Evaluation of Urban Measles Mass Campaigns for Children Aged 9–59 Months in Mali

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There are an estimated 234,000 cases of measles and 13,851 measles-related deaths per year in Mali. In 1998 and 1999, 548,309 children aged 9–59 months were vaccinated against measles during mass campaigns in urban centers across Mali. After the first campaign, measles incidence decreased by 95% in districts encompassing vaccinated urban centers and by 41% in nonvaccinated districts. There was no shift in the proportion of cases by age group in vaccinated centers. Measles in vaccinated districts after the campaign was likely related to persistent transmission in age groups not targeted for vaccination and among children living in nonvaccinated districts. The second campaign (1999) did not change the incidence of measles in vaccinated compared with nonvaccinated centers. Urban mass measles vaccination probably did not affect overall measles transmission in Mali. Mass vaccination of all children in Mali, targeting a larger age group, will be necessary to reach measles control objectives.

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0022-1899/2003/18710S-0011$15.00

METHODS

Mali is divided into eight administrative regions plus the capital district of Bamako. The regions are subdivided into 49 districts, and the capital is divided into
six communes. Each district and commune is serviced by a reference health center. Districts are subdivided into arrondissements, most of which are serviced by a peripheral health post. In addition, there are four national tertiary referral hospitals in Bamako and 10 regional hospitals located throughout the country. In 1998, the population of Mali was estimated at 9,790,492 persons [6].

Measles is one of seven reportable infectious diseases in Mali. Each week, the number of measles cases by location (arrondissement), patient age group in years (<1, 1–4, 5–14, ≥15), patient vaccine status, and clinical outcome is transmitted by radio from peripheral health posts at the arrondissement level through the district and regional reporting systems to the national level. Prior to 1998, case location was reported by district, not by arrondissement. Though all hospitals, reference health centers, and peripheral health posts are required to participate in communicable disease surveillance, the true number of measles cases is underestimated. Health services are underused in Mali: There are 0.2 new consultations/person per year, compared with 0.4–0.8/person for the rest of Africa [7, 8]. In addition, reporting is sometimes incomplete: One region, representing 14% of the population did not report in 1996–1997, and there is no reporting from private health facilities or traditional healers.

Serum samples obtained from persons with suspected measles cases are analyzed at l’Institut National de la Recherche en Sante´ Publique, the national virologic reference laboratory located in Bamako. Laboratory analysis of suspect cases began in 2001, 14 months after the second measles campaign. At present, specimens are collected nonsystematically on the pediatric service of one of the National Reference Hospitals and in several of the regional hospitals. Each specimen is tested for measles and rubella anti-IgM, using an ELISA (Enzygnost; Behring).

During the first mass campaign (December 1998), measles vaccine was given to 392,205 children aged 9–59 months in the urban centers of 20 arrondissements, including the 6 communes of Bamako and all arrondissements in the region of Kidal. Vaccination was limited to urban centers within the arrondissements. In 1999, during the second campaign, 210,060 children were vaccinated. This group included children living in the arrondissements covered during the first campaign but who had been too young for vaccination in 1998 and children aged 9–59 months in 146 other smaller urban centers throughout the country.

The MS limited the measles vaccination campaigns to children <5 years of age in urban centers for practical and epidemiologic reasons. Little data were available at the time to support vaccination of older children. It was suggested that mass vaccination in urban centers with high levels of measles transmission could reduce measles incidence among nonvaccinated children in peri-urban centers [9]. The MS wanted to profit from the mobilization of human and financial resources linked to poliovirus NIDs without compromising polio eradication efforts, which had begun in 1997 [10]. Urban centers provided the necessary infrastructure to deliver large quantities of measles vaccine quickly and safely without compromising polio vaccination during NIDs.

For the purposes of this analysis, arrondissements targeted for vaccination will be referred to as “vaccinated” arrondissements; those not targeted for vaccination are referred to as “nonvaccinated” arrondissements. Nonvaccinated arrondissements are further classified as “nonvaccinated, adjacent” if they border a vaccinated arrondissement or “nonvaccinated, non-adjacent” if they do not.

Our analysis is a retrospective evaluation of measles cases notified at the national level. Data were collected and analyzed by use of EPI INFO 6.0b (Centers for Disease Control and Prevention). Estimates of the population were based on 1998 national census data [6].

RESULTS

Table 1 presents target populations and vaccine coverage during the 1998 and 1999 campaigns. The impact of the campaign was analyzed by using surveillance data from the arrondissement level since no data were available from the level of the specific urban centers vaccinated. For the analysis, campaign coverage was considered to be the number of children vaccinated divided by the number of children in the entire arrondissement. At the completion of the 1998 and 1999 campaigns, 548,309 children (35% of all Malian children aged 9–59 months) had been vaccinated against measles.

Analysis of the impact of the 1998 campaign. Figure 1 shows the number of measles cases by month in vaccinated and nonvaccinated arrondissements before and after the 1998 campaign. In the early part of 1998, before the campaign, Mali experienced a measles epidemic with 8008 notified cases. Table 2 shows the yearly incidence of measles before (1998) and after (1999) the first mass campaign for vaccinated and nonvaccinated arrondissements. The percent reduction in measles cases/

Table 1. Measles vaccine coverage during mass campaigns in participating arrondissements in Mali, 1998 and 1999.

<table>
<thead>
<tr>
<th>Variable</th>
<th>1998</th>
<th>1999 (cumulative)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of arrondissements</td>
<td>20</td>
<td>146</td>
</tr>
<tr>
<td>Population in urban zones</td>
<td>324,350</td>
<td>210,060 (534,410)</td>
</tr>
<tr>
<td>(target population)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| Total population in arrondisse-
| ments                          | 411,950 | 752,326 (1,164,276) |
| No. vaccinated                  | 392,205 | 254,156 (548,309)* |
| Coverage at level of vaccinat-
| ed arrondissements              | 95%  | 47%               |

* Population vaccinated in 1998 × 0.75 to exclude children >59 months of age (i.e., those vaccinated in 1998).
incidence was 95% in the vaccinated arrondissements, compared with 41% in the nonvaccinated arrondissements. The difference in percent reduction of 54% between the two groups of arrondissements was significant ($\chi^2 = 54.5, P < .01$).

Between 1994 and 1997, 47% of all measles cases in Mali occurred among people $\geq 5$ years of age. During the epidemic of 1998, the proportion of measles cases among those $\geq 5$ years of age decreased to 36% in arrondissements subsequently targeted for vaccination, compared with 54% in nonvaccinated arrondissements. During the 1999–2001 postcampaign period, the percentage of measles cases among persons $\geq 5$ years of age in vaccinated arrondissements was less (40%) than that in nonvaccinated arrondissements (45%); however, the difference was not significant.

To examine the effect of urban measles vaccination on nonvaccinated peri-urban populations, data were analyzed from three types of centers: 20 vaccinated arrondissements, 84 nonvaccinated, adjacent arrondissements, and 187 nonvaccinated, nonadjacent arrondissements. Before the campaign (1998), the incidence of measles was highest in vaccinated arrondissements, followed by nonvaccinated, nonadjacent arrondissements and then by nonvaccinated, adjacent arrondissements. By 1999, measles incidence was reduced by 8% in nonvaccinated, adjacent arrondissements, compared with 50% in nonvaccinated, nonadjacent arrondissements.

**Analysis of the cumulative impact of the 1998 and 1999 campaigns.** The incidence of measles before (1998) and after (2000) the campaigns is compared in Table 2. The percent reduction of measles cases between the two periods was greatest in the vaccinated arrondissements; however, the incidence of measles was similar in vaccinated and nonvaccinated arrondissements after the two campaigns (year 2000).

**Impact of campaigns on measles-related mortality.** The effect of the campaigns on measles-related mortality is difficult to determine since data on disease outcome are incomplete in Mali. Since 1994 in, 43% of reported measles deaths occurred among persons $\geq 5$ years of age (29% among those 5–14 years old and 14% among those >14 years old). The campaign had little effect on the age group of reported deaths: Before the campaign (1994–1998), 45% of deaths were reported in children $\geq 5$ years old, compared with 44% reported deaths in this age group after the campaigns (2000–2001).

**Serologic analyses.** Serologic analyses of suspected measles cases presenting in the year 2000 are available from 27 specimens obtained in Bamako, where all 9- to 59-month-old children were vaccinated during the campaigns of 1998 and 1999. Eight (30%) suspect cases were confirmed as measles. Eleven (41%) of the children with these suspected cases were $\geq 5$ years of age; 1 case was confirmed as measles. Rubella was confirmed in 7 (26%) of the 27 specimens.

**DISCUSSION**

In the setting of routine measles vaccine coverage of $<60\%$, mass measles vaccination campaigns provide an opportunity to offer a second dose of measles vaccine to children already vaccinated and to reach children not normally vaccinated by routine services. Several African countries have used human and financial resource mobilization during polio NIDs to introduce limited mass campaigns for measles [11]. After the 1998 campaign in Mali, a
reduction in the number of measles cases was observed in both vaccinated (95%) and nonvaccinated (41%) arrondissements. Immunization of children during the campaign may be only one explanation for this reduction. Measles incidence before the campaign was greater in vaccinated than in nonvaccinated arrondissements (232.6/100,000 population vs. 51.7/100,000 population) suggesting that the measles epidemic preceding the 1998 campaign disproportionately affected centers that were subsequently targeted for vaccination. Natural infection reduced the number of susceptible children at a different rate in vaccinated than nonvaccinated arrondissements, which may explain why measles virus transmission was reduced after the 1998 campaign in vaccinated arrondissements.

Within targeted urban centers, measles vaccine was probably given to children already immunized by the 1998 epidemic or by routine immunization. In 1998, 64% of measles cases in vaccinated arrondissements occurred among children <5 years of age, compared with 46% in nonvaccinated arrondissements, suggesting that the epidemic affected the same age group subsequently targeted for vaccination. In addition, the campaign targeted urban centers where routine coverage is generally better than in rural areas. The 1998 Malian EPI review confirmed that third-dose coverage of diphtheria-tetanus toxoids–pertussis vaccine in urban centers was 75%, compared with 40% in rural areas. In the centers targeted for vaccination, it is possible that few susceptible children remained to be protected by the mass campaign, with many having been covered by routine immunization or by the measles epidemic preceding the campaign.

Despite the reduction observed after the 1998 campaign, the incidence of measles in vaccinated arrondissements remained high (10.9/100,000 population) relative to the experience of southern African countries, where the rate of measles has been <0.1/100,000 population for 3 years after mass campaigns (unpublished data). This may be due to persistent measles virus transmission among children <1 year of age after the campaign. In Mali, there was little change in the proportion by age group of cases in vaccinated arrondissements following the campaign: In 1999, 26% of measles cases were observed among children <1 year of age in those arrondissements vaccinated in 1998. This is consistent with observations from other African urban centers, where the circulation of measles virus among children <1 year of age is greater than in rural areas [12] and results in epidemics even when routine coverage is high [13, 14]. High postcampaign measles incidence among children <1 year of age may be related to the persistence of measles transmission in children ≥5 years of age who were not targeted during mass immunization campaigns. High coverage during a campaign targeting older children will probably be necessary to reduce transmission to children <1 year of age and thus to reduce overall measles transmission.

The large number of susceptible children introduced annually into the population may also explain the relatively high postcampaign incidence of measles in Mali. Each year, 450,000 children are born in Mali, of which ∼54% are vaccinated by routine immunization. This means that, assuming a vaccine efficacy of 85%, 244,000 new children become susceptible to measles each year.

It is also possible that many suspected cases seen after the campaign were not measles. In Bamako, where all children were vaccinated in the campaigns of 1998 and 1999, serologic testing of a limited number of specimens in 2000 confirmed measles in 30% of suspected cases. This observation underscores the importance of laboratory confirmation of suspected measles cases in the evaluation of mass vaccination.

Our analysis may lack the sensitivity to detect a change in the incidence of measles or a shift in the age group of cases related to the campaign. Specific epidemiologic data about measles cases occurring in the urban centers within the arrondissements targeted for vaccination were not available; data were available only from the entire arrondissements. In this way, data from each vaccinated arrondissement considered a proportion of children who were not, in fact, targeted for vaccination. The cumulative coverage in vaccinated arrondissements was only 47% after the second campaign, reflecting the large rural population not targeted for immunization. Accordingly, there was no reduction of virus transmission in vaccinated arrondissements compared with nonvaccinated arrondissements following the two campaigns. The incidence of measles in 2000, after the epidemic in 1998 and the campaigns of 1998 and 1999, was almost identical in vaccinated and nonvaccinated arrondissements (15.2 and 15.6/100,000 population, respectively). High campaign coverage rates

**Table 2. Measles incidence and percent reduction of measles cases in vaccinated and nonvaccinated arrondissements in Mali, 1998–2000.**

<table>
<thead>
<tr>
<th>Year of campaign</th>
<th>Incidence (cases/100,000 population)</th>
<th>% reduction</th>
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<tbody>
<tr>
<td>1998</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vaccinated arrondissements (n = 20)</td>
<td>232.6 10.9 —</td>
<td>95</td>
</tr>
<tr>
<td>Nonvaccinated arrondissements (n = 271)</td>
<td>51.7 30.4 —</td>
<td>41</td>
</tr>
<tr>
<td>1999</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vaccinated arrondissements (n = 146)</td>
<td>106.2 — 15.2</td>
<td>85</td>
</tr>
<tr>
<td>Nonvaccinated arrondissements (n = 145)</td>
<td>52.4 — 15.6</td>
<td>70</td>
</tr>
</tbody>
</table>
are necessary to achieve a reduction of measles transmission, especially in areas with low routine coverage. In Niger, measles epidemics followed mass vaccination that covered <70% of the targeted population (unpublished data). It is likely that much higher coverage is necessary in the entire arrondissement, not just the urban center, before an overall effect due to mass vaccination can be demonstrated.

Effective vaccine coverage was probably too low in vaccinated arrondissements to affect measles transmissions in adjacent centers. Though a small reduction in measles incidence was observed in nonvaccinated arrondissements bordering those that were vaccinated, this reduction was less than that observed in nonvaccinated arrondissements not sharing borders with vaccinated arrondissements. Several epidemics were noted in nonvaccinated border arrondissements following the 1998 campaign (data not shown). Urban vaccination did not appear to influence measles transmission in peri-urban, nonvaccinated arrondissements.

The impact of the campaigns on measles mortality was also difficult to demonstrate. The case fatality rate for reported measles in Mali between 1994 and 2001 was 1.2%, well below that difficult to demonstrate. The case fatality rate for reported measles in peri-urban, nonvaccinated arrondissements. Urban vaccination did not appear to influence measles transmission in peri-urban, nonvaccinated arrondissements.

The impact of the campaigns on measles mortality was also difficult to demonstrate. The case fatality rate for reported measles in Mali between 1994 and 2001 was 1.2%, well below that reported from other countries of the subregion [3, 15]. This may reflect an undernotification of measles deaths. Nevertheless, >40% of notified measles deaths since 1995 in Mali were among persons ≥5 years of age. This may represent a notification bias; older individuals in Mali may be more likely than younger children to present to health centers with severe cases of measles. It is also possible that these deaths in older children are due to rash illnesses other than measles. In Bamako after the 1998 campaign, only 1 in 11 suspected measles cases among persons ≥5 years of age was confirmed. Nevertheless, given the observation that 13.6% of notified, suspected measles deaths occur in children and adults ≥15 years of age, it is probable that measles represents an important cause of morbidity and mortality in this age group in Mali and that persistent circulation of measles virus in older individuals represents an important source of transmission to younger children.

Campaign organizers were concerned that associating measles vaccination with NIDs would compromise polio eradication efforts. At present, however, acute flaccid paralysis surveillance conforms to certification standards, and the last case of laboratory-confirmed polio was detected in December 1999. The measles mass campaigns in Mali seem not to have delayed polio eradication.

**CONCLUSION**

It is difficult to demonstrate the impact of mass vaccination in urban centers in Mali in the context of an antecedent epidemic and the lack of data that make a sensitive analysis possible. If campaigns limited to urban centers do not have an effect on overall measles transmission, experience in the southern African subregion of WHO has shown that mass measles vaccination for the entire country, targeting a larger age group and achieving a coverage of 90%, can significantly reduce the incidence of measles even in the context of routine coverage of <80%. Data from Mali suggest that there remain many susceptible children between the ages of 5 and 15 years and that deaths continue to occur in this age group. A mass measles vaccination targeting all children in Mali between 9 months and 15 years was planned for 2001–2002. This campaign and efforts underway to improve routine immunization coverage should assist Mali in achieving its measles control objectives.

**References**