of vaccines in those facilities.

The frequency of MOV for vaccines with shortages during the study period are similar to those reported in studies of other vaccines [8-14, 21, 22]. While vaccine stockouts limited the capacity of routine vaccination services in Oaxaca, the population's demand for vaccines did not appear diminished; In a recent model of vaccine demand, Chen found that shortages may increase demand for vaccines [23]. A similar dynamic may have occurred in Oaxaca, and our findings suggest that health facilities working under conditions of limited vaccine availability must strive to take advantage of the relatively increased demand for immunization services, minimizing other causes of MOVs related to the health system.

The high frequency of MOVs in children aged <2 months and those aged 1-4 years is likely related to the absolute shortage of vaccines administered in these age groups (HB, DPT, and MMR vaccines). In addition, children aged 1-4 years had higher odds of MOVs than children aged <1 year, consistent with previous findings in Mexico and the Dominican Republic [12- 14].

Most commonly the health worker's mistaken belief that the child's immunization schedule was complete and misconceptions regarding contraindications for vaccination, similar results were documented in two literature review [24, 25].

Of the total number of children who went to a health unit for any reason, 61.7% visited exclusively for vaccination and the rest went for different reasons. The fact that a proportion of the caregivers whose children had MOVs did not view all visits to the health center as opportunities to receive required vaccines highlights the need to strengthen the public's awareness during visits to health units, about the need to check the vaccination card, and identify the missing doses of vaccines.

The knowledge that vaccination is necessary to prevent some infectious diseases and to preserve the health of children must be communicated to parents and caregivers [26, 27]. Promotion activities should feature community involvement and be carried out in day cares, kindergartens, schools, and waiting rooms of health facilities, by the other hand, education of the users of the vaccination program and their tracking by health workers have been documented as successful interventions to improve vaccination coverage [28].

Unlike other studies [29, 30], we did not find that the age, sex, schooling, marital status, and the occupation of the caregiver were associated statistically significantly with MOVs. Vaccine refusal was not identified as a barrier. Indeed, vaccine shortages may increase the public's demand for immunization, highlighting the need to minimize other causes of MOVs during times of vaccine scarcity [24, 25, 31].

It should be noted that results cannot be extrapolated to all health facilities that provide immunization services in Oaxaca or Mexico as in our study, we used a non-random sample of health facilities.

Conclusions

The timely and sufficient supply of vaccines at the national and subnational level, would decrease on an important way the MOV´s. However, we need work in the other causes detected in this study, and develop activities focus to mitigate the impact of false contraindications, and failure of health personnel to review children's immunization histories.

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Declaration of potential conflicts of interests

All authors declare that they have no conflict of interest for the development of the study, nor for the analysis of results nor writing this manuscript.

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