SUPPLEMENT ARTICLE

Impact of Alternative Approaches to Accelerated Measles Control: Experience in the African Region, 1996–2002

Mac W. Otten, Jr.,[1] Jean-Marie Okwo-Bele,[1] Robert Kezaala,[1] Robin Biellik,[1] Rudi Eggers,[1] and Deogratias Nshimirimana[2]

[1]World Health Organization (WHO) Regional Office for Africa, Vaccine Preventable Diseases, Harare, Zimbabwe; [2]WHO Regional Office for Africa, Vaccine Preventable Diseases, Abidjan, Cote D'Ivoire

From 1996 to 2000, several African countries accelerated measles control by providing a second opportunity for measles vaccine through supplemental campaigns. Fifteen countries completed campaigns in children aged 9 months to 14 years. Seven countries completed campaigns in children aged 9–59 months. In almost all countries that conducted campaigns in children aged 9 months to 14 years, measles deaths were reduced to near zero. In six countries, near-zero measles mortality has been maintained for 4–6 years. Supplemental immunization in children <5 years old was only partially effective (range, 0–67%) in reducing mortality. Measles cases decreased by 50% when routine vaccination coverage increased from 50% to 80%. Initial measles campaigns in children aged 9 months to 14 years, follow-up campaigns in those aged 9–59 months every 3–5 years, and increased routine coverage to 80% will be needed to reduce and maintain measles deaths in African countries at near zero.

Half of the world's measles deaths continue to occur in sub-Saharan Africa [1]. In 1999, the World Health Organization (WHO) Regional Office for Africa estimated that measles caused about 45% (n = 445,000) of all vaccine-preventable deaths (~1 million, excluding *Streptococcus pneumoniae*) in the African Region. There was little progress in the decade of the 1990s in reducing this burden. Africa-wide coverage with measles vaccine increased from very low levels before 1975 to nearly 60% in 1990, the target date for universal childhood immunization by the United Nations, United Nations Children's Fund (UNICEF), and WHO. However, since 1990, the average Africa-wide measles vaccination coverage through routine immunization has remained stagnant at about 60%. The number of measles cases, and presumably measles deaths, did not decline substantially during the 1990s.

In 1996, the polio eradication initiative had its first series of large-scale mass oral poliovirus campaigns in African countries [2]. As the polio eradication initiative became increasingly successful in eliminating wild poliovirus, African countries became more interested in accelerating the control of their number one vaccine-preventable disease priority—measles. In 1998, the WHO African Region Office drafted a regional measles control plan with a target of near-zero measles mortality for most countries.

Here we describe three different measles control approaches used in Africa in recent years and discuss their impact in relation to the regional goal of near-zero measles deaths in most countries. The first approach was an initial campaign in children aged 9 months to 14 years plus follow-up campaigns every 3–4 years in children aged 9 months to 47–59 months. The second approach was measles campaigns in children 9–59 months old (hereafter termed <5 year olds). The third

Reprints or correspondence: Dr. Mac W. Otten, Jr., World Health Organization, Highlands, Harare, Zimbabwe (mwo2@cdc.gov).

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approach was to increase routine measles vaccination coverage from 50% to about 80%.

METHODS

Strategies. For approach 1, we describe two groups of countries that conducted mass campaigns in <15 year olds with follow-up campaigns every 3–4 years: seven countries in southern Africa (Namibia, Botswana, South Africa, Zimbabwe, Malawi, Swaziland, and Lesotho) in 1996–2000 [3] and eight west, central, and eastern African countries in 2001 and 2002 (Mali, Burkina Faso, Ghana, Togo, Benin, Cameroon, Tanzania, and Kenya). The seven southern Africa countries aimed to eliminate measles [3], while the other eight countries sought near-zero measles deaths.

For approach 2, we show information from seven countries that conducted campaigns in <5 year olds with routine coverage of 40%–80% (Zambia, Cameroon, Burkina Faso, Mali, Uganda, Mozambique, and Tanzania). For approach 3, we describe three countries where routine immunization increased from about 50% to 80% over several years (Ghana, Cote D'Ivoire, and Mozambique). These countries did not conduct supplemental measles campaigns during the time routine coverage was increasing.

Trends in measles cases and deaths. In general, we used the trends in measles cases and deaths in the 3–5 years before the mass campaign and for 1–2 years after the campaign to evaluate the impact. We used several methods to examine trends in cases and deaths and obtained data by district by month and year from routine surveillance systems in all countries. In addition, we collected data from retrospective record reviews of inpatient and outpatient registers in provincial hospitals, usually over a 5-year period and used line-listing (age and vaccination status) of routinely reported measles cases (Zambia). We also used case-based measles surveillance with laboratory testing from campaigns targeting children <15 years old. The quality of the case-based measles surveillance in the seven southern Africa <15-year-old campaign countries was good [3]. For Uganda and Tanzania, we used line-listed data from sentinel sites on measles cases and deaths (age and vaccination status). Except where references are shown, data are from unpublished surveillance data reports and hospital record reviews written by Ministries of Health (MOH) and WHO country immunization officers or consultants.

Measles deaths averted. To estimate the number of deaths averted, we first estimated the number of measles deaths before the campaign. We based our estimate on 1998 WHO (Geneva) calculations for all countries worldwide to assess the progress that countries had made in reaching the World Summit for Children and World Health Assembly goals of a 95% reduction in measles deaths and a 90% reduction in measles cases compared with preimmunization estimates.

The WHO African Regional Office updated 1995 WHO (Geneva) spreadsheet data with 1998 population and 1999 measles vaccine coverage data [4]. In brief, to calculate measles-related deaths, we multiplied the estimated number of surviving infants in 1998 not protected by measles vaccine (by using routine measles vaccination coverage and a measles vaccine efficacy rate of 85%) by the estimated national average case-fatality rate. This method assumes that all children vaccinated are not infected with measles virus prior to vaccination and that all children not immune from vaccination are infected with measles virus. The case-fatality rate used for most countries in west and central Africa was 4%–6%. Countries with high routine measles coverage (e.g., Malawi) or high economic status (South Africa) were assigned lower case-fatality rates (≤1%–2%).

To calculate the number of deaths averted, we used the percentage decline in cases and deaths for each country from table 1 (<5-year-old campaign countries), 100% for southern African countries [3], and values from [11] and unpublished MOH surveillance data for campaigns for children <15 years old in Burkina Faso, Mali, Benin, Ghana, Togo, and Cameroon in December 2001. The duration of effectiveness used was 3 years for campaigns that targeted children <15 years old (in countries with <80% routine coverage), 1.5 years for campaigns that targeted children <5 years in Mali and Uganda, and 2 years for campaigns aimed at children <5 years old in Burkina Faso and Tanzania (see Results section).

Cost per death averted. To estimate the cost per death averted, we used the total external (donor) funds provided to each country for the campaigns (vaccine, needles, syringes, operational costs). We did not include salary, national MOH financial support, in-country contributions, or in-kind contributions.

RESULTS

Approach 1: mass campaigns for those <15 years old with follow-up campaigns every 3–4 years. In the seven southern African elimination countries, routine vaccination coverage in all countries was about 80% [4]. Adequate measles case-based surveillance with laboratory testing (laboratory specimens collected for all reported suspected cases) was in place in most countries during 1999–2002. In 1999, there were four reported measles deaths after the campaigns; in both 2000 and 2001 there were no reported measles deaths [3]. All seven countries completed their first follow-up campaigns in 2001–2002. The interval between the campaigns was 3 years (two countries) or 4 years (five countries).

Eight countries implemented campaigns targeting children <15 years old in 2001 and 2002. In 2001, there were three

Table 1. Impact of different types of measles mass campaigns in children <5 years or <15 years old in 14 countries in the WHO African Region, 1998–2001.

Campaign type, country, date	% covered with measles vaccine		% reduction observed		Comments and data source
	Before campaign[a]	During campaign (administrative method)	Cases[b]	Deaths[b]	
<5-year-old children					
Burkina Faso, urban only, 1998	48	79 (survey)	0		Urban [5, 6]; Burkina Faso MOH-WHO report
Cameroon, 14 cities, 1999–2000	46	87–120	0	0	Urban; unpublished Cameroon MOH-WHO report
Mali, 19 towns, 1998	54		53		Urban, widespread [7]; unpublished Mali MOH-WHO report
Mali, 146 towns, 1999	54		16		Urban, widespread [7]; unpublished Mali MOH-WHO report
Mozambique, 11 cities, 1998–1999	90		0		Urban [8]
Tanzania, 2/3 of country, 1999–2000	78		66	33	Unpublished Tanzania MOH-WHO consultant report
Uganda, 2/3 of districts, 1999–2000	56	21–174	45	67	Entire districts [9]
Zambia, 1999–2000	74				
4 largest urban areas		81	0	0	Urban [10]
2/3 of all districts			50		Unpublished Zambia MOH-WHO consultant report, [3], and MOH surveillance data reported to WHO
<15-year-old children					
Botswana, 1997–1998	79		99	100	Nationwide
Lesotho, 1999–2000	54		99	100	Nationwide
Malawi, 1998	87		100	100	Nationwide
Namibia, 1997	57[c]		99	100	Nationwide
South Africa, 1997–1998	76		99	100	Nationwide
Swaziland, 1998	57		99	100	Nationwide
Zimbabwe, 1998	73		99	100	Nationwide

NOTE. MOH, ministry of health.

[a] Data from WHO/UNICEF annual expanded program on immunization or national survey data.

[b] For year immediately after campaign.

[c] Data for recent unofficial demographic and health survey show routine measles immunization coverage closer to 80%.

nationwide (Mali, Burkina Faso, Togo) and four subnational (Ghana, Tanzania, Benin, Cameroon) campaigns. Kenya completed a nationwide campaign in 2002. Ghana, Tanzania, Benin, and Cameroon were scheduled to complete remaining provinces in December 2002. In six countries with available surveillance data (including case-based measles surveillance with laboratory testing in 2002), the decline in reported cases and deaths was 78%–99% in the 12 months after the campaign compared with both 2001 and the 6-year average for 1996–2001 [11].

Approach 2: measles campaigns for children <5 years old in countries with routine 40%–80% coverage. The second approach to accelerated measles control was tried from 1998 to 2001. Measles supplemental immunizations in children <5 years old were conducted and adequately evaluated in seven countries: Mali [7], Burkina Faso [5, 6], Tanzania (unpublished WHO consultant report, 2000), Zambia ([10] and unpublished Zambia MOH-WHO report), Mozambique [8], Uganda [9], and Cameroon (unpublished WHO Cameroon Office Report, 2001). In Mali, children <5 years old in provincial and district capital towns were immunized during supplemental activities in 1998 and in provincial, district, and subdistrict capitals in 1999. In Burkina Faso, 9 cities had supplemental activities in 1998, followed by a nationwide campaign in 1999. In Tanzania, one-third of districts had a campaign in 1999 and a second third of districts had campaigns in 2000. In Uganda, one-third of districts were covered each year from 1999 to 2001. In Zambia, 4 urban cities had campaigns that targeted <5 year olds in 1999 and one-third of districts had similar campaigns in 2000. In Mozambique, 11 provincial capitals had campaigns, and in Cameroon, campaigns of <5 year olds were conducted in 14 cities in the north.

The impact of campaigns in <5 year olds was measured in most countries by calculating the percentage decline in hospital deaths and cases compared with data for 3–5 years before the campaign and for 1–2 years after the campaign. The urban

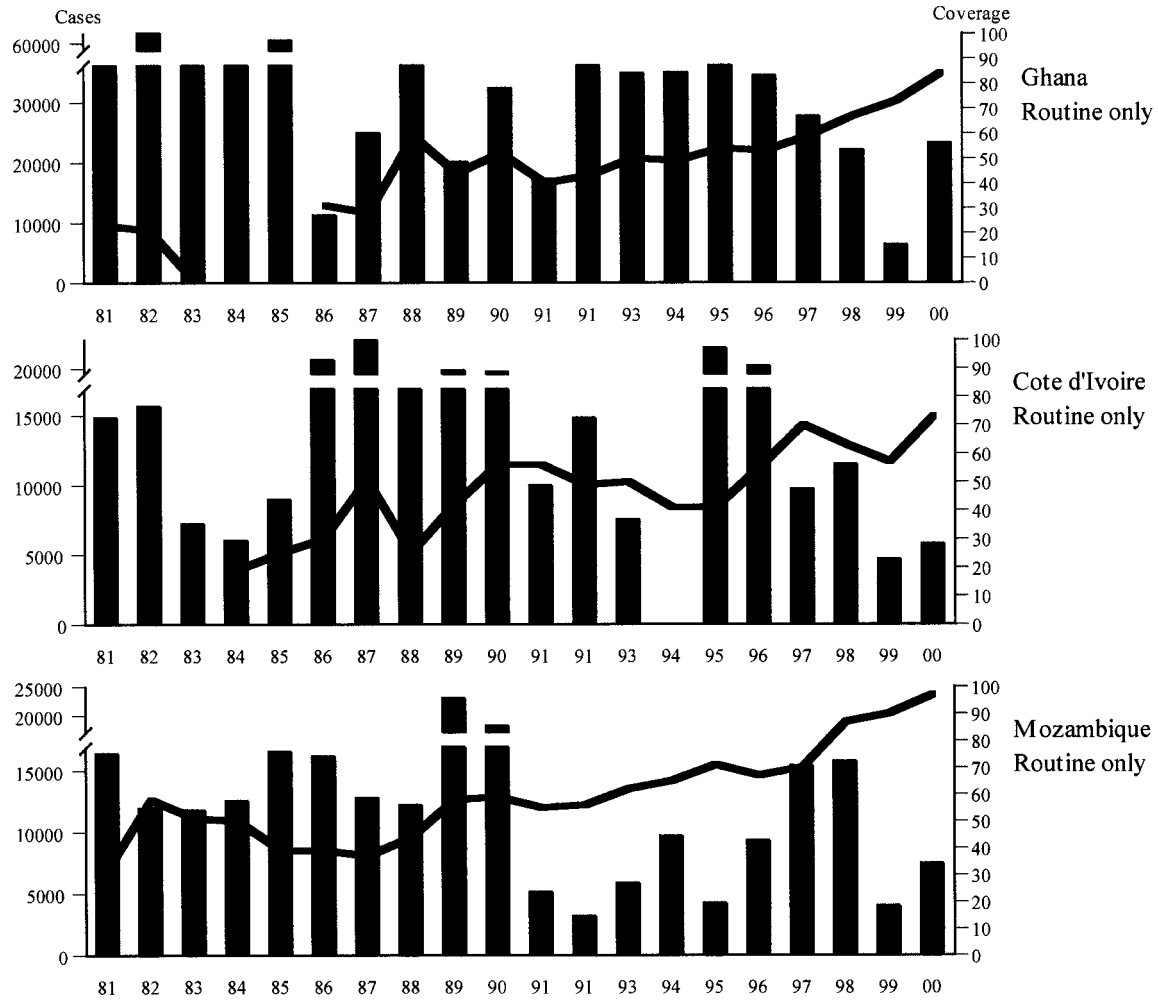

Figure 1. Reported measles cases/deaths and measles routine immunization coverage by year in selected African countries (Ghana, Cote d'Ivoire, and Mozambique) with significant increases in routine measles immunization coverage during the 1990s.

campaigns in Zambia, Mozambique, and Cameroon had no measurable effect. In countries that vaccinated one-third to one-half of children <5 years old (Tanzania, Mali, Burkina Faso, Zambia), declines ranged from 16% after the second, larger campaign in children <5 yeas in 1999 in Mali to 33% in Tanzania to 67% in Uganda. The percentage decline in cases was not related to routine vaccination coverage before the campaign.

Three countries had information on duration of effect of campaigns in children <5 years old. In Burkina Faso the effect was maintained in the second year (in fact, there was slightly more effectiveness in the second year than in the first year; [5], unpublished Burkina Faso MOH-WHO data). In Mali, cases were reduced by an estimated 16% in the second year compared with 53% in the first year ([12], unpublished Mali MOH-WHO report). In Uganda, the effect lasted 15–22 months until cases increased to pre-campaign levels [9].

Approach 3: increasing routine immunization coverage from ~50% to 80% over several years. Figure 1 shows trends in measles cases and routine measles immunization coverage from 1981 to 2000 for Ghana, Cote D'Ivoire, and Mozambique. On average, there was about a 50% decline (range, 41%–53%) in reported measles cases when routine immunization increased from 50% in the early or mid-1990s to 73%–90% in 1999.

In Ghana, a mean of 33,513 measles cases occurred during 1991–1996, when routine coverage was 40%–53%, and 19,687 (a decline of 41%) during 1997–2000, when routine coverage increased from 59% in 1997 to 84% in 2000. In Cote d'Ivoire, a mean of 16,606 measles cases occurred during 1991–1996, when routine coverage was 41%–56%, but just 7859 (a decline of 53%) during 1997–2000, when routine coverage was 57%–73%. In Mozambique, a mean of 15,093 measles cases was reported for 1981–1990, when routine measles vaccine coverage was 32%–59%, and 7931 cases during 1991–2000 (a decline of 47%), when routine coverage increased from 55% in 1991 to 87%–97% in 1998–2000. In Ghana, Mozambique, and

Cote d'Ivoire, it took 4–9 years for routine immunization coverage to increase from about 50% to ⩾80%. Although reported cases declined over time in all three countries, in 2000 cases rebounded to >5000 in Mozambique and Cote d'Ivoire and >23,000 in Ghana.

Age distribution of cases, deaths, case-fatality rates in Africa. Table 2 and table 3, respectively, show the age distribution of deaths and cases. In most countries (even those with routine measles vaccine coverage of 50%: Mali, Burkina Faso, Togo, Cameroon), there was an epidemiologic transition to significant percentages of measles cases in older age groups. In several countries, ⩾10%–15% of cases occurred in persons ⩾15 years old (table 3). Data in table 3 show that for four of six locations (Mali, Burkina Faso, Cameroon, rural Zambia) about 30%–50% (except for 12% in urban Lusaka, Zambia, and 7% in Uganda) of measles deaths occurred in children ⩾5 years old, even before supplemental mass campaigns in countries with 50% routine coverage (Mali, Burkina Faso, Cameroon). In Zambia, Burkina Faso, and Uganda (table 4), the case-fatality rates in older children (⩾5 years) were lower than in children <5 years, but remained one-half to one-third of the case-fatality rates of children <5 years old. In Burkina Faso, the case-fatality rate for persons >15 years old was just half that of children <5 years old (3% and 6%, respectively) for several years (1994–1997) before the campaigns.

Deaths averted. We estimated that 17,190 deaths were averted by measles supplemental activities during campaigns of children <5 years old in Mali, Burkina Faso, Uganda, and Tanzania and that 18,421 lives will be saved by the campaign targeting children <15 years old in one-third of Tanzania (September 2002 campaign). We also estimated a savings of 14,289 lives in the seven southern African countries during 1999–2001 and the averting of 100,535 measles-related deaths in 2002–2005 in Mali, Burkina Faso, Togo, Ghana, and Cameroon by campaigns targeting children <15 years old in December 2001.

Cost per death averted. The external (donor) cost per targeted child ranged from $0.55 to $0.86 for campaigns targeting children <5 years and <15 years old. The cost per death averted in the six west and central African countries that conducted campaigns targeting children <15 years old in December 2001 was $122 (unpublished MOH and WHO data) compared with $328 in Malawi. The cost per death averted in Malawi was higher because the initial high routine immunization (90%) resulted in fewer pre-campaign deaths.

DISCUSSION

Our primary conclusion was that only campaigns that targeted children <15 years old with follow-up led to mortality reductions consistent with the regional target of near-zero measles deaths. To maintain measles deaths near zero, the campaign strategy for persons <15 years old must be combined with routine measles vaccination coverage ⩾80% and there must be follow-up campaigns in children aged <4 to 5 years every 3–4 years. Measles deaths did not reach (nor were maintained at) near zero after campaigns targeting those <5 years old or after routine coverage of 80% alone.

Our findings have several limitations. Because our observations were uncontrolled, we could not account for or control for different factors among the different approaches. The post-campaign observations from countries that conducted measles vaccination campaigns for children <5 years old were available for <3 years in most countries. The duration of post-campaign observations was limited because most countries with campaigns that targeted children <5 years conducted a second campaign in children <15 years old. In estimating the numbers of measles deaths in 1998 prior to the campaigns, our estimate of the average case-fatality rates may be too high in some coun-

Table 2. Age distribution of measles deaths in WHO African Region countries, 1994–2001.

Country	Data type	% measles coverage[a]	% ⩾5 years old	Comments
Burkina Faso				
Before nationwide campaign, 1994–1997	Hospital records	49	36	Lower population density
After nationwide campaign, 2000	Hospital records	49	37	Lower population density
Cameroon, before campaign, 2001	Hospital records	49	45	Moderate-to-high population density
Mali				
Before campaigns in <5 year olds, 1994–1997	Routine surveillance	54	30–50	Lower population density
After campaigns in <5 year olds, 1998–2001	Routine surveillance	54	40–50	Low population density
Uganda, 6 sentinel hospitals, 2001	Hospital records	53	7	Low coverage, high population density
Zambia, 2000	Hospital records	74		
Choma, rural			35	Lower population density
Lusaka, urban			12	High population density

[a] Routine coverage data reported to WHO in 1999 or 2000.

Table 3. Age distribution of measles cases (percentages) before supplemental measles immunizations, WHO African Region, 1994–2001.

Country, city, year	Other information	Routine measles coverage, 2000 or survey	<5 years	5–14 years	>15 years
Very low routine coverage, high population density					
Nigeria, Kano, 2001	3 health facilities	30	81	19	
Moderate-to-high routine coverage, high population density					
Ethiopia, Addis Ababa, 2000	Routine surveillance	93	20	80	0
Zambia, Lusaka (urban)					
2000	Outpatients	74	52	34	14
1996–2000	Inpatients	74	80	17	3
Moderate-to-low population density					
Angola, 1999–2001	Outpatients		57		
Burkina Faso, 1995–1997	Inpatients, 11 provincial hospitals	49	43	34	23
	Outpatients, 11 provincial hospitals	49	46	34	20
Cameroon, 2000	25 hospitals	49	55	38	
Ethiopia, 2000	Routine surveillance	34	54	38	
Liberia, 2001	Routine surveillance	~50	59		7
Mali, 1994–1997	Routine surveillance	54	55–45	45–55	
Mauritania, 2001	Routine surveillance	56	34	33	
Senegal, 2001	Routine surveillance	48	63	29	8
Uganda, 1997–2001	Routine surveillance	53	64		
Uganda, 1997–2001	Inpatients, 6 sentinel hospitals	53	83	10	7
Benin	Routine surveillance	92	50		
Tanzania, 1997	Outpatients	69	48		
Tanzania, 1998	Outpatients	72	54		
Zambia, Choma (rural), 2000	Outpatients	74	22		32

tries. We did not account for population growth or for children being infected with measles prior to vaccination (many children are vaccinated substantially after age 9 months). Because measles is cyclical, the impact of the campaigns in children <5 years old may be under- or overestimated depending on the timing of the campaigns and the cycle of measles outbreaks. The age distribution of cases was primarily from health facility data and not population based. However, age distributions by population density and measles vaccine coverage were remarkably consistent across countries (table 3). In addition, health facility cases are likely to be more severe, which is of more interest for a mortality reduction strategy.

The ages of cases (table 2) and deaths (table 3) suggest why campaigns in children <5 years old had a low impact (table 1). The epidemiologic factors responsible for decreased effectiveness of these campaigns are that there are more cases in children ⩾5 years old than previously thought, case-fatality rates in older children are higher than previously thought, measles virus infection in children ⩾5 years is a reservoir and source of infections in younger children, and therefore many nonimmune children (those born since last campaign, missed by routine immunization and supplemental campaigns, and nonimmune despite vaccinations) and children infected prior to routine vaccination after the campaign are not being protected.

Although we could not account for all factors, the effect of the age group (<15 vs. <5 years) was consistent across several factors. Campaign coverage was >80% in all campaigns. The campaigns that targeted persons <15 years old had the same effectiveness whether they were subnational, national, or split over 2 years. Campaigns targeting children <5 years old had the same effectiveness whether they were subnational, national, or split over 2–3 years. Both approaches were used by countries with relatively low and relatively high routine coverage.

Data show that limited and urban campaigns had a very low impact (table 1). For most countries, the <15-year-old age group is the appropriate group for an initial mass campaign, even in low-coverage countries (40%–60%) with low population density and for any country with age shift of measles cases to older age groups. A campaign targeting children aged <10 years might only be considered in countries with very low

Table 4. Case-fatality ratios (percentages) among hospitalized measles cases by age, WHO African Region, 1995–2001.

Country, type	<9 months	9–59 months	>5 years
Burkina Faso, nationwide, routine system, 1995–2001[a]	6	6	3
Tanzania, 16 sentinel sites, 2000	4	6	2
Uganda, 6 sentinel sites, 2001	—	11	4
Zambia			
Choma (rural), special study, 2000	2	4	2
Lusaka (urban), special study, 2000	6	7	3

[a] Case-fatality rate 3% in persons >15 years old.

routine coverage (30%–50%), a moderately high population density (>100 persons/km^2), and where >90% of reported measles cases are <10 years old.

The results for campaigns for children <15 years and <5 year old were consistent with other data. The campaign for children <15 and follow-up strategy in southern Africa provided the same dramatic decline in mortality and morbidity as in the Americas [13, 14]. Limited age group mass campaigns conducted in Africa in the 1960s that were associated with smallpox campaigns and at other times also showed limited duration of effectiveness [15–18].

Most countries that have conducted measles campaigns in persons <15 years old achieved routine coverage of about 80% (7 southern African countries plus Benin, Ghana, Tanzania, and Kenya). However, four countries (Mali, Burkina Faso, Togo, Cameroon) initiated supplemental immunizations when routine measles vaccination coverage was about 50%. It is expected that these four countries will reach 80% coverage by 2005, the target set by the Global Alliance for Vaccines and Immunizations (GAVI). There is evidence from routine immunization reporting to WHO from Mali and Burkina Faso that routine coverage increased in the last 12–18 months. Fortunately, momentum is building from three directions to increase routine coverage to 80% in most African countries by 2005—the polio eradication initiative (to prevent circulating vaccine-derived poliovirus from emerging [19]), the measles initiative (to maintain measles deaths near zero), and GAVI (increased routine immunization infrastructure and introduction of more expensive new vaccines: hepatitis B and *Haemophilus influenza* type B). A remaining question is the role of supplemental immunization in countries with very weak immunization infrastructure (routine measles coverage <50%) that is not significantly increasing. Funds may be more profitably put into routine immunization in those countries.

The $122 cost per death averted makes measles vaccination campaigns in persons <15 years old and follow-up second-opportunity supplemental campaigns cost-effective public health interventions. No other public health interventions available to African countries can reduce a top-five cause of child mortality to a sustainable level of near-zero deaths at such a low cost. The child mortality rate in Africa remains nearly twice that of other regions [20] and urgent action is needed to accelerate the decline of child mortality. Although 170,000 measles deaths were averted in the last 5 years by the activities described, nearly 2.5 million African children died of measles since these activities started in 1996. Funding shortages were critical factors for conducting partially effective campaigns in children <5 years old instead of targeting children <15 years old. It is puzzling why countries and partner agencies have not been more aggressive in applying this intervention to dramatically reduce child deaths in Africa. At $0.14 per dose of measles vaccine, we may never again see a more cost-effective public health intervention.

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References

1. World Health Organization, United Nations Children's Fund. Measles: Mortality Reduction and Regional Elimination Strategic Plan, 2001–2005. Geneva: WHO, **2001** (WHO/V&B/01.13).
2. Progress toward poliomyelitis eradication—Africa, 1996. MMWR Morb Mortal Wkly Rep **1997**; 46:321–5.
3. Biellik R, Madema S, Taole A, et al. First five years of measles elimination in southern Africa: 1996–2000. Lancet **2002**; 359:1564–8.
4. World Health Organization. WHO vaccine-preventable diseases: monitoring system. 2001 global summary. Department of Vaccines and Biologicals. Geneva: WHO, **2001** (WHO/V&B/01.34).
5. Kambiré C, Konde MK, Yaméogo A, et al. Measles incidence before and after mass vaccination campaigns in Burkina Faso. J Infect Dis **2003**; 187(Suppl 1):S80–5 (in this issue).
6. Zuber PL, Conombo KS, Traore AD, et al. Mass measles vaccination

in urban Burkina Faso, 1998. Bull World Health Organ **2001**; 79: 296–300.
7. Kertesz DA, Touré K, Berthé A, Konaté Y, Bougoudogo F. Evaluation of urban measles mass campaigns for children aged 9–59 months in Mali. J Infect Dis **2003**; 187(Suppl 1):S69–73 (in this issue).
8. Cliff J, Simango A, Augusto O, Van der Paal L, Biellik R. Failure of targeted urban supplemental measles vaccination campaigns (1997–1999) to prevent measles epidemics in Mozambique (1998–2001). J Infect Dis **2003**; 187(Suppl 1):S51–7 (in this issue).
9. Nanyunja M, Lewis RF, Makumbi I, et al. Impact of mass measles campaigns among children less than 5 years old in Uganda. J Infect Dis **2003**; 187(Suppl 1):S63–8 (in this issue).
10. Measles incidence before and after supplementary vaccination activities—Lusaka, Zambia, 1996–2000. MMWR Morb Mortal Wkly Rep **2001**; 50:513–6.
11. Progress in Measles Control in West and Central Africa. MMWR Morb Mortal Wkly Rep **2003** (in press).
12. Kertesz D. Measles control in Mali: evaluation of mass campaign. Presented at the East African Immunization Meeting (Nairobe, Kenya), 2000.
13. de Quadros CA, Olive JM, Hersh BS, et al. Measles elimination in the Americas—evolving strategies. JAMA **1996**; 275: 224–9.
14. Hersh BS, Tambini G, Nogueira AC, Carrasco P, de Quadros C. Review of regional measles surveillance data in the Americas, 1996–99. Lancet **2000**; 355:1943–8.
15. Abdool Karim SS, Abdool Karim Q, Dilraj A, Chamane M. Unsustainability of a measles immunization campaign—rise in measles incidence within 2 years of the campaign. S Afr Med J **1993**; 83:322–3.
16. Foster SO, Pifer JM. Mass measles control in West and Central Africa. Afr J Med Sci **1971**; 2:151–8.
17. Breman JG, Coffi E. Evaluation of a measles-smallpox vaccination campaign by a sero-epidemiologic method. Am J Epidemiol **1975**; 102: 564–71.
18. McBean AM, Foster SO. Evaluation of a mass measles immunization campaign in Yaounde, Cameroon. Trans R Soc Trop Med Hyg **1976**; 70:206–12.
19. Kew O, Morris-Glasgow V, Landaverde M, et al. Outbreak of poliomyelitis in Hispaniola associated with circulating type 1 vaccine-derived poliovirus. Science **2002**; 296:356–9.
20. Ahmad OB, Lopez AD, Inoue M. The decline in child mortality: a reappraisal. Bull World Health Organ **2000**; 78:1175–11.