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Late vaccination reinforcement during a measles epidemic in Niamey, Niger (2003–2004)

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Abstract

Low measles vaccination coverage (VC) leads to recurrent epidemics in many African countries. We describe VC before and after late reinforcement of vaccination activities during a measles epidemic in Niamey, Niger (2003–2004) assessed by Lot Quality Assurance Sampling (LQAS). Neighborhoods of Niamey were grouped into 46 lots based on geographic proximity and population homogeneity. Before reinforcement activities, 96% of lots had a VC below 70%. After reinforcement, this proportion fell to 78%. During the intervention 50% of children who had no previous record of measles vaccination received their first dose (vaccination card or parental recall). Our results highlight the benefits and limitations of vaccine reinforcement activities performed late in the epidemic.

Keywords: Measles; Epidemic; Lot quality assurance; Sampling studies; Vaccination; Immunization programs

1. Background

Measles is the leading cause of vaccine-preventable disease death worldwide causing 282,000 deaths in Africa in 2003 [1]. Despite a safe, effective and inexpensive vaccine, national childhood immunization program coverage has remained low in many African countries. As a result, countries with low coverage continue to face recurrent measles epidemics.

Measles is endemic in Niger with large epidemics occurring every 2 or 3 years. The Expanded Program on Immunization (EPI) was introduced in Niger in 1987. Measles vaccination consists of a one-dose strategy for children aged 9–11 months with all children under age 5 eligible [2,3]. National vaccination coverage (VC) for measles in 2003 was estimated to be 64% in children under 5 [4].

In November 2003, the measles surveillance system in Niger, consisting of weekly morbidity and mortality reports compiled by the "Direction Régionale de la Santé Publique" (Regional Direction of Public Health, DRSP), identified an increased number of measles cases in the capital of Niamey (population 770,000) and other parts of the country. Between January and March 2004 more than 21,000 cases were reported nationwide including more than 3000 cases in Niamey. In April 2004, 23 weeks after the outbreak started (Fig. 1), the Ministry of Health (MoH) and the World Health Organization (WHO) organized a 1-week reinforcement of EPI activities in Niamey with the support of the medical non-governmental organization Médecins Sans Frontières (MSF). The goal of the reinforcement activity was to vaccinate 50% of all children aged 6–59 months. This objective was estab-

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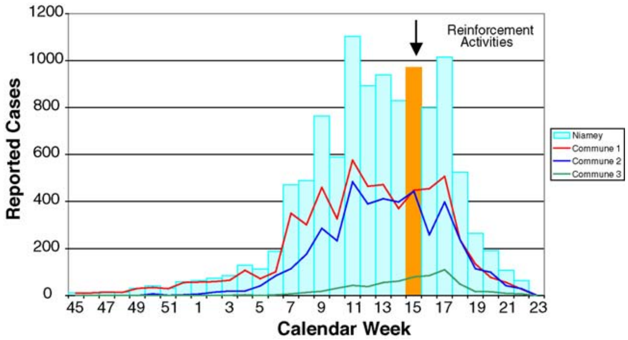

Fig. 1. Reported cases of measles by calendar week for the city as a whole and by Commune, 1 December 2003–6 June 2004, Niamey, Niger. The vaccination coverage reinforcement activity is shown in orange (Week 23).

lished considering the extent of the epidemic and limited resources available at that time, and was reached in 1 week during which 57% (84,563/148,595) of children 6–59 months were vaccinated. At the same time, case management activities were supported by the distribution of measles treatment kits in health centers and hospitals. When the epidemic subsided, a total of 10,880 cases and 397 deaths related to measles had been recorded by the surveillance system in Niamey, which represents a case fatality ratio of 3.3% [5].

In the week following the reinforcement activity, we performed a Lot Quality Assurance Sampling (LQAS) survey in Niamey. The main objective of this survey was to identify areas of the city with low VC. Another objective was to assess the measles VC before and after reinforcement of EPI activities during the measles epidemic in Niamey in 2003–2004.

2. Methods

Niamey is divided into three administrative districts (Commune I, II, III) consisting of 108 neighborhoods with a total population estimated to be 769,500 (Central Office for Census, Niger, France). The 108 neighborhoods of Niamey were grouped into 46 areas, called lots, based on geographic proximity and population homogeneity (Mapping Department, Central Office for Census, Niger). The population of the lots ranged from 3780 to 43,680 residents. Of the 46 lots, 19 lots were in Commune I, 18 lots in Commune II and 9 lots in Commune III.

The sample size for each lot was calculated using cumulative binomial probabilities (SampleLQ v1.10) [6]. First, a lower threshold of 70% VC was set based on a 2003 estimate of VC at the Commune level for children between 9 and 11 months. An upper threshold was fixed at 85% VC to identify areas with higher VC. In order to correctly identify 95% of the lots with low VC (<70% VC) and 90% of the lots with high VC (≥85% VC), 65 children had to be sampled in each lot (α-error = 5%, β-error = 10%). A maximum of 13 unvaccinated children in each lot were allowed for the lot to be classified as having a high VC, otherwise it was considered to have inadequate VC.

To identify lots with very low VC, we repeated the LQAS analysis (using the same data) with a lower threshold of 50% and an upper threshold of 80%. For a sample of 65 children, 25 unvaccinated children resulted in a classification of VC below 50% (α-error = 4% and β-error = 5%). As complete samples were taken from each lot, we also looked at each lot individually to explore whether there were pockets of low VC within the city.

We developed a systematic sampling plan to randomly select 65 children between 6 and 59 months (same age group as the reinforcement activities) within each lot. A central location (i.e., intersection, mosque, market) was chosen as the starting point in each lot. A random direction was chosen and the closest compound in that direction was visited. A sampling interval of every fifth door was used thereafter continuing in the same direction. The sampling interval of five was chosen to cover the largest geographic area within each lot. When households were exhausted along a transect, a random direction was identified and sampling continued.

The survey team identified children between 6 and 59 months within the household and if more than one child within the age range was present, one was chosen using a random number table. The age, sex, vaccination status before and after reinforcement and approximate vaccination dates were assessed by asking the head of household present. This information was noted on a standardized data collection form. Vaccination status was noted as either verified by vaccination card or by oral confirmation (parental recall). If the survey team ascertained that an eligible child resided in the selected household but was not present, the team returned later the same day for ascertainment. When more than one household resided within the same compound, one household was chosen randomly.

Results of the LQAS surveys are presented for card-confirmed vaccination status (card) and for vaccination status based on parental recall. For data analysis of VC after the reinforcement activities, children were classified as "ever vaccinated." That is, a child was considered vaccinated regardless of whether the child was vaccinated during reinforcement activities or previously.

We also assessed the proportion of children who were vaccinated previously and then re-vaccinated during the reinforcement activity and those without any record of prior vaccination. Finally, we estimated the citywide VC by calculating the weighted average of the VC of all lots before and after EPI reinforcement for vaccination status.

3. Results

The LQAS survey was conducted between 19 and 25 April 2004 (3 days after the end of reinforcement activities). Twenty survey teams of two persons each collected information on a total of 2990 children aged 6–59 months residing in the 46 lots.

Table 1
Number of rejected lots (<70% vaccine coverage) by Commune, children 6–59 months, Niamey, Niger, April 2004 before and after EPI reinforcement activities

Places	Lots	Before		After	
		Card (%)	Card/recall (%)	Card (%)	Card/recall (%)
Commune I	19	19 (100)	18 (95)	19 (100)	9 (47)
Commune II	18	16 (89)	11 (61)	13 (72)	3 (17)
Commune III	9	9 (100)	8 (89)	4 (44)	0 (0)
Niamey	46	44 (96)	37 (80)	36 (78)	12 (26)

Table 2
Number of rejected lots (<50% vaccine coverage) by Commune, children 6–59 months, Niamey, Niger, April 2004 before and after EPI reinforcement activities

Commune	Lots	Before		After	
		Card (%)	Card/recall (%)	Card (%)	Card/recall (%)
Commune I	19	12 (63)	3 (16)	8 (42)	1 (47)
Commune II	18	4 (22)	1 (6)	3 (17)	0 (0)
Commune III	9	4 (44)	3 (33)	0 (0)	0 (0)
Niamey	46	20 (44)	7 (15)	11 (24)	1 (2)

Before reinforcing EPI activities, 96% ($n = 44$) of lots had a VC below 70% considering vaccination status based on vaccination cards. Results of the LQAS survey varied by Commune: in Commune II 89% ($n = 16$) of lots were considered to have insufficient VC, while in Commune I ($n = 19$) and Commune III ($n = 9$) 100% of lots were rejected.

After reinforcement of EPI activities, the number of lots that were below the threshold of 70% VC had been reduced to 36 (78%) (card). The largest VC improvement following the implementation of reinforcement activities was seen in Commune III, where the number of rejected lots was reduced to 4 (44%). In Commune I and II, 100% ($n = 19$) and 72% ($n = 13$) of lots, respectively, were still considered below the lower threshold.

Results based on parental recall indicated a lower proportion of lots with VC below 70% both before and after reinforcement activities. Table 1 presents the number of rejected lots (<70% VC) by Commune and information source.

When the survey data was evaluated decreasing the lower threshold of VC to 50%, before the reinforcement intervention, 43% ($n = 20$) of lots had very low coverage (card). After the intervention this proportion decreased to 24% ($n = 11$). Results by Commune based on card and parental recall are presented in Table 2.

As complete samples were collected in each lot (65 children), we examined the range in VC between lots. We found that before the vaccination reinforcement the median number of children vaccinated was 41 (inter-quartile range (IQR): 34–44). After the reinforcement the median number of children vaccinated increased to 46 (IQR: 41–51). Fig. 2 presents the proportion of children vaccinated in each lot.

The citywide VC (weighted average) before reinforcement of EPI activities was 60.1% (95% CI: 57.9–61.9) based on vaccination card and 70.9% (95% CI: 68.8–72.6) considering parental recall and vaccination card. After reinforcement of EPI activities, the VC estimate increased to 69.5% (95% CI: 67.4–71.2) based on vaccination card and to 84.5% (95% CI: 82.7–85.7) considering vaccination card and parental recall (Table 3).

In the survey population, 28.8% (861/2990) of children had no prior record of vaccination. During the reinforce-

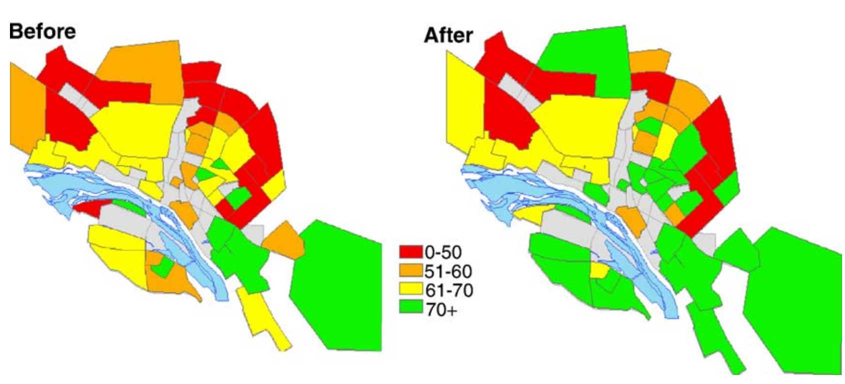

Fig. 2. Proportion of children vaccinated out of 65 before and after reinforcement activities. Lots with less that 50% of children in the sample vaccinated are shown in red, 51–60% in orange, 61–70% in yellow and above 70% in green. Areas shown in grey were uninhabited areas within Niamey.

Table 3
Vaccination coverage (lot weighted), children 6–59 months, Niamey, Niger, April 2004 before and after reinforcement activities

Assessment	Measles VC (%)	95% CI
Before reinforcement		
Card	60.1	57.9–61.9
Card/recall	70.9	68.8–72.6
After reinforcement		
Card	69.5	67.4–71.2
Card/recall	84.5	82.7–85.7

ment, 48.5% (1450/2990) of children were vaccinated. Of these, 71.0% (1029/1450) had a prior record or verbal history of measles vaccination and therefore received a second dose. The remaining 29.0% (421/1450) received their first dose during the reinforcement. Therefore, a total of 48.9% (421/861) of children without prior record or verbal history of vaccination were vaccinated during the intervention.

4. Discussion

The results of this survey confirm the low VC in Niamey prior to the 2003–2004 epidemic and identify areas of the city with inadequate VC. In this survey, 50% of children with no prior record of vaccination received their first dose during the reinforcement. The reinforcement activities also provided a second opportunity for previously vaccinated children.

This study highlights the benefits and limitations of reinforcement vaccination activities performed 23 weeks after cases are first reported. The resources needed to conduct a large-scale response and the current WHO recommendation to control measles epidemics were key factors that affected the choice of the MoH and WHO strategy (vaccinating 50% of children from 6 to 59 months). The current WHO recommendation during a measles epidemic is “accelerated immunization activities, i.e., improving coverage amongst high-risk populations and supplementary immunization in areas not yet affected by the epidemic,” though no clear VC objective is specified [7]. The recommendations also state that “the immunization response in most outbreaks occurs too late to affect the impact of the outbreak [7]”.

Although reinforcement of vaccination activities occurred late in this epidemic, there were still benefits identified. In Niamey, more than one-half (56.9%, 84,563/148,595) of children between 6 and 59 months were vaccinated over the course of 1 week. Of the children vaccinated, 30% received their first dose suggesting that previously vaccinated children were easier to reach during the outbreak than unvaccinated children. This also explains why the citywide VC increased only by 10% after the reinforcement. This highlights the importance of using vaccination strategies during measles epidemics that reach those children never vaccinated previously. However, the provision of a second opportunity for measles vaccination for all children is not negligible and is part of the WHO/UNICEF strategy for measles mortality reduction [8].

There are also limitations to such a late intervention. The direct impact of vaccination interventions implemented so late after the beginning of the epidemic is difficult to estimate in terms of number of cases and deaths averted. In Niamey, we observed that the weekly number of cases dropped noticeably 2 weeks after this intervention (Fig. 1). In Niger, measles epidemics usually coincide with the dry season (October–April), and number of cases starts decreasing with the beginning of the rainy season. In this case, the first rain in Niamey came at the end of April (Week 18), 2 weeks after the intervention when cases had already started decreasing (Fig. 1).

Many cases would likely have been averted if reinforced vaccination activities had taken place in the first weeks of the epidemic. Recent analyses on the spread of this epidemic suggest that measles spreads more slowly within Niamey that previously thought [9]. This slow speed of spread may help explain the long duration of the epidemic and emphasizes the importance of further analysis of the dynamics of measles epidemics in similar contexts. Over the course of the epidemic, cases were first reported in Commune I and II. If the intervention had occurred before cases spread to Commune III (6 weeks after cases were reported in Commune I), it is likely that many of these cases could have been averted.

LQAS has been used successfully in the health sector for a range of purposes including monitoring of immunization program performance and identifying areas with high prevalence of disease [10,11]. The method may be implemented rapidly, requires relatively small sample sizes and the results are easily interpreted. Compared to a classical two-stage cluster sampling method [12] to evaluate VC, LQAS allows specific identification of areas with low VC permitting the planning of targeted response activities. The LQAS method can be repeated quickly after an intervention and thus is a good tool to assess the effectiveness of the intervention.

To prevent future epidemics in Niamey, VC should rapidly be increased in areas identified with low VC through increased EPI (including two-dose strategy) or/and supplemental vaccination activities. A mass vaccination campaign took place in December 2004 where 94% of children aged 9 months to 14 years were vaccinated over a 2-week period (13–26 December 2004) in the six most populated regions of Niger [13]. This is a clear step in the right direction.

As a complete sample was collected in each lot, we were able to identify lots with very low VC (<50%). The initial threshold of 70% was chosen as a VC less than 70% is sufficient to trigger a large outbreak in a city like Niamey, and justify an immediate intervention to raise VC. VC calculated by lot could be presented, albeit with wider confidence intervals, and the method may also be modified to provide a finer classification system using alternative sampling plans [14].

There are data and methodological limitations to this research, which require note. As with any survey, misclassification is a clear concern. We attempted to minimize the potential for misclassification of vaccination status by differentiating between vaccination card confirmed and parental recall confirmed vaccination status. In some neighborhoods, vaccination cards were not systematically distributed during the EPI reinforcement. However, as the LQAS survey took place the week following the reinforcement activities it can be presumed that the risk of parental recall bias was small. For this reason, we believe that the true VC after reinforced EPI likely lies between the coverage estimates based on vaccination card and the estimate based both on vaccination card or parental recall. This point also highlights the importance of vaccination card distribution when reinforcement activities or mass campaigns are undertaken. Further, although almost 30% (861/2990) of children vaccinated had no record of vaccination prior to the reinforcement activities, it is not possible to determine the true proportion of children susceptible (i.e., had no acquired immunity through natural infection or were vaccinated).

Choice of lots was based on homogeneity of the population and geographic proximity. Ideally, choice of lots with similar population sizes is preferable to facilitate a weighted average of the VC. As with any survey, the results presented here should be interpreted with caution when extrapolating.

Finally, LQAS surveys appear to be slightly more resource demanding (both in terms of human and financial resources) than the two-stage cluster sampling method. As we wanted to provide an overall estimate of VC, we sampled 65 children per lot instead of stopping when the number of defects allowed in the sample had been exceeded. As a result, costs in terms of time and human resources for this survey were high. These costs would be reduced if sampling stopped once a lot classification has been made.

5. Conclusion

One of the current objectives of the WHO strategic plan for measles is to reduce the number of measles deaths by half by 2005 (relative to 1999 estimates) through four strategies: achieve high-routine VC (>80%); provide a second opportunity for measles vaccination for all children; implement a strong surveillance system; and improve measles case management [8]. The results of this research point to the need for a clear and directed effort to achieve high VC in urban areas like Niamey if the WHO objective is to be achieved. Reinforcement of routine immunization activities, i.e. by increasing opportunities to vaccinate children under 5 is a first necessary step for Niamey. The supplemental vaccination activities that took place in December 2004 in the six most populated regions of Niger [12] were a first response to increase the prevalent low VC. The well-established effective surveillance system in Niger should be utilized further to provide timely analysis of data for prompt detection of measles epidemics and the consequent implementation of appropriate control measures.

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