Impact of Mass Measles Campaigns among Children Less Than 5 Years Old in Uganda

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In 1999–2001, a national measles control strategy was implemented in Uganda, including routine immunization and mass vaccination campaigns for children aged 6 months to 5 years. This study assesses the impact of the campaigns on measles morbidity and mortality. Measles cases reported from 1992 through 2001 were obtained from the Health Management Information System, and measles admissions and deaths were assessed in six sentinel hospitals. Measles incidence declined by 39%, measles admissions by 60%, and measles deaths by 63% in the year following the campaigns, with impact lasting 15 to 22 months. Overall, 64% of measles cases were among children <5 years of age, and 93% were among children ≤15 years old. The cost per child vaccinated was $0.86. Routine immunization coverage remained low, at 61% in 2001. To eliminate measles in Uganda, routine immunization should be strengthened, campaigns should be conducted among those <15 years of age, and nationwide case-based measles surveillance should be put in place.

Although an effective measles vaccine was licensed in 1963 [1, 2], almost 30 million measles cases and 777,000 deaths continue to occur every year, with most occurring in sub-Saharan Africa [3, 4]. In Uganda, the mortality rate among children <5 years old is 152/1000 live births [5], with measles ranking fourth among causes of morbidity and mortality. Coverage for routine measles immunization (given in a single dose at 9 months of age) peaked at 82% in 1995 but dropped to 59% by 1998. This decline was associated with outbreaks of measles that mainly affected children <5 years old. In line with a World Health Organization recommendation to offer children a second opportunity for measles immunization [3], Uganda implemented an accelerated measles control plan in 1999–2001, including mass measles vaccination and vitamin A campaigns for children <5 years of age, strengthening routine immunization, and improving measles surveillance.

In 2001, Uganda had 56 districts with a population of 22,525,923, 46.6% of whom were <15 years of age and 19.6% of whom were <5 years of age. Measles vaccination campaigns with vitamin A supplementation were conducted in all districts within 26 months, targeting children aged 6–59 months, the most affected age group. The purpose of the campaigns was to reduce morbidity and mortality due to measles in children <5 years old, with the objectives of achieving 90% coverage and reaching previously unimmunized children. District-wide vaccination campaigns were implemented in three phases from September 1999 to November 2001, either in combination with Polio National Immunization Days or as stand-alone campaigns. In each phase,

17 to 20 districts (one-third of the country) were covered (figure 1A). The purpose of this study is to assess the impact of the measles control strategy in Uganda, particularly the mass measles vaccination campaigns among children <5 years of age.

METHODS

Source of data. To assess the impact of the mass campaigns, a time series analysis was conducted. The number of measles cases and the routine measles vaccination coverage reported by each district was obtained from the Uganda National Expanded Programme on Immunisation and the national Health Management Information System (HMIS) for 1992–2001. Completeness of monthly reports for 1997–2001, years for which computerized data were accessible, was calculated by multiplying the proportion of health units reporting in each district by the proportion of districts reporting to the national level. The estimated annual measles incidence was calculated by dividing...
Mass campaign immunization coverage for each district was the number of doses of measles vaccine administered to children aged 6 to 59 months divided by the projected population in that age group for the year of the campaign. Vaccine and vitamin A doses administered were recorded on the same tally sheet according to age (6–59 months), so coverage was the same for both. The cost per child vaccinated was the direct cost of supplies and operational costs divided by the number of children <5 years old who were actually vaccinated in the stand-alone measles campaigns.

**Measles surveillance sentinel sites.** Case-based measles surveillance was established in six sentinel sites in June 2000 to obtain data on hospitalized measles patients and deaths. For each case patient, information on the age in months, vaccination status (vaccinated, unvaccinated, or unknown), vitamin A administration during the present illness (received, did not receive), and outcome (discharged, died, unknown) was collected. Measles case-investigation forms and blood and urine specimens were forwarded to the National Measles Laboratory at the Uganda Virus Research Institute. Outpatient registers and inpatient charts were also reviewed to identify measles cases for January 1997 through May 2000.

A clinical measles case was defined as a person with a generalized rash, fever, and at least one of the following symptoms: cough, coryza, or conjunctivitis. For cases obtained by records search or from the HMIS, a case was a person diagnosed with measles, as written in the medical register or reported on HMIS forms.

**Serology.** Whole blood specimens were obtained from all clinical measles cases on admission to the sentinel sites and centrifuged at 450 g for 5 min. The separated serum was transferred to serum tubes and stored at −20°C until transported to the Measles Laboratory in a specimen carrier with ice packs, when they were again stored at −20°C until testing. Dade Behring kits were used to perform measles indirect IgM assays on all sera, and indirect rubella IgM assays were performed on specimens negative or indeterminate for measles IgM.

HMIS data, sentinel site case-investigation forms, and assay results were entered into a standardized database and analyzed by use of Epi Info (Centers for Disease Control and Prevention) and Excel (Microsoft) software programs.

**RESULTS**

**Measles immunization coverage.** Vaccination coverage in the mass campaigns was 98% in 1999–2000 and 115% in 2001, with 61% and 85% of districts, respectively, exceeding 90% (figure 1A). The cost per child vaccinated in the March 2000 measles campaigns was $0.86, with $0.42 for vaccine and injection material and $0.44 for operational costs. The routine measles immunization coverage for Uganda in 2000 and 2001 was 61% of the estimated 1.1 million children born each year (figure 1B), ranging from 24% to 107%, according to district, in 2001.

**Descriptive epidemiology of measles cases.** The measles cases reported annually were as follows: 57,347 in 1997, 61,372 in 1998, 66,908 in 1999, 43,931 in 2000, and 48,308 in 2001 (figure 1B). Completeness of reporting each year ranged from 52% to 70%. Cases reported monthly ranged from 2141 to 16,074 (average, 4631), with a national interepidemic interval of 18 months, varying by district (figure 2).

Between 1997 and 2001, the estimated number of cases decreased from 110,909 to 74,458. The estimated annual measles incidence dropped by 39%, from 543 to 331 cases per 100,000 inhabitants (figure 2) and from 1723 to 1058 cases per 100,000 children <5 years of age. An estimated 97,284 cases were averted in 2000–2001, including 55,651 among children aged <5 years. Assuming a case-fatality ratio (CFR) of 3%–5%, 2919 to 4864 deaths were averted over 2 years.

Of the 277,866 measles cases reported during 1997–2001 through the HMIS, 64% were among children <5 years old. Of the 13,644 cases found by records review in 474 health facilities, 14% overall were <9 months of age, 55% were 9 months to 4 years old, and 24% were 5 to 15 years old. Age distribution before and after mass campaigns was the same.

From 1997 through 2001, 2965 patients were hospitalized with measles in the six sentinel sites. That number represents 0.8% of the cases reported nationally. Of these, 1173 (40%) had vaccination status recorded, of which 292 (25%) were vaccinated against measles and 881 (75%) were not. Of 801 case patients for whom detailed age data were available, 83% were children <5 years old (18% were <9 months old) and 96% were <15 years old. The median age was 15 months (mean, 34 months; range, 2 months to 37 years). The CFR for measles in the sentinel sites was 9.3% overall, with 10.8% in children <5 years old and 3.6% in children ≥5 years old.

**Pre- and post-campaign trends in sentinel sites.** In the sentinel sites, 642 measles cases were identified in 1997, 800 in 1998, and 692 in 1999. In 2000 and 2001, after the 6 districts had completed mass campaigns, 257 and 578 cases, respectively, were seen, resulting in a reduction of 60% in 2000 and 10% in 2001 compared with 1997. The minimal reduction in 2001 was due to a marked rise in measles cases in the fourth quarter. The number of measles-related deaths reported in the 6 sentinel
Figure 2. Reported measles cases and estimated incidence—Uganda, 1997–2001. Measles data were from the Uganda Ministry of Health’s (Kampala) Health Management Information System reports, and the population figures were from the Uganda Bureau of Statistics (Entebbe).

The post-campaign decline in measles cases varied with the routine and mass campaign immunization coverage in the districts.

Mbale district reported routine measles immunization coverage of 107% in infants in 2000 and mass campaign coverage of 117% in 1999. After the campaign, measles admissions at the district hospital dropped by 73% over 22 months (thereafter rising to pre-campaign levels in <60 days), and the number of deaths declined by 83% over 24 months, compared with a similar pre-campaign period (figure 3). Measles cases comprised 4.2% (1201/28,628) of pediatric admissions at the hospital during 1997–1999 and 2.0% (418/20,634) in 2000 and 2001. Of all pediatric deaths in Mbale hospital, the annual measles-specific mortality rate was 5%, 11%, and 10% from 1997 to 1999, respectively, and 2% in both 2000 and 2001 after mass campaigns. The hospital-based CFR for measles decreased steadily from 12.7% in 1997 to 3.6% in 2001.

In contrast, Kampala district reported routine measles coverage of 45% in 2000, and the March 2000 mass campaign reached only 20% of the target population (77% when repeated). In the 15 months following the campaign, the number of measles case patients admitted to Rubaga hospital dropped by 51% and deaths declined by 17% compared with cases and deaths in a similar pre-campaign period. Thereafter, measles admissions and deaths exceeded pre-campaign levels. Measles comprised 2.8% (239/8416) of admissions in 1997–1999 and 2.0% in 2000 and 2001 (90/4515). The measles-specific mortality rate was 4%, 13%, 3%, 8%, and 10%, in 1997–2001, respectively, and the CFR varied from 5% to 17%.

**Laboratory results.** The laboratory received 16 serum specimens in the pre-campaign period, all of which were positive for measles IgM, giving a positive predictive value (PPV) of 100% for the clinical case definition in hospitalized cases. Of 182 specimens collected after mass campaigns, 119 were analyzed at the time of writing, and 75 were positive for measles IgM, yielding a PPV for the case definition of 63%. Of the 44 cases serum-negative or indeterminate for measles IgM, 4 (9%) were positive for rubella IgM.

**DISCUSSION**

The measles control strategy implemented in Uganda from 1999 to 2001, with mass campaigns for children <5 years of age, reduced the estimated annual incidence of measles by more than one-third and measles-associated deaths by two-thirds. However, the impact at district level was short-lived. Measles remains endemic in Uganda, and outbreaks continue to occur, causing preventable deaths among children.

Mass measles campaigns in partially immunized communities are expected to reduce measles incidence and shift the age distribution of cases to older children [6]. The 39% decline in measles incidence observed in Uganda between 1997 and 2001 may be attributed to the mass vaccination campaigns conducted in 1999 and 2000, as routine immunization coverage was stable during that time. The impact of the campaigns lasted 15–22 months and was followed by a rapid rise in measles
admissions, suggesting a sudden explosive reintroduction of measles virus to the community. This is similar to the experience in other parts of Africa, where campaigns among children <5 years old had a limited and transient impact [7–9]. In Uganda, the magnitude and duration of the reduction in measles cases and deaths in the districts varied with routine and campaign immunization coverage. With routine coverage of ~60% and measles vaccine efficacy of 85% at 9 months of age [10, 11], 49% of infants in each birth cohort remain unprotected against measles. A pool of susceptible individuals accumulates quickly, sustaining virus transmission and reintroducing it to younger children [12]. This is confirmed by the low proportion (25%) of vaccinated children among measles cases and the absence of a shift in age distribution after mass campaigns. The best way to protect infants from measles is by creating herd immunity through sustained high vaccination coverage in the community [13].

In addition to low routine immunization coverage before and after campaigns, several aspects of campaign strategy also contributed to the partial and short-lived impact of the campaigns and to the rapid recurrence of measles in Uganda. The campaigns targeted children <5 years old, a group that represent only two-thirds of the susceptible population, and were phased over >2 years in noncontiguous areas, facilitating reintroduction of measles virus into campaign districts from non-campaign districts. Many districts had campaign coverage below the 95% necessary for interrupting measles transmission [14, 15]. Coverage did improve with successive campaigns as experience was gained in microplanning, logistics, and social mobilization.

Other countries in Africa and the Americas have shown that measles can be eliminated through wider age-group campaigns combined with maintaining high routine coverage [13, 15–19]. In seven southern African countries, measles cases declined by >99.9% following “catch-up” campaigns among children <15 years of age, and deaths decreased by 100% to zero. The low measles incidence is maintained by routine “keep-up” vaccination in children <1 year of age and by “follow-up” campaigns every 4 years for children aged 1–4 years [16]. The cost per child vaccinated in Uganda was similar to the $0.85 to $1.10 observed in other African countries [16].

As measles incidence declines, surveillance becomes increasingly important to identify groups at risk and to assess the effectiveness of control measures [11, 16]. The role of the laboratory is to confirm each suspected case because other febrile rash illnesses can be falsely diagnosed as measles. In this study, the positive predictive value of the clinical measles case definition decreased from 100% before the campaign to 63% after the campaign, and 3.4% of the cases reported as measles were laboratory-confirmed rubella cases. Given the quality-control procedures in the laboratory, this is not likely to be due to laboratory error. In southern Africa, PPV declined to 5% after the catch-up campaigns among children <15 years old, and 33% of reported measles cases were laboratory-confirmed rubella cases [16].

The data reported here have some limitations inherent in national health information systems. Population denominators projected from a census conducted a decade ago may be inaccurate, resulting in under- or overestimates of immunization coverage. In adjusting for underreporting to facilitate year-to-year comparisons of incidence, it was assumed that reporting and nonreporting health units and districts had the same measles incidence. As it is more likely that nonreporting units have fewer cases, our incidence figures may be overestimates. Con-
versely, in an endemic setting with limited access to health services, many cases may not present to health units and, thus, lead to underreporting. Given the magnitude of measles in Uganda and the observed trends in reported cases, these issues are unlikely to affect our conclusions. The rolling nature of the campaigns makes it difficult to distinguish their impact at the national level from the epidemic cycle of measles. Nonetheless, even expected epidemics appeared to be of lower magnitude following the mass campaigns. Although the HMIS does not provide mortality data, the sentinel sites are regionally distributed in districts with different levels of immunization coverage. Due to admission of severe cases, the 9.3% CFR in sentinel sites was higher than the 3%–5% found in communities, but it was comparable to the 10%–30% in other hospitals [20].

Measles vaccination, even in the form of a mass campaign, is a cost-effective intervention [21]. Nonetheless, this study shows that in an area such as Uganda, where measles is endemic, the duration of impact of campaigns among children ≤5 years of age does not exceed 2 years, even in the best circumstances of high routine and campaign coverage. Since 93% of all measles cases and 97% of severe cases are among children ≤15 years of age, all children ≤15 years should be immunized, a strategy proven to interrupt transmission of the measles virus and eliminate measles deaths [15, 16, 18]. Uganda should implement catch-up mass measles campaigns among children ≤15 years old, covering large contiguous areas in ≤1 year, and it should have follow-up campaigns 3–4 years later. Efforts to continue improving routine immunization and sustain the impact of mass campaigns should be reinforced. The Ministry of Health should establish national case-based measles surveillance, strengthen the measles laboratory, and emphasize appropriate case management. With children ≤15 years of age comprising 47% of the country’s population, this plan, which is essential for measles control in Uganda, calls for extensive resource mobilization and participation of all stakeholders.

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