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Impact of the 1996–1997 supplementary measles vaccination campaigns in South Africa

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Background In South Africa, as part of an effort to eliminate indigenous measles by 2002, vaccination campaigns were conducted in 1996–1997 targeting all children aged 9 months to 14 years; coverage was estimated at 85%. The impact of the campaigns on measles disease burden was evaluated in 1999.

Methods We analysed routine measles surveillance data and undertook a retrospective review of hospital registers in two of South Africa's nine provinces.

Results In Mpumalanga in the pre-campaign years (1992–1996), 4498 measles cases and 6 deaths were reported; 182 cases and no deaths were reported in 1997–1998. Hospital registers showed 1647 measles hospitalizations and 11 deaths in the pre-campaign period, and 60 hospitalizations and no deaths after the campaign (1997–April 1999). In Western Cape in pre-campaign years (1992–1997), 5164 measles cases and 19 deaths were reported; 132 cases and no deaths were reported in 1998. Hospital registers showed 736 measles hospitalizations and 23 deaths in the pre-campaign period, and 29 measles hospitalizations and no deaths post-campaign (1998–July 1999).

Conclusions Study findings indicate that reported measles cases, measles-related hospitalizations and deaths were considerably reduced in both provinces after the campaign compared with the pre-campaign period. Longer observation is needed to evaluate the long-term impact of the campaigns.

Keywords Measles, vaccination, South Africa

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In South Africa, routine administration of measles vaccine to infants was first introduced in 1975; since then, various vaccination schedules and vaccine types have been used.[1,2] The current schedule was introduced in 1995 and includes two doses of measles vaccine (Schwartz strain) administered to children aged 9 months (first dose) and 18 months (second dose). In 1994, the first national vaccination coverage survey estimated that 85% of children aged 12–23 months had received at least one dose of measles vaccine; the coverage in the nine provinces of South Africa ranged from 72% to 95%.[3]

Measles has been a notifiable disease in South Africa since 1979. During the 1980s, 15 000 to 20 000 measles cases and 250 to 500 deaths were reported each year (Figure 1). During the 1990s, measles remained endemic and epidemics continued to occur periodically, but the case fatality ratio sharply declined at the beginning of the decade and remained at low levels. In contrast to the 1980s when 60% to 70% of reported measles cases were among children aged <5 years, most cases reported during the 1990s occurred among school-aged children and young adults.

Since 1995, seven southern African nations, including South Africa, have launched measles elimination initiatives in accordance with the recommendations of the World Health Organization (WHO) Regional Office for Africa.[4] Recommended strategies include programmes to: (1) achieve and sustain routine immunization coverage of ⩾95% with one dose of measles vaccine administered at 9 months of age; (2) implement

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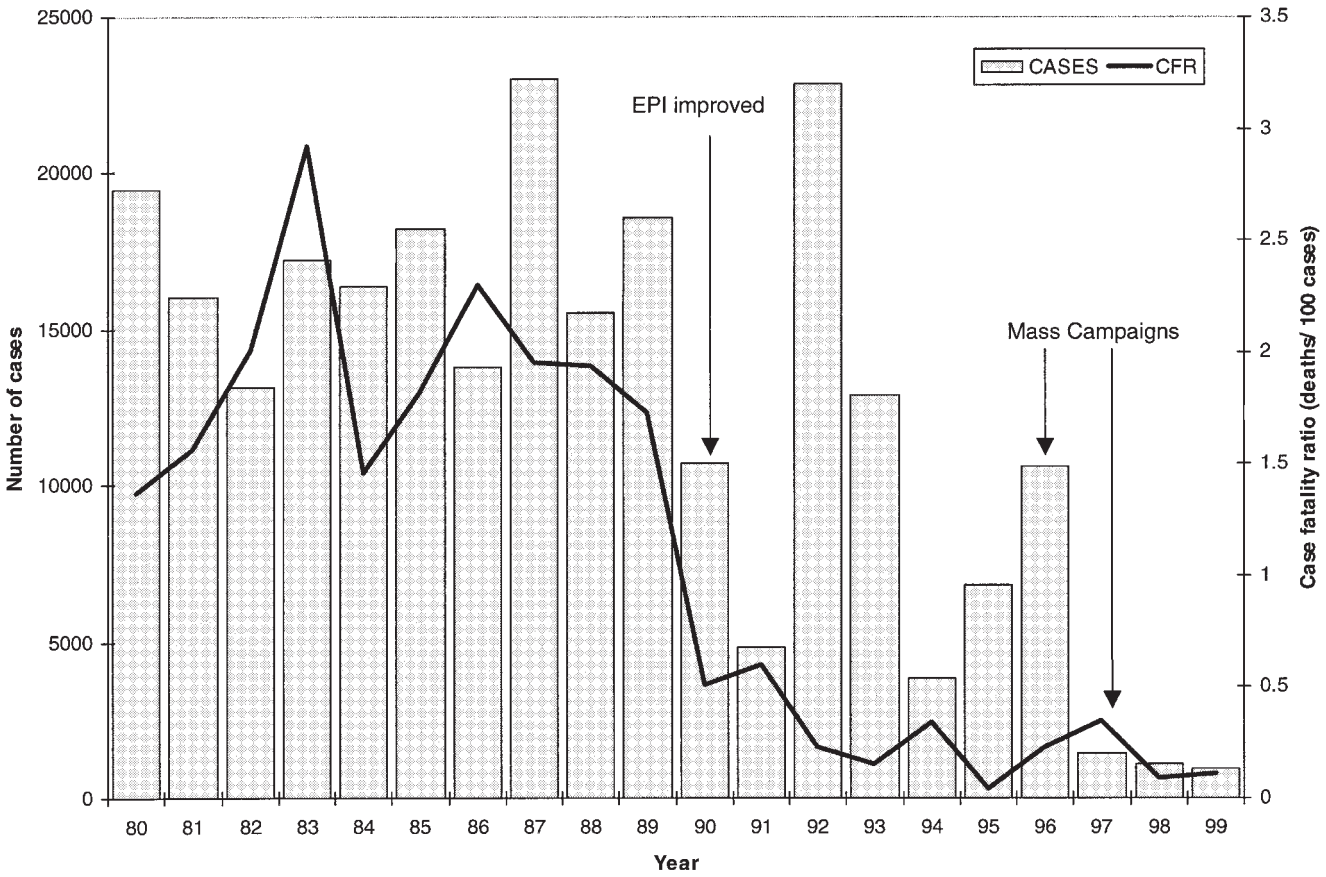

Figure 1 Measles cases and case fatality ratio (CFR) by year of report, South Africa, 1980–1999

a one-time national 'catch-up' measles vaccination campaign (a nationwide campaign targeting all children, usually those aged 9 months–14 years, regardless of history of measles disease or vaccination); (3) implement periodic national 'follow-up' vaccination campaigns (subsequent nationwide vaccination campaigns conducted every 2–5 years targeting all children born after the 'catch-up' campaign, usually those aged 9 months–4 years); and (4) establish case-based measles surveillance with laboratory confirmation.[4]

In 1996–1997, measles vaccination campaigns were implemented in all nine provinces of South Africa targeting all children aged 9 months–14 years (Table 1). Overall campaign coverage was estimated at 85%.[4]

To evaluate the impact of the 1996–1997 campaigns in Mpumalanga and Western Cape, two provinces with very different socioeconomic structure and pre-campaign levels of measles control, we analysed routine measles surveillance data and undertook a province-wide retrospective review of the hospital registers.

Materials and Methods

Study provinces

Mpumalanga is a predominantly rural province in the northeast of South Africa. The population is 2.8 million; Blacks/Africans represent the largest ethnic group (89%).[5] In 1994, the province incorporated a number of densely populated areas formerly designated as '*homelands*' for Blacks/Africans during the former *apartheid* regime. These areas were historically neglected in terms of economic and infrastructure development, and most of their residents still live in poverty. In the 1994 national survey, routine measles vaccination coverage among children aged 12–23 months in Mpumalanga was 79%.[3]

Western Cape Province is urbanized with good infrastructure. The province's population of 3.9 million consists of diverse ethnic groups, with South African Mixed race (in South African official statistics referred to as Coloureds) being the largest (54%), followed by Blacks/Africans and Whites (each 21%).[5] Most of the population resides in the provincial capital of Cape Town and in surrounding densely populated townships. Routine measles vaccination coverage is the highest in the country and was estimated by the 1994 national survey at 95%.[3]

Together, these two provinces comprise approximately 17% of South Africa's population of 41 million.

Measles surveillance

From 1979 to 1998, measles surveillance in South Africa involved reporting of physician-diagnosed measles cases and deaths on a standard notification form to the National Department of Health in Pretoria through the respective Provincial Departments of Health. Reported data include the International Classification of Diseases, Ninth Revision (ICD-9) code of the

Table 1 Supplemental measles vaccination campaigns 1996–1997 by province, target age group and reported vaccination coverage

	1996 Campaign		1997 Campaign	
Province	Target age group	Coverage (%)	Target age group	Coverage (%)
Eastern Cape	6 months–9 years	99	9 months–14 years	84
Free State	9 months–15 years	89	–	–
Gauteng	9 months–5 years	76	6–14 years	85
KwaZulu-Natal	9 months–4 years	82	5–15 years	87
Mpumalanga	9 months–14 years	94	–	–
Northern Cape	9 months–14 years	94	9 months–14 years (selected areas only)	83
Northern Province	9 months–4 years (selected areas only)	89	9 months–15 years	70
North-West	9 months–14 years	87	–	–
Western Cape	9 months–4 years	99	5–14 years	85

Source: Expanded Programme on Immunization, Department of Health, Pretoria, August 2000.

disease (055 for measles), age, sex, race, date of disease onset, magisterial district, province, and outcome (alive/died). The new measles surveillance system with requirements for epidemiological investigation and laboratory confirmation of suspected measles cases was implemented in late 1998, but it was not fully functional throughout the nation at the time of this study.

Hospital record review

The Provincial Departments of Health in Mpumalanga and Western Cape identified the acute care hospitals in which patients with measles could have been cared for during 1992–1998. A questionnaire was sent by fax to these hospitals to request their participation in the study and to obtain baseline information about the availability of hospital records for the study period, annual number of measles hospitalizations, and hospital policy on admitting suspected measles cases. Hospitals that had a policy not to admit suspected measles cases and those without hospital registers available for review were excluded from the study. Measles-related hospitalization was defined as a patient diagnosed with measles on admission and/or on discharge from 1 January 1992 through the date of the hospital record review (March–April 1999 in Mpumalanga, and July 1999 in Western Cape). Hospital nurses were trained to review the admission registers and compile a line-list of case-patients on a standard form. The following patient information was abstracted: age, gender, ethnicity, admission and discharge dates and diagnoses, and the outcome of hospitalization (died in the hospital or discharged alive). Admission and discharge diagnoses were abstracted exactly as they appeared in the hospital registers.

To estimate the rate of measles-related complications we counted the number of measles patients for whom one or more of the following diagnoses were recorded on hospital admission and/or on discharge: pneumonia, gastrointestinal complications (diarrhoea, vomiting), otitis media, and neurological complications (convulsions, meningitis and encephalitis). In Mpumalanga, the rate of recorded complications was calculated on a subset of patient records (N = 1090), because some records were listed only in the 'measles book' which contained no other diagnoses. Hospitalized measles patients for whom the hospitalization outcome in the hospital register was recorded as 'died' were considered measles-related deaths.

We could not assess the accuracy of the clinical diagnosis of measles in either the surveillance reports or in the hospital study because diagnoses were not routinely confirmed by serology before October 1998. Also, in the hospital study it was not possible to assess the appropriateness of other recorded diagnoses and the accuracy of the recorded hospitalization outcome.

Data analysis

Routine measles surveillance data for 1980–1998 gathered through the disease notification system were available as an EpiInfo summary file, and were used to analyse demographic characteristics and plot the time series of measles cases reported during the study period in both provinces.

Data from the hospital study were entered in an EpiInfo database. Analyses were conducted using EpiInfo software[6] and statistical significance was evaluated using the χ^2 test or the Kruskal-Wallis test for two groups. Evaluation of the difference between medians was done by the median test using SAS software.[7]

Results

Mpumalanga Province

Routine surveillance

In Mpumalanga in 1980–1998, 10 371 measles cases and 101 deaths were reported through the routine surveillance system. During 1980–1996, 10 189 measles cases and 101 deaths were reported; the lowest pre-campaign annual number of measles cases (135) was reported in 1990 and 1991, and the highest in 1992 (2583 cases). During the 5-year pre-campaign period (1992–1996), 4498 measles cases were reported, an annual average of 900 cases (Table 2). After the 1996 campaign, no measles deaths and record low numbers of measles cases were reported in 1997 and 1998 (92 and 90 cases, respectively). Both before and after the 1996 campaign, most reported cases occurred among Blacks/Africans; after the campaign, the proportion of reported measles cases in this group increased significantly.

Hospital record review

Sixteen of 27 public hospitals in Mpumalanga participated in the hospital study, representing 3512 (82%) acute-care hospital

Table 2 Characteristics of reported measles cases in Mpumalanga Province, South Africa, 1992–1998

	Before the campaign	After the campaign	*P*-value
Years	1992–1996	1997–1998	
Notified measles cases	4498	182	
Average annual number of notifications	900	91	
Age distribution[a]			
<1 year	190 (4%)	6 (3%)	0.51
1–4 years	1067 (24%)	50 (28%)	0.28
5–9 years	1938 (45%)	87 (49%)	0.43
10–14 years	867 (20%)	26 (15%)	0.08
⩾15 years	289 (7%)	9 (5%)	0.42
Black African race	3701 (83%)	172 (95%)	**<0.0001**
Female gender	2225 (50%)	93 (51%)	0.65
Died	6	0	

[a] Data on age was available for 4529 reported measles cases.

beds. One of six private hospitals participated. From January 1992 through April 1999, 1707 measles-related hospitalizations occurred in the participating hospitals (Figure 2). The average annual number of measles-related hospitalizations declined by 91%, from 329 during the 5 pre-campaign years to 29 in the first 2 post-campaign years (Table 3). Both before and after the campaign, most hospitalizations occurred in four hospitals located in former '*homeland*' areas. Compared to the 5 pre-campaign years, declines were observed during 1997–1998 in the mean age of hospitalized patients, the proportion of patients with one or more measles-associated complications, the proportion of patients diagnosed with pneumonia, and the mean duration of the hospitalization. None of the patients hospitalized with measles was recorded as human immunodeficiency virus (HIV) positive. All 11 measles-associated deaths occurred among patients hospitalized during the pre-campaign period (1992–1996), for a pre-campaign case fatality ratio of 0.7 deaths per 100 measles-related hospitalizations.

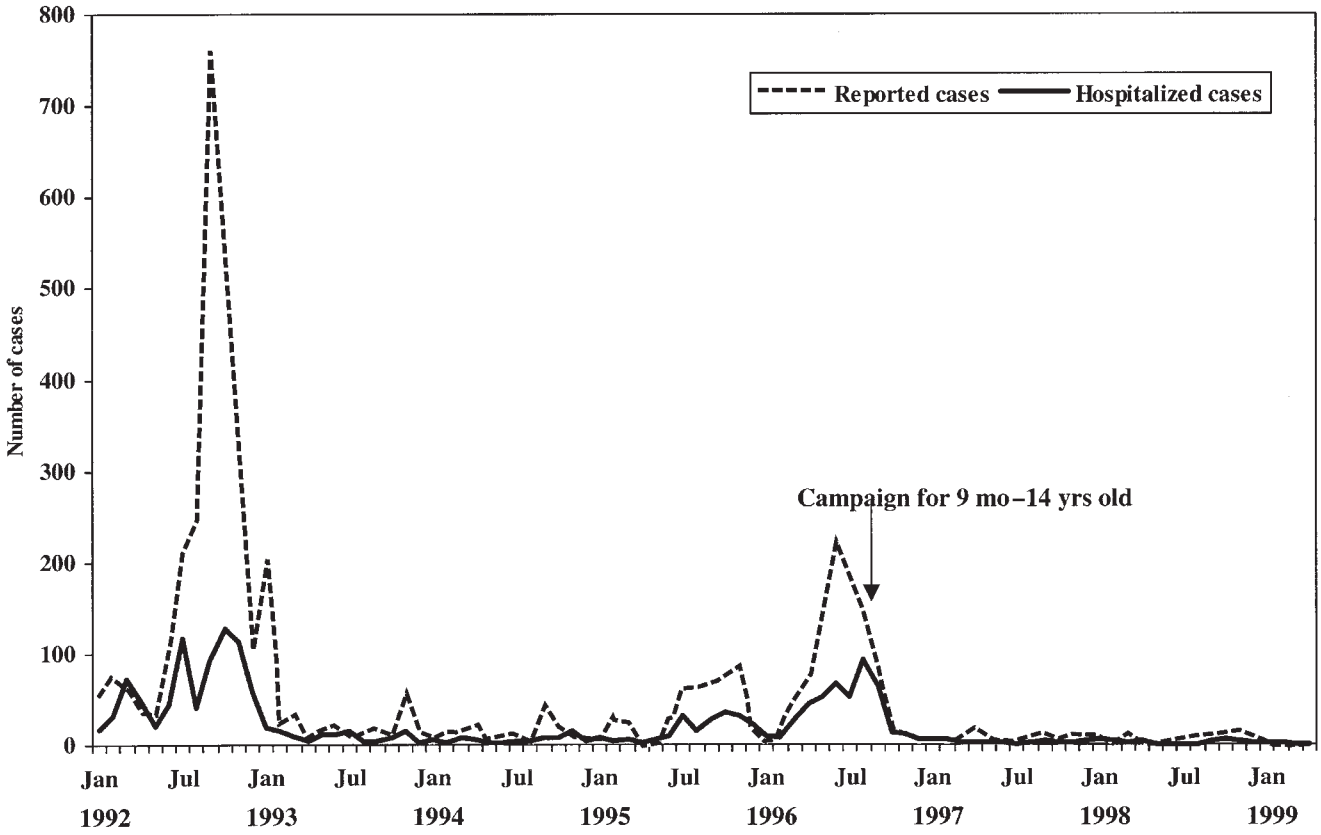

Figure 2 Number of reported and hospitalized measles cases by month, Mpumalanga Province, 1992–1998

Table 3 Characteristics of patients hospitalized with measles in Mpumalanga Province, South Africa, 1992–April 1999

	Before the campaign	After the campaign	*P*-value
Years	1992–1996	1997–April 1999	
Number of hospitalizations	1647	60	
Average annual number of hospitalizations	329	29[a]	
Age distribution[b]			
<1 year	156 (10%)	7 (13%)	0.48
1–4 years	533 (33%)	21 (39%)	0.37
5–9 years	622 (39%)	21 (39%)	0.99
10–14 years	221 (14%)	2 (4%)	**0.03**
⩾15 years	64 (4%)	3 (5%)	0.83
Mean age in months (SD)	70.7 (52.7)	59.1 (57.4)	**0.03**
Median age in months	60	48.5	**0.02**
Female gender	48%	41%	0.31
Hospital located in a former homeland[c]	1240 (75%)	44 (73%)	0.77
At least one recorded complication	224 (22%)	3 (6%)	**<0.01**
Diagnosed with pneumonia on admission and/or discharge	161 (16%)	3 (6%)	**<0.05**
Mean hospital stay in days (SD)	6.9 (7.5)	5.5 (3.5)	0.09
Median hospital stay in days	6	5	0.28
Died in the hospital	11	0	

[a] Average annual number of hospitalizations for 1997–1998.

[b] Information on age was available for 1650 patients.

[c] Hospitals Themba, Embhuleni, Shongwe and Philadelphia.

Western Cape Province

Routine surveillance

In Western Cape in 1980–1998, 16 406 measles cases and 260 deaths were reported through the routine surveillance system. During 1980–1997, 16 274 cases and 260 deaths were reported for an annual average of 901 cases and 15 deaths; the lowest annual number of measles cases was reported in 1991 (240 cases), and highest in 1992 (1431 cases). During the 6 pre-campaign years (1992–1997), 5164 measles cases were notified for an annual average of 860 cases (Table 4). In 1998 following the 1996–1997 campaigns, a record low number of measles cases (132 cases) was reported. In 1998, when compared to the 6 pre-campaign years (1992–1997), the proportion of notified measles cases among children aged 0–4 years increased, while the proportion of cases aged ⩾10 years decreased. During 1992–1996, 19 measles deaths were reported through the routine surveillance system in Western Cape; no measles-related deaths were reported in 1997–1998.

Hospital record review

Twenty-seven of 34 acute-care public hospitals in Western Cape participated in the hospital study, representing 6300 (94%) acute care hospital beds in the public sector. Eight of 33 private hospitals participated. From January 1992 through July 1999, 765 measles-related hospitalizations occurred in the participating hospitals (Figure 3). Following the campaigns, the average annual number of measles-related hospitalizations declined by 84%, from 123 during the 6 pre-campaign years to 20 in 1998, the first post-campaign year (Table 5). Thirteen hospitals in the Cape Town Metropolitan area accounted for the majority of hospitalizations both before and after the campaigns. Compared to the pre-campaign period, the proportion of patients diagnosed

Table 4 Characteristics of reported measles cases in Western Cape Province, South Africa, 1992–1998

	Before the campaign	After the campaign	*P*-value
Years	1992–1997	1998	
Notified measles cases	5164	132	
Average annual number of notifications	860	132	
Age distribution[a]			
<1 year	644 (13%)	30 (23%)	**<0.001**
1–4 years	1424 (28%)	61 (46%)	**<0.0001**
5–9 years	1376 (27%)	28 (21%)	0.11
10–14 years	788 (16%)	7 (5%)	**<0.01**
⩾15 years	782 (16%)	6 (5%)	**<0.001**
South African mixed race	3604 (70%)	90 (68%)	0.65
Female gender	2498 (49%)	49 (45%)	0.39
Died	19	0	

[a] Information on age was available for 5146 reported measles cases.

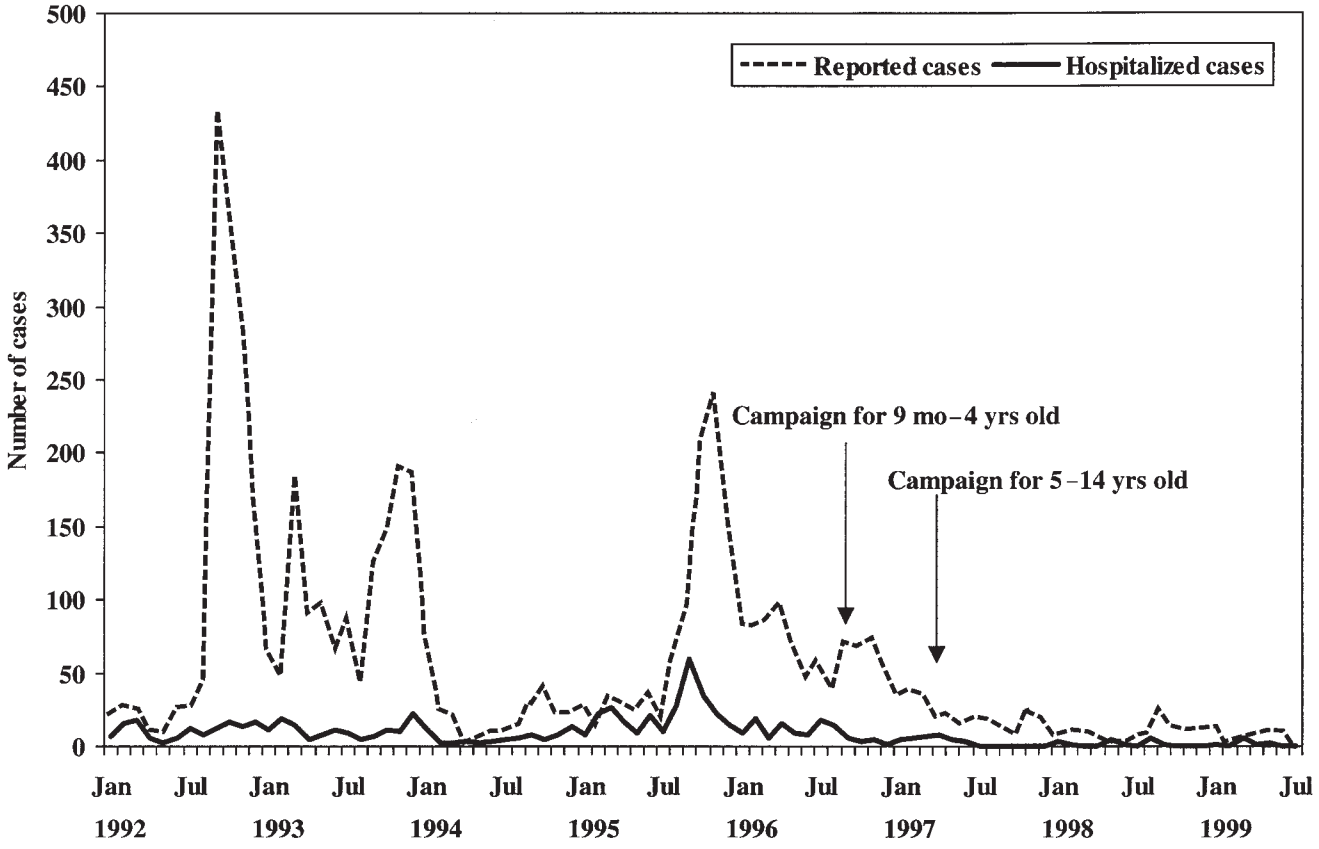

Figure 3 Number of reported and hospitalized measles cases by month, Western Cape Province, 1992–1998

Table 5 Characteristics of patients hospitalized with measles in Western Cape Province, South Africa, 1992–July 1999

	Before the campaign	After the campaign	*P*-value
Years	1992–1997	1998–July 1999	
Number of hospitalizations	736	29	
Average annual number of hospitalizations	123	20[a]	
Age distribution[b]			
<1 year	215 (37%)	12 (57%)	0.06
1–4 years	167 (29%)	3 (14%)	0.14
5–9 years	72 (13%)	5 (24%)	0.24
10–14 years	32 (5%)	1 (5%)	0.74
≥15 years	92 (16%)	0	0.09
Mean age in months (SD)	70.7 (102.1)	36.3 (46.4)	0.14
Median age in months	19	11	0.12
Female gender	322/688 (47%)	7/28 (25%)	**0.02**
Hospital located in Cape Town[c]	518 (70%)	24 (83%)	0.14
At least one recorded complication	241 (33%)	2 (7%)	**<0.01**
Diagnosed with pneumonia on admission and/or discharge	175 (24%)	2 (7%)	**0.03**
Mean hospital stay in days (SD)	6.1 (7.4)	7.0 (10.6)	0.17
Median hospital stay in days	4	3	0.20
Died in the hospital	23	0	

[a] Annual number of hospitalizations for 1998.

[b] Information on age was available for 599 patients.

[c] Thirteen hospitals in the Cape Town Metropolitan Area, including three academic hospitals.

with at least one measles-associated complication, the proportion of patients diagnosed with pneumonia, and the proportion of female patients declined in the post-campaign period. Seven patients were co-diagnosed as HIV positive, all of whom were hospitalized in 1995–1996 in two Cape Town hospitals and discharged alive. All 23 measles-related deaths occurred among patients hospitalized in 1992–1996 yielding a case fatality ratio of 3.1 deaths per 100 measles hospitalizations.

Discussion

To our knowledge, this is the first study undertaken in Africa to evaluate impact of a 'catch-up' vaccination campaign on measles disease burden by using data from two mutually independent sources—routine measles surveillance and province-wide hospital record review.

South Africa has a well-developed, predominantly hospital-centred health care system in which approximately 80% of the population receives their health care mainly in the public sector.[8] Even though racial inequalities in access to health care services inherited from the previous *apartheid* system still persist in some areas, in general one may assume that measles-related hospital admissions would occur if there was ongoing measles transmission in surrounding communities. The completeness of measles reporting in South Africa was not formally evaluated but is thought to be low because of the passive nature of the routine surveillance system that has multiple deficiencies.[9] Nonetheless, the routine surveillance system was an adequate method for monitoring overall trends in disease incidence, as evidenced by a close parallelism between the routine surveillance data and the hospital admission data. In the absence of a fully functional case-based surveillance system with laboratory confirmation of all suspected measles cases, the review of the hospital registers in Mpumalanga and Western Cape was useful in verifying the reduction in measles morbidity and mortality observed in the routine surveillance system.

Several limitations should be considered when interpreting results of this study. First, diagnosis of measles in the routine surveillance system and in South African hospitals during 1992–1998 was entirely clinical; no laboratory confirmation was performed. Second, hospital registers were not complete for the entire study period in some participating hospitals, and alternative sources with less complete patient information (e.g. nursing turn-over records, measles record books, infection control registers) were used to supplement admission registers where available. In Mpumalanga, two hospitals located in the Eastern Highveld Region were excluded from the study because hospital registers were unavailable. This resulted in under-representation of that part of the Province. In addition, seven hospitals, including the three largest, either did not have the admission registers for 1992–1993 available for review or the registers were grossly incomplete. In Western Cape, the hospital registers from a major Cape Town hospital that was closed permanently in 1994 were not available for review. This hospital was a referral centre for paediatric measles-related admissions and was reportedly admitting hundreds of measles cases each year in the early 1990s. However, in both provinces, most participating hospitals had complete admission registers for recent years (1996–1999), providing a more precise assessment of the measles-associated hospitalizations in the post-campaign period. Third, the 1996–1997 measles vaccination campaigns coincided with an increase in reported measles incidence in both provinces, and it was not possible to separate the effect of the campaigns from that of the 1995–1996 measles epidemic on the subsequent reduction in measles morbidity and mortality. Fourth, since information on vaccination was not collected either in the routine surveillance system or in hospital admission registries, the vaccination history of measles cases could not be ascertained. Lastly, the one-time retrospective nature of the hospital record review and the short post-campaign observation time limit inferences about the duration of the reduction in measles disease burden resulting from the campaigns.

It is unlikely that our study overestimated the post-campaign reduction of measles-related hospitalizations and hospital-based deaths given the high participation rate of public hospitals in both provinces and the availability of generally complete hospital registers for post-campaign years. Moreover, it is likely that the proportion of patients incorrectly diagnosed with measles may have increased following the 1996–1997 campaigns compared to the pre-campaign period, due to decreased predictive value positive of the clinical diagnosis of measles in the presence of reduced disease incidence.[10,11] In both study provinces, the proportion of hospitalized measles cases diagnosed with pneumonia was significantly lower after the campaign. This finding may reflect misdiagnosis of milder illnesses (e.g. rubella) as measles or admission of milder measles cases after the campaign.

Currently available data from the new case-based measles surveillance system that requires laboratory confirmation suggest that measles virus does not cause the majority of clinically diagnosed measles cases in South Africa reported after the 1996–1997 campaigns. Of 904 suspected measles cases reported in 1999, serum specimens were taken for analysis and test results were available for 817 (90%); of these 79 (10%) tested positive for measles-specific IgM antibodies.[12] In 2000, of 1449 suspected measles cases, 1303 (90%) had laboratory test results available; of these, 77 (6%) tested positive.[13] From January to December 2001, 901 suspected cases were reported; of these, 859 (99%) were tested and only 8 (1%) were confirmed as measles.[14] This consistently low proportion of reported measles cases confirmed by the laboratory during the period 1999–2001 is consistent with a sustained reduction of measles virus transmission in South Africa.

The implications of the ongoing HIV/AIDS pandemic on measles control have not yet been fully elucidated, but concerns have been raised that HIV/AIDS might impede measles elimination efforts due to reduced vaccine effectiveness in infected children.[15] We did not find evidence that this was the case in South Africa, a country with one of the worst HIV/AIDS epidemics in the world.[16] However, our study was not specifically designed to investigate the interaction between the HIV/AIDS epidemic and measles elimination efforts.

For continued success of measles elimination activities in South Africa, vaccination strategies aimed at preventing a major accumulation of susceptibles in new birth cohorts that could result in measles resurgence will be critically important. Experience in the Americas has shown that routine measles immunization of infants can be successfully complemented, but not replaced, with mass vaccination campaigns while pursuing measles elimination.[17]

In Mpumalanga in 1998, a province-wide vaccination coverage survey conducted at district level estimated the routine measles vaccination coverage among children aged 12–23 months at 71%, with a marked heterogeneity of district-specific coverage, indicating the need for additional supplemental immunization activities to achieve and sustain measles elimination.[18] In the same study, a strong negative correlation was observed between each district's rank for vaccination coverage achieved in the1996 'catch-up' campaign and the rank for routine measles vaccination coverage. This suggests that children residing in the areas where routine coverage was low particularly benefited from an additional opportunity for immunization offered through the campaign.[18] Earlier studies in South Africa found that the impact of previous supplemental measles vaccination campaigns was short-lived in rapidly growing peri-urban informal settlements.[19,20] The statistically significant increase in the proportion of Blacks/Africans among measles cases reported in Mpumalanga during 1997–1998 may possibly be explained by limited measles virus circulation in some communities among remaining susceptibles; however, in the absence of laboratory confirmation for these cases, this could not be ascertained. While continuing efforts to improve routine childhood measles vaccination coverage with two doses of measles vaccine to ⩾95% in all districts are essential, South Africa will need to implement 'follow-up' campaigns at 3- to 5-year intervals. In June 2000 all provinces of South Africa successfully implemented a 'follow-up' measles vaccination campaign targeting all children aged 9–59 months.

Our study has documented a short-term reduction of measles disease burden in Western Cape and Mpumalanga following the 'catch-up' campaigns implemented 1996–1997 to historic low levels, but a longer observation period is needed to evaluate success of the measles elimination strategies implemented in South Africa. The ultimate goal is to strengthen the surveillance system so as to enable routine laboratory confirmation and detailed epidemiological investigations of all suspected measles cases and all outbreaks, and generate information on proportion of imported cases, distribution of outbreak sizes, and distribution of the duration of outbreaks (useful for assessing the progress toward elimination of indigenous measles).[21] Molecular epidemiology techniques based on virus isolation and genomic sequencing may be useful in evaluating origins of measles virus importations. Lastly, further research is needed to evaluate interaction between the HIV/AIDS epidemic and measles elimination strategies.

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KEY MESSAGES

- This is the first study undertaken in Africa to evaluate impact of a 'catch-up' vaccination campaign on measles disease burden.
- Following implementation of the 1996–1997 measles mass vaccination campaigns that targeted children aged 9 months to 14 years, the number of measles cases and deaths reported through the routine surveillance system in South Africa declined to record low levels.
- In Mpumalanga and Western Cape Provinces, two mutually independent sources—routine measles surveillance and hospital record review—showed that the 1996–1997 campaigns resulted in a major reduction in measles disease burden in the 1–2 years that followed.
- For continued success of measles elimination activities in South Africa, vaccination strategies aimed at preventing a major accumulation of susceptibles in new birth cohorts that could result in measles resurgence will be critically important.

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Commentary: Accelerated measles control/measles elimination in southern Africa

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The World Health Organization (WHO) has developed a global plan for accelerated measles control which calls for implementation of a strategy based on that used to successfully control measles in the Americas—a 'catch-up' campaign providing measles vaccine to all children (usually 9 months [or 1 year] to 14 years of age) regardless of prior history of immunization or disease, followed by high levels of routine coverage with measles immunization ('keep-up'), and periodic 'follow-up' campaigns targeting all children 1–4 years of age.[1]

The article by Uzicanin *et al*. is an exciting and impressive preliminary report on the short-term impact of adoption of this strategy, starting with a 'catch-up' measles immunization campaign in South Africa.[2] The dramatic results seen in the short-term are to be expected, particularly since routine measles coverage before the 'catch-up' campaign was sufficiently high to have prolonged the inter-epidemic cycle of measles in South Africa. As the authors point out, the real test of long-term control/elimination will be the ability of the country to maintain high levels of routine coverage with measles vaccine along with periodic 'follow-up' campaigns to provide a second opportunity for measles vaccine for all young children. Nonetheless, the striking reduction in average annual morbidity and mortality gives cause for optimism about the longer-term impact of the programme.

In addition to the obvious short-term impact of the campaign, two other aspects are notable—the concurrence of two different systems of surveillance and the ability of the campaign to reach children who had not previously been vaccinated (the 'hard to reach').

In the absence of a case-based reporting system backed up by laboratory confirmation, there are always questions about the accuracy/representativeness of passive reporting systems such as existed in South Africa until recently. The fact that hospital admission data closely paralleled reported morbidity increases confidence that the morbidity reporting system at least reflected trends in incidence. Given the fact that not all cases of measles seek medical attention and that, even for those who do seek attention, medical care providers do not always report cases as they should, the number of cases reported almost certainly underestimates reality unless there are major confounders from other illnesses such as rubella.

It is clear that case reporting includes many non-measles illnesses, as manifested by the fact that, after the campaign, only approximately 10% of reported 'measles' cases were positive for

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measles-specific IgM antibody. In the face of this confounding, it is highly likely that the campaign resulted in an even greater reduction in true measles morbidity than is reflected by reporting. One could even make some 'guesstimates' about the true impact. If only 10% of currently reported cases are truly measles and there was a 90% reduction in total reported cases, the true reduction in measles incidence may have been of the order of 98% assuming a constant incidence of non-measles disease reported as measles. Introduction of individual case investigation supported by laboratory testing makes it possible to become more confident about the true level of circulation of measles virus.

The authors report a 'strong negative correlation' between individual districts' rankings for routine measles immunization coverage and coverage attained during the campaign, suggesting that the campaigns were reaching children who had previously been missed ('hard to reach'). In Mpumalanga province routine coverage was 71% whereas the campaign coverage was reported as 104% (partly reflecting population flows across provincial and international borders).[3] This finding is similar to that in other countries, where mass campaigns (either for polio or measles) commonly reach children who had been missed by routine services. For example, Zuber *et al*. found that, in urban settings in Burkina Faso, where only 57% of children 9–59 months of age had received measles vaccination through routine activities, 78% of previously unvaccinated children (and 81% of previously vaccinated children) received measles vaccine during National Immunization Days.[4]

A strategic plan for accelerated measles control in southern Africa has been developed, based on the strategy developed in the Americas and seven countries in southern Africa have brought about dramatic reductions in reported morbidity and the mortality due to measles even in the face of markedly improving surveillance.[5] Although the data presented by Uzicanin *et al*. cannot demonstrate the lasting impact of the campaign, there is strong corroborating evidence, subsequent information from South Africa and other countries in southern Africa which have undertaken aggressive approaches to accelerate measles control/elimination. During January–April 2002 there were only 369 reported suspected measles cases in the seven southern Africa countries that have launched measles elimination. Of these 357 (97%) were investigated and 71 of 333 cases with laboratory results available were confirmed as having measles. Sixty-six of the 71 laboratory-confirmed cases occurred in Namibia as a result of spread from an outbreak in Angola, demonstrating the importance of maintaining high routine immunization coverage and effective 'follow-up' campaigns.[6]

Uzicanin *et al*. have shown that, in countries with good access to hospitals, retrospective searches for measles cases at district hospitals are a useful tool for strengthening measles surveillance and building the communication links between hospital infection control nurses/disease surveillance clerks and the health department. The study itself was a training component that helped develop case-based surveillance in the two provinces.

The WHO estimates that there are still 770 000 deaths due to measles each year, with half of these occurring in sub-Saharan Africa.[7] These early results are very encouraging about the prospects of effective control of measles in sub-Saharan Africa and the possibility that measles elimination could be achieved as a step toward global ereadication.[8]

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