The 1992 measles epidemic in Cape Town — a changing epidemiological pattern

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Abstract **Over the last 6 years there has been a decline in the incidence of measles in Cape Town. However, during August 1992 an outbreak occurred, with cases reported at many schools in children presumably immunised. The objectives of this study were to characterise the epidemic in Cape Town and to determine possible reasons for the outbreak. The investigation consisted of two components — a description of the epidemic and an investigation of an outbreak at one primary school. Results indicate that during the last 4 months of the year, 757 cases were notified in Cape Town, compared with 144 in the first 8 months. The epidemic affected mainly white and coloured children over 5 years of age ($P < 0,001$). In contrast, during the period before the epidemic most cases occurred in black children and in those aged less than 1 year ($P < 0,001$). There was no significant increase in hospitalised cases. Investigation of the outbreak at one school revealed that the attack rate was 7,6% (25/329 children). Immunisation coverage (at least one dose of any measles vaccine) was 91% and vaccine efficacy was estimated to be 79% (95% CI 55 - 90); it was highest for monovalent measles (100%) and lowest for measles-mumps-rubella (74%). The epidemiology of measles in Cape Town has thus changed as evinced in this epidemic, with an increase in the number of cases occurring in older, previously vaccinated children. The possible reasons for this include both primary and secondary vaccine failure. To prevent epidemics of this nature, immediate reimmunisation of all children at schools where outbreaks were identified is recommended and, in the long term, reimmunisation of all children before they start school should be considered.**

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Measles remains one of the leading causes of childhood morbidity and mortality worldwide. The World Health Organisation estimates that over 70 million cases of measles occur globally each year and that more than 1,5 million children die.[1] Measles is most prevalent in developing countries, where it is principally a disease of unimmunised infants and young children.[2,3] In industrialised countries, measles is now a disease of older children and young adults, who are unimmunised or in whom primary immunisation has failed, and of minority-group and disadvantaged preschool children living in densely populated neighbourhoods where immunisation coverage is low.[4,5]

In South Africa the importance of measles as a major public health problem is no different from that in other developing countries. Annual notifications and reported deaths over the last decade have averaged about 15 000 and 300 respectively.[6] This can be ascribed to problems with the immunisation services.[7] However, since 1990, a country-wide decline in measles notifications has been noted. This could be attributed to the cyclical nature of herd immunity to measles in the population and to some extent the 1990/1991 national measles immunisation strategy.[8]

During August 1992 a possible outbreak of measles at a primary school (school A) in Cape Town was reported. Concern was expressed as to whether the disease was indeed measles, and if so why so many cases were occurring in previously vaccinated children. Subsequent to this, other similar outbreaks in school-going children were reported and a general increase in measles notifications was noted in Cape Town. This study was thus undertaken to investigate the measles epidemic in Cape Town.

Methods

The objectives of this study were to characterise the epidemic in Cape Town and to determine possible reasons for the outbreak; this included an assessment of measles vaccine efficacy. The investigation consisted of two components. The first was a description of the epidemic in Cape Town, and the second an investigation of the outbreak at school A.

Cape Town epidemic

A descriptive analysis was undertaken of trends in measles notifications in Cape Town and admissions of measles patients to the City Hospital for Infectious Diseases (CHID) during 1992. This hospital serves as the referral centre for measles cases in the greater Cape Town region. Official notifications received by the health departments of the City Council of Cape Town (CCC) and the Western Cape Regional Services Council (WCRSC) were collated and stratified for age, race and month of occurrence. Similar data from the CHID admission register were analysed. In addition the trends in the notifications and hospital admissions over the last 20 years were documented.

Outbreak at school A

This investigation entailed a descriptive component and a retrospective cohort study of the outbreak at school A. School A is a private primary school for boys situated in the southern suburbs of Cape Town and serves children from a high socio-economic group. The school has 329 pupils, divided into standards 1 - 5, with three classes per standard.

Case ascertainment involved scrutiny of school absenteeism records for potential cases. In order to confirm the diagnosis of measles, case histories obtained

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from case investigation reports (completed for all notified cases) of the CCC at the WCRSC were reviewed. In addition detailed clinical histories of 10 patients were collected via telephonic interviews of parents. The following measles case definitions were applied in this study: (*i*) **definite case** — high fever, generalised maculopapular rash for 3 or more days, and one or more of the following: coryza, cough, conjunctivitis and Koplik spots. Cases with positive measles IgM serology were also classified as definite cases; (*ii*) **probable case** — fever with generalised rash, epidemiologically related to a definite measles case, and diagnosed by a physician as a case of measles; (*iii*) **suspected case** — fever and rash only.

Only definite and probable cases were used in describing the epidemic and in calculating vaccine efficacy. Where the date of disease onset was unknown, an estimated date was calculated by subtraction of 2 days from the date the child was first reported absent from school.

Serological tests to confirm measles were undertaken on a convenience sample of 5 reported cases. Measles IgG and IgM antibody tests were performed with commercial enzyme-linked immunosorbent assays (ELISAs) according to manufacturers' instructions (Antimeasles IgG ELISA, Genoclin Diagnostica, Offenbach, Germany; Measlestat M, Whittaker Bioproducts, Walkerville, USA).

Immunisation histories for all patients and unaffected children were obtained by means of a questionnaire survey to the parents of all pupils at the school. Information included demographic details, age at immunisation, type of vaccine (measles-mumps-rubella combination (MMR) or monovalent vaccine (Schwarz)), where and by whom the child was vaccinated.

Statistical methods

Vaccine efficacy was calculated with the following formula, and 95% confidence intervals are given for each estimate (AR = attack rate).[9]

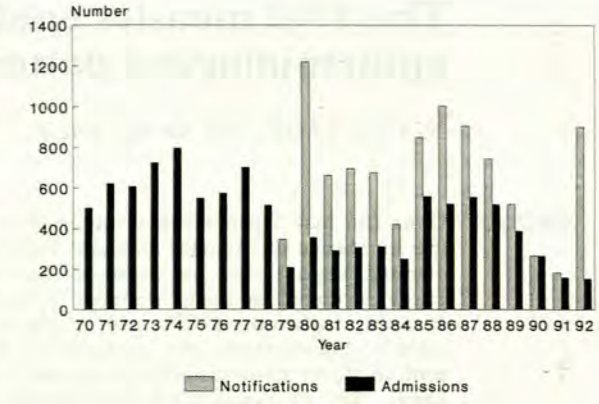
$$\text{Efficacy (\%)} = \frac{\text{(AR unvaccinated)} - \text{(AR vaccinated)} \times 100}{\text{AR unvaccinated}}$$

The approximate risk of measles in children according to age and race categories after the onset of the epidemic compared with before the epidemic was calculated by means of the relative risk ratio.[10] Categorical data were evaluated by the χ^2-test and continuous data by the Kruskall-Wallis test.

Results

Cape Town epidemic

Fig. 1 shows the notifications and hospital admissions to CHID for the period 1970 - 1992. Measles notifications were incomplete before 1979. In the decade after the introduction of routine measles immunisation in Cape Town during 1974, there was a downward trend in the number of notifications and hospital admissions. Measles incidence (based on notifications) for the period 1981 - 1984 stayed relatively constant with an average rate of 42/100 000 total population. In 1985 a resurgence of measles occurred, leading to a peak in notifications in 1986. Since 1988 there has been a progressive decline in notifications and admissions, with the lowest number of notifications and cases in the last 20 years recorded in 1991 (Fig. 1). Measles incidence also declined progressively over this period, from 51/100 000 in 1986 to 8/100 000 in 1991. The year 1992, however, saw a dramatic increase in the notifications but not the admissions.



Notifications prior to 1979 - incomplete

FIG. 1.
Annual measles notifications in Cape Town and admissions to CHID, 1970 - 1992.

In 1992, the notifications and admissions remained low for the first 8 months, averaging 17 and 9 per month respectively (Fig. 2). In September, a dramatic increase in measles notifications occurred with 138 cases reported; 314 were reported in October, 193 in November and 110 in December. In the last quarter of the year there was also a slight increase in the number of hospital admissions which was, however, not significant. Table I lists the race and age distribution of the notified cases. In children aged less than 1 year significantly fewer cases occurred after the outbreak (relative risk 0,23, 95% CI 0,17 - 0,30; $P < 0{,}001$), while significantly more cases occurred in the children aged more than 5 years during the outbreak (risk ratio > 2 for age groups 5 - 9 years, 10 - 14 years, and over 14 years; $P < 0{,}001$). There was no difference in the occurrence of measles in 1 - 4-year-old children before or after the outbreak ($P = 0{,}12$). The risk of measles following the outbreak in white and coloured children was 9,37 and 1,60 respectively ($P < 0{,}001$) (Table I). In black children the relative risk was 0,13, i.e. fewer cases occurred in this group ($P < 0{,}001$) or, from another perspective, significantly more cases occurred in this group before the epidemic. There was no difference in the age distribution of black notifications when the number of cases before the epidemic was compared with the number of cases following the epidemic ($P = 0{,}28$).

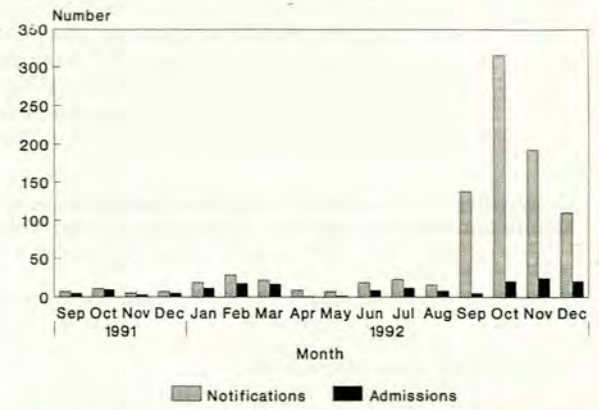


FIG. 2.
Monthly measles notifications in Cape Town and admissions to CHID, Sept 1991 - Dec 1992.

TABLE I.
Measles notifications in Cape Town — 1992: race and age distribution

Month	No.	Black	Coloured	White	Age distribution (yrs) < 1	1 - 4	5 - 9	10 - 14	> 14
Jan	19	10	9	–	8	6	3	1	1
Feb	29	17	12	–	21	6	0	1	1
Mar	22	16	6	–	9	9	3	1	0
Apr	9	6	3	–	4	4	0	1	0
May	7	4	3	–	2	3	2	0	0
Jun	19	11	8	–	9	6	3	1	0
Jul	23	11	9	3	7	10	6	0	0
Aug	16	5	10	1	6	4	4	2	0
Subtotal	144	80	60	4	66	48	21	7	2
Sep	138	5	65	68	5	26	49	32	26
Oct	316	21	207	88	31	93	110	50	32
Nov	193	22	146	25	26	57	64	23	23
Dec	110	7	87	16	16	25	33	22	14
Subtotal	757	55	505	197	78	201	256	127	95
Total	901	135	565	201	144	249	277	134	97
RR*		0,13	1,60	9,37	0,23	0,80	2,32	4,09	9,04
95% CI		0,1 - 0,18	1,31 - 1,95	3,54 - 24,8	0,17 - 0,30	0,61 - 1,03	1,54 - 3,49	1,84 - 9,09	2,25 - 36,24
P		< 0,001	< 0,001	< 0,001	< 0,001	0,12	< 0,001	< 0,001	< 0,001

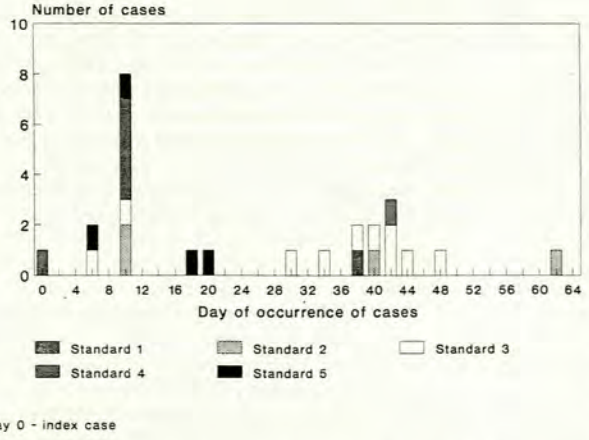
* RR – the relative risk refers to the risk of measles developing in children (according to race or age category) after the onset of the epidemic, i.e. the second subtotal group compared with children before the epidemic, i.e. the first subtotal group.

Outbreak at school A

A total of 25 boys had clinical case histories that met the criteria for classification as cases of measles. The mean age of patients was 11,4 years (range: 9,8 - 14,0) and this did not differ significantly from that of controls ($P = 0,4$). Cases had a median rash duration of 5 days with a range of 3 - 7 days. In 4 of the 5 children tested measles-specific IgM antibody titres were significantly raised. Serological investigations were negative in the remaining patient who also gave a clinical history of mild fever without rash or other signs, and therefore did not meet the clinical criteria for classification as a measles patient.

Epidemic curve

The occurrence of the 25 cases according to date of onset is shown in Fig. 3. The index patient became ill on July 29 (day 0) and had no history of travel or contact with measles patients. His most likely source of exposure was at a national judo tournament (in Cape Town) in the 2 weeks preceding the onset of disease.



Day 0 - index case

FIG. 3.
Epidemic curve of measles cases at school A.

Two peaks representing second- and third-generation cases are clearly identified in the epidemic curve. The second-generation cases represent an outbreak concentrated mainly in the Standard 4 and 5 classes, and the third-generation cases in the Standard 3 classes. On 11 September (day 44) the headmaster issued a circular to all parents asking them to have their children vaccinated against measles if there was uncertainty as to their immunisation status. The school holidays commenced on 25 September (day 58) and the last case occurred on 29 September (day 62). The highest attack rates were recorded in Standard 4 (8,3%) and Standard 3 (14,9%), with an overall attack rate for the school of 7,6% (Table II).

TABLE II.
Measles attack rates and immunisation coverage rates by standard at school A

Standard	Census	No. of cases	AR (%)	% Vaccinated*
1	61	1	1,6	93
2	59	4	6,8	94
3	67	10	14,9	90
4	72	6	8,3	94
5	70	4	5,7	84
Total	329	25	7,6	91

*First dose of any vaccine.
AR = attack rate.

Immunisation status

A 90% (295/329) response rate was obtained for the vaccine history questionnaire sent to the parents of all boys at the school. Ninety-one per cent (268) of boys had been vaccinated at least once against measles before the onset of the epidemic. Immunisation coverage was over 90% in Standards 1 - 4, with Standard 5 classes having the lowest coverage, 84% (Table II). Details of immunisation status according to type of vaccine, dose, age at immunisation, location and provider are given in Table III.

TABLE III.
Measles attack rates and vaccine efficacy according to immunisation history at school A

	No. of children	No. of cases	AR (%)	VE (%)	95%CI
Vaccine history					
Yes*	268	17	6,3	79	55 - 90
No	27	8	29,6	–	
Doses of vaccine					
1 dose†	168	11	6,5	78	50 - 90
2 doses	100	6	6,0	80	47 - 92
Vaccine type†					
MMR	119	9	7,6	74	40 - 90
Monovalent	41	0	0,0	100	
Unknown	8	2			
Age at immunisation†					
≤ 12 mo.	40	3	7,5	75	13 - 93
> 12 mo.	109	6	5,5	81	51 - 93
Unknown	19	2			
Vaccine provider†					
MMR					
Clinic	47	1	2,1	93	46 - 99
Private practice	58	8	13,7	53	0 - 80
Unknown	14	0			
Monovalent					
Clinic	28	0	0	100	
Private practice	8	0	0	100	
Unknown	5	0			
Place vaccine given†					
Cape Town	109	9	8,3	72	35 - 88
South Africa	42	1	2,4	92	39 - 99
Overseas	13	0	0,0	100	
Unknown	4	1			

* First dose of single or double dose vaccines (MMR or monovalent vaccine).
† Single dose vaccines only.
VE = vaccine efficacy.

Vaccine efficacy

Attack rates and vaccine efficacy estimates for different immunisation history categories are given in Table III. The overall vaccine efficacy for children who had been vaccinated at least once (with any type of measles vaccine) was 79% (95% CI: 55 - 90).

Discussion

The most recent epidemic in Cape Town shows a very distinct change in the epidemiology of measles, with an increase in the proportion of cases in children over 5 years of age (above the target age group for immunisation). The epidemic occurred after several years of low and decreasing incidence which can be attributed both to the improved and sustained immunisation coverage in Cape Town during the late 1980s and the impact of the 1990 'measles strategy'.[8] This change in the age distribution of measles patients and the possible lengthening of the interepidemic period are expected consequences of a relatively successful immunisation programme the target age group of which was children under 1 year.[11] This phenomenon is similar to that found in developed countries where measles outbreaks occur predominantly in older schoolchildren and adolescents, and has also been described recently in developing countries with sustained infant immunisation programmes, such as Swaziland and Lesotho.[11] In the USA during the pre-immunisation era, only about 10% of cases occurred in those aged over 10 years, whereas by 1976, 13 years after the introduction of immunisation, more than 60% of cases were in those over 10 years old.[12] Despite the rapid onset of the epidemic there was no significant increase in hospital admissions. This may be attributed to the fact that the outbreak affected mainly older children, who tend to have a lower complication rate than infants and young children. This shift in measles cases to older children is thus a very positive result of the immunisation programme.

The occurrence of most cases in coloured and white children contrasts with trends before the onset of the epidemic when the highest proportion of cases was in black children. White and to some extent coloured children represent a higher socio-economic sector who may not have been compliant with immunisation schedules. They may also have had reduced exposure to wild measles virus because of the recent relatively successful immunisation coverage in infants in low socio-economic areas and peri-urban squatter settlements. That the outbreak occurred in a highly vaccinated older population (91% of children at school A were vaccinated at least once and reports from other schools in Cape Town would suggest a similar situation) is not unexpected. Children are susceptible to measles for a number of reasons. These include primary vaccine failure (2 - 8%) even when the vaccine is given at the optimal age, i.e. 15 months, no immunisation at all or immunisation at too early an age (at 9 months of age the vaccine is only effective in 80 - 85% of cases).[13] Over a period of time, especially if not exposed to natural measles, there is a build up of these susceptible individuals and all that is needed is a single measles case ('superspreader') to initiate an epidemic in a closed environment.[14] The beginning of the school vacation in December probably resulted in a decline in the notifications and may have heralded the end of the outbreak.

A major limitation of this study was the validation of immunisation histories against actual immunisation records. This was not possible in all pupils as some parents were unable to trace their child's immunisation card. Because proof of immunisation is not a legal requirement for school entry in South Africa, complete immunisation records were also not available at the school. Validation of immunisation histories against school records was therefore not possible. Immunisation histories could also not be validated against provider records as children had received their immunisations from a wide variety of health services in different locations and countries. Children were thus classified as not having received measles vaccine if their immunisation records could not be traced, or if their parents were not certain of their immunisation status.

An important aspect of outbreaks at schools that was not investigated during this epidemic is that cases serve as a source of infection for susceptible younger siblings who are more prone to complications. Studies from Guatemala have found that when the primary patient was an older child of school-going age the secondary attack rate was higher than when the primary patient was a young child.[15]

Despite these shortcomings and the small numbers involved, the study found that vaccine efficacy following monovalent measles vaccine was 100% while that following MMR was suboptimal (74%), especially when given by a private practitioner (53%). This would suggest that there may have been a break in the cold chain at some point. The need to maintain the cold chain in the private practice circuit needs to be re-emphasised. In 1989, a study in Cape Town reported significant breaks in the MMR vaccine cold chain.[16] As expected, vaccine efficacy also appeared to be better if the vaccine was given after the age of 1 year.[13]

The implications of the findings of this study are important. It remains our priority to vaccinate infants because of the high morbidity and mortality rates at this age. In keeping with WHO criteria,[17] all children in South Africa are vaccinated with the Schwarz strain at 9 months or at 6 months (with a second dose at 9 months) in high-risk areas. To prevent further outbreaks such as have occurred in Cape Town and other centres

in South Africa,[18] consideration should be given to re-immunisation of children at preschool or school entry as is the case in the USA.[19] The major drawback of such a programme, particularly in situations of scarce resources, is that it may result in the diversion of resources from routine immunisation services. It should only be implemented if the routine services will not be affected. In the absence of such a reimmunisation programme it is suggested that any outbreak that occurs within a preschool or school should be investigated immediately and all contacts immunised. This is in accordance with recent recommendations of the Department of National Health.[20] Ongoing evaluation of our measles strategy through coverage surveys and active surveillance of disease trends is important.

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