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**Autor:** Imperato, Pascal James / Sow, Ousmane / Benitieni-Fofana  
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## Miscellanea

### The Persistence of Smallpox in Remote Unvaccinated Villages during Eradication Program Activities

PASCAL JAMES IMPERATO<sup>1</sup>, OUSMANE SOW<sup>2</sup>, and BENITIENI-FOFANA<sup>3</sup>

Smallpox Eradication-Measles Control Program, CDC-USPHS, Bamako, Mali, and  
The Ministry of Public Health, Republic of Mali

#### Introduction

In January 1967, the Republic of Mali launched a smallpox eradication program as part of a coordinated regional effort in which twenty nations of West and Central Africa are participating. This program is being carried out with the technical and material assistance of the U.S. Agency for International Development, the Center for Disease Control of the U.S. Public Health Service and the World Health Organization. By June of 1971, the attack phase of this program had been completed in Mali and four and a half million persons vaccinated, approximately 90 percent of the country's population. There have been no known cases of smallpox in Mali since January 1969, when one case was imported from the Republic of Niger.

Smallpox has also been absent from the rest of West Africa during calendar year 1971 (WHO 1971). It has been the belief for many years that smallpox is one of the more contagious of the infectious diseases (TOP 1968). Because of this belief, many eradication programs and control efforts were oriented towards the systematic vaccination of the population of given geographic areas whether smallpox was present or not. Many of these programs were planned according to the population characteristics of a given area, little attention being given to the distribution of smallpox within the population. Their goal was to increase immunity to smallpox throughout the entire population.

Detailed epidemiologic studies of smallpox transmission in Mali conducted in 1967, demonstrated that smallpox was not a highly contagious disease (IMPERATO 1970, FOFANA et al. 1971, IMPERATO et al. 1972). This observation has also been made in other parts of West Africa and in India (FOEGE et al. 1971, NAT. INST. Communicable Dis. India 1968). FOEGE et al. (1971) have observed that in West Africa infected persons rarely transmit the disease to an average of more than two or three persons and that most transmission occurs within the infected household. These epidemiologic characteristics of smallpox were also observed in Mali in 1967 (IMPERATO 1970, FOFANA et al. 1971). It was also seen in Mali that smallpox rarely involved more than a small percentage of the villages in a given area at any given time (IMPERATO 1970, FOFANA et al. 1971). Similar observations have

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<sup>1</sup> Director, Bureau of Infectious Disease Control, City of New York Department of Health. Assistant Clinical Attending Physician, Cornell University Medical Center-New York Hospital.

<sup>2</sup> Director, Division of Socio-Preventive Medicine, Ministry of Public Health, Republic of Mali.

<sup>3</sup> Minister of Public Health, Republic of Mali.

been made in India where only from 0.3 percent to 1 percent of the villages in an endemic district were found to have smallpox at any one time (NAT. INST. Communicable Dis. India 1968).

Because of the epidemiologic characteristics of smallpox observed in Mali in early 1967, the national smallpox eradication program was organized so that the mass vaccination campaign first reached those population groups where outbreaks were clustered (IMPERATO 1967). The use of this approach effectively interrupted smallpox transmission in Mali by December 1968, when only two million people had been vaccinated, less than fifty percent of the total population of the country. This strategy for conducting smallpox eradication programs was described in 1966 by DICK and called "Selective Epidemiological Control". In September 1968, this approach was implemented in the seven other West African states, where smallpox was still present, raising to eight the total number employing the technique. Selective epidemiologic control or "eradication escalation" as it was also called in West Africa includes four types of activity: outbreak investigation, outbreak control, active surveillance and communication of disease intelligence (FOEGE et al. 1971). In practice it involves the conducting of vaccination programs based on the knowledge of where the disease is present and when, where and to whom it is likely to spread. This approach proved to be more effective in eliminating smallpox than routine mass vaccination because it permitted the rapid achievement of the goal of eradication at a lower economic cost in less time and employing fewer personnel.

Although selective epidemiologic control had been employed in most of Mali with great success, its implementation in the central part of the country adjacent to the Upper Volta frontier was hindered by a number of logistical problems related to the difficult terrain and by local attitudes towards vaccination. Because of this, active surveillance of these areas was below the desired level. Outbreak control activities were also modified by field personnel unwilling to walk long distances to reach isolated villages. The consequence of this was that populations designated for vaccination were not vaccinated and outbreaks of smallpox continued undiscovered as small islands in an otherwise smallpox free area. Activities were also modified by field personnel in that they summoned the inhabitants of remote and isolated villages to assembly points for vaccination instead of entering the villages themselves. The consequence of this unauthorized alteration of program strategy was that the populations of remote villages were not vaccinated, they being unwilling to walk the long distances to the assembly points. Likewise, smallpox transmission in such villages continued undetected, it neither being reported by the villages to the local medical authorities nor uncovered by the active surveillance system. Thus, although a vigorous program of selective epidemiologic control was in effect, islands of smallpox and susceptibles continued to exist in remote unvaccinated villages.

### **Results of selective epidemiologic control**

In 1967 the central area of Mali adjacent to the Upper Volta frontier had the highest attack rate for smallpox in the country (30/100,000). The attack rate for Mali as a whole was 6.4/100,000. This high attack rate was due to presence of smallpox in a highly susceptible population. The high degree of susceptibility of this population was accounted for by the following. Approximately twenty-five percent of the population are pastoral nomads who because of their transhumance movements and cultural attitudes had infrequently been vaccinated in the past. A large proportion of the sedentary agriculturists in the area live in remote mountain villages accessible only on foot.

Unlike the nomads who are predominantly Moslem, the sedentary population is strongly animist and had always refused the services of mobile medical teams. Although this area had been the object of a mass vaccination effort in 1965, an assessment of those over two years of age in 1967 revealed that only 45.7% had been vaccinated. During the 1965 mass vaccination program the population was requested to come to assembly points which were on the average ten kilometers from individual villages. The use of assembly points for the delivery of preventive health services is rarely successful in areas of low population density and this proved to be the case in 1965. The cohorts reached in 1965 were primarily those of the young adults and children who were willing to be vaccinated and who were able to walk the distance to the vaccination assembly point. Children who were too big to be carried on their mothers' backs and yet too small to walk were not vaccinated. Likewise the old and infirm were not reached.

It was quite evident from the results of the 1965 program that a successful epidemiologic control program had to reach all of the villages and nomad camps in the area. This meant that vaccination teams had to physically enter the villages and camps which in itself was to require enormous effort since vehicles and bicycles could not be used. In addition, it was incumbent on them to exercise considerable tact and patience with uncooperative villagers, in order to convince them of the necessity of being vaccinated. The achievement of this goal was difficult because of the great stresses and strains of the climate (120 °F in the shade and 15% humidity) and the rigors of living outdoors for many months on end. The salary scales of mobile medical workers were the same as those of workers at fixed curative dispensaries. Thus, the absence of any compensation above their usual salary did not motivate them to take on what were without question, heroic efforts.

Between October 14th and December 23rd, 1967, 521,000 smallpox vaccinations were administered by six vaccination teams in the target area along the Mali-Upper-Volta frontier. During this program teams encountered a considerable number of villages where the inhabitants either refused to be vaccinated or else hid the women and children when they arrived.

On March 4, 1968, three months after the completion of the mass vaccination program in the area, the medical authorities reported the presence of six cases of smallpox in the village of Koula. Epidemiologic investigations carried out between March 4th and 25th revealed a total of 12 cases of smallpox in Koula and 28 in the village of Berekan, twelve kilometers to the northwest. While these villages had been vaccinated in November 1967 by the mass vaccination teams, the investigation revealed that many parents had hidden their children in the granaries. Smallpox was restricted to those children who had not been vaccinated. Two vaccination teams were sent into the area on March 7th and under the close supervision of a medical officer conducted concentric peri-focal vaccination in and around the two villages. At the time of this investigation it was learned that smallpox cases had been seen in the village of Kouna, a very remote village situated atop a mountain some twenty-eight kilometers to the north of Koula. The local medical officer sent his assistant to Kouna to investigate the suspected presence of smallpox.

This assistant returned and reported he found no smallpox in Kouna. Thus, it was thought that the disease was absent from the village. Unknown to us at the time was the fact that because Kouna was so inaccessible, the vaccination team responsible for vaccinating the village had disobeyed instructions and sent word to the villagers to come to Lanfera, ten kilometers away to be vaccinated. As was discovered many months later, only a handful of villagers came to Lanfera to be vaccinated.

*Discovery of smallpox in the remote village of Kouna*

On October 31, 1968, the Ministry of Health of Upper Volta received a telegraphic message from the medical officer of the Dedougou District that smallpox had been reported from some villages along the Malian frontier. This district, which borders on the one in which Kouna lies, had not as yet been vaccinated in Upper Volta's mass vaccination campaign. An investigation conducted by C.D.C. personnel and the Upper Volta medical authorities revealed 40 cases of smallpox in the mountain top village of Gani. The index case had come to Gani in May 1968 from the village of Kouna which lies fifteen kilometers away, higher up in the same mountain valley. Outbreak control vaccinations were administered on the Upper Volta side of the frontier. On November 6th, the Upper Voltan health authorities informed the Malian health authorities of the findings of their epidemiologic investigation along the frontier. On the same day the Malian health authorities proposed a joint search for smallpox along the frontier by Malian and Upper Voltan health personnel and the personnel of the Smallpox Eradication-Measles Control Program of USAID-CDC. Over the next few days the details for this joint undertaking were arranged.

The mutually agreed upon plan called for a joint meeting of the personnel of the preventive medical services of Mali and Upper Volta and the personnel of the USAID-CDC Smallpox Eradication-Measles Control Program, a joint search on the Malian side of the frontier for smallpox and the implementation of epidemic control measures on both sides of the frontier. Initially there was much skepticism about the report of smallpox being present in Kouna, particularly since a medical assistant had visited the village in March and had found none. On November 14th the joint investigation team met in Mali. During discussions with the administrative authorities, it was learned that Kouna could only be entered on foot and that the approach from the Upper Volta side of the frontier was easier. For this reason the team crossed over into Upper Volta and then the following day walked the twelve kilometers across the mountains and valleys to reach Kouna.

*The village of Kouna*

On arriving in Kouna, it was discovered that the village is composed of eight separate quarters or units, each separated from the other by a distance of about one-half kilometer. Prior to the colonial era, each of these quarters was a separate and autonomous village. Although Kouna was and is regarded administratively as a single integrated village, it is in fact a congregation of eight separate villages, each having a traditional authority system. In addition, there are two ethnic groups living in Kouna, the Dogon and the Marka, the former living on the mountain ridges and the latter down in the valleys. When the medical assistant visited Kouna in March of 1968, he had in reality visited only the most peripheral of the quarters where smallpox was not present. Unaware as we were of the sociological and physical complexity of the village, we accepted this report thinking Kouna to be a compact single village.

*The epidemic*

Sixty-five persons who had had smallpox were observed in Kouna, three of whom were in the desquamation phase, the others being healed (Table 1). No attempt was made to determine the date of onset of each case. The epidemic was said to have begun with a ten-year-old girl who entered Kouna some time in late



*Table 1.* Cases of smallpox in Kouna village by age and sex, Republic of Mali, 1968

Age	Number examined	Cases of smallpox			Attack rate %	Percentage distribution by age (this outbreak)	Percentage distribution by age (other Mali outbreaks)
		male	female	total			
0-5 mo.	18	2	0	2	11.0	3.1	2.6
6 mo.-7 yrs	75	4	0	4	5.0	6.2	34.6
5-14 years	199	19	11	30	15.0	46.1	55.0
15-44 years	183	13	14	27	15.0	41.5	7.1
45+ years	42	1	1	2	5.0	3.1	0.7
Total	517	39	26	65	12.5	100.0	100.0

1967 with smallpox. This child had previously traveled through adjacent parts of Mali and Upper Volta. The last case occurred in October 1968. The disease spread to all other quarters, being still present at the time of the investigation in Kouna Gadala. Overall, 83.7% of the villagers lacked vaccination scars (Table 2). Of those who had scars, the majority were from scarification vaccinations performed years ago. The villagers confirmed that the vaccination team had not entered Kouna in 1967. Rather, word had been sent for the villagers to assemble at Lanfera, a village 10 kilometers away.

#### *Attack rate*

Among the 517 people examined in the village, 65 (12.6%) had evidence of smallpox contracted during the present outbreak. Presuming that all or most cases were seen, the attack rate for the village of Kouna as a whole would be 4.8%. However, not all cases were seen nor were the fatal cases taken into account. No estimate of the mortality rate was made since no one could say for certain how many had died during the outbreak.

#### *Age distribution of cases*

The age distribution of cases in this epidemic differs greatly from that observed in previous investigated epidemics in Mali. Of the total, 41.5% of cases occurred in the 15-44-year age group compared to 7.1% in other Malian epidemics. Only 6.2% of cases occurred in the 6-month to 4-year age group compared to 34.6% in other epidemics.

Most outbreaks in Mali in 1967-68 occurred in areas where a large percentage of the population above 5 years of age had been vaccinated at one time or another. The highest attack rates, therefore, were seen in the pediatric age groups and smallpox in Mali was characterized, as a consequence, as a disease of unvaccinated children. The vaccination status of Kouna differed from other villages with outbreaks. In this village, remote and inaccessible except by foot, 83.7% of the population was unvaccinated. In no instance was more than 30% of any given age group found to have vaccination scars. The highest percentage of unvaccinated individuals was in the less than 5-year age group.

Thus, one might expect the outbreak in Kouna to involve all age groups, as, in fact, it did. Although the variation in rates by age might be accounted for by the small numbers involved, one would have expected a higher attack rate in the 6-month to 4-year age group. Possible reasons for the lower rate are 1) parental failure to bring children who had smallpox to the vaccination site; 2) a high mortality rate in this group; 3) a substantial number in this group without visible scars of smallpox.

#### *Outbreak control measures*

A total of 541 vaccinations were administered by the investigation team with the jet injector apparatus among inhabitants of the eight quarters of Kouna. Vaccination teams on both sides of the frontier undertook active surveillance of villages under the close supervision of medical officers. Smallpox vaccinations were administered in a concentric fashion in villages on the Upper Volta side of the frontier and in those neighboring villages in Mali where coverage had been poor during the 1967 campaign. These efforts effectively interrupted smallpox transmission in the area.

#### *Discussion*

Because of the policy of the Malian national smallpox eradication program to practice selective epidemiologic control at the outset of the attack phase, it was possible to interrupt smallpox transmission in the country when less than fifty percent of the population had been vaccinated. Had certain difficulties not arisen in the implementation of this strategy, it is likely that smallpox transmission would have been effectively interrupted a year earlier when less than twenty-five percent of the population of the country had been vaccinated. The outbreak in Kouna evolved because of a series of deficiencies in the implementation of the theoretical model of selective epidemiologic control. The common denominator underlying all of these deficiencies was the village's extreme inaccessibility. Because of its distance from the nearest administrative center and from a passable roadway and its location in a mountainous region, passive surveillance was extremely poor. Villagers rarely leave the mountain and no one from Kouna went to the administrative center at Koula to report the outbreak. This lack of reporting was also prompted by the fact that the villagers did not view smallpox as a particularly serious problem and by their stated opinion that they thought nothing would have been done anyway, even if they had reported the outbreak. In spite of all these difficulties, however, word did eventually arrive in the administrative center of Koula with travelers who said they had seen people with smallpox in Kouna. The credibility of this report was questioned by the local medical officer, because the village had theoretically been vaccinated by a mobile team. However, at our insistence he did send his assistant into Kouna on an active surveillance mission. Had this individual been more conscientious in his mission he would have discovered the smallpox cases which were then present in the village. Kouna is in reality a conglomeration of eight separate and traditionally independent villages. This fact only became known to us when we ourselves visited the locality. It was then discovered that the active surveillance agent had visited only one of these eight villages, one where smallpox was not present. He did not visit the other seven because of the physical effort and time which would have been required to obtain the information he thought he had satisfactorily obtained from

Table 2. Vaccination status of 537 inhabitants of Kouna village, Republic of Mali, 1967

Age	Male Vaccination scar absent			Female Vaccination scar absent		
	total	number	percent	total	number	percent
0-5 mo.	29	29	100.0	37	36	97.3
6 mo.-7 yrs	61	59	96.7	64	60	93.8
5-14 years	85	61	71.8	46	35	76.1
15-44 years	82	61	74.4	65	52	80.0
45+ years	40	32	88.0	28	25	89.2
Total	297	242	81.5	240	208	86.7

the inhabitants of the one quarter. They told him they were unaware of any smallpox in the other quarters.

The third of the deficiencies which chronologically was probably the first, was the failure of the vaccination team in late 1967 to physically enter the village as instructed. This failure would probably not have occurred had there been a more effective supervisory structure present. The team's failure to carry out their instructions was primarily due to their unwillingness to expend the physical effort which would have been required to reach the village. This is an understandable attitude considering the poor remuneration, difficult working conditions and low level of professional motivation of vaccinators. Although there is much advantage to employing nonprofessionals for administering smallpox vaccinations, their use also requires a tight supervisory structure of professionals since motivation is generally poor. Such a structure was not present at the time Kouna was scheduled for vaccination, but was imposed later on in the attack phase of the program. Likewise, it was possible later on to pay team members a per diem allowance for each day in the bush which amounted to fifty percent of their usual daily earnings. The implementation of these two measures improved team morale, motivation and performance.

The team's use of an assembly point for vaccinating the villagers from Kouna was not innovative. They had employed the technique in the 1965 program and naturally preferred it since it meant less work and travel for them. From the vaccination scar data (Table 2) it is obvious that most people in Kouna did not go to the assembly point at Lanfera. The time (an entire day), effort and physical stamina required for walking from Kouna and for transporting children there to the assembly point was considered too great. The use of such assembly points in areas of low population density, such as the one in question, fails to reach the majority of the population when a service such as smallpox vaccination is being offered. The more recent experience with cholera vaccinations in Mali has been different because cholera is a highly contagious disease carrying a high mortality and as such creates enormous fear in most African populations. As a consequence they readily come to assembly points (IMPERATO 1972).

The outbreak in Kouna demonstrated once again that smallpox is not one of the more contagious diseases. It required approximately 300 days for smallpox to achieve an attack rate of 12.6% among 517 people, 450 (83.7%) of whom did



not have a visible vaccination scar. The outbreak of smallpox in Kouna illustrates what can occur when there is deficient implementation of a sound theoretical model. In this instance there were clear cut failures in the performance of active surveillance, the investigation of suspected cases and the administration of smallpox vaccinations. In developing countries the use of para-professional personnel for these kinds of field activities is both economically preferable and necessary because of the limited cadres of professional personnel. Although these levels of nonprofessionals and para-professionals can learn a variety of techniques and employ them successfully, they require close and constant supervision by professional staff if programs are to be executed as planned.

The discovery of the smallpox outbreak in Kouna and its subsequent investigation and control demonstrates the achievement of a high level of international cooperation in communicable disease control. This outbreak and its containment once again points out the well known fact that infectious diseases do not respect boundaries and that their successful control and eradication require close cooperation and coordination between neighboring states.

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