Epidemiol. Infect. (1995), **115**, 309–314

Priorities in global measles control: report of an outbreak in N'Djamena, Chad

A. NDIKUYEZE[1], A. COOK[2], F. T. CUTTS[2]* AND S. BENNETT[2]

[1] *World Health Organization, Chad*

[2] *London School of Hygiene and Tropical Medicine, Keppel Street, London WC1E 7HT, UK*

(*Accepted 28 March 1995*)

SUMMARY

In N'Djamena, capital of Chad, measles vaccination coverage of 12–23-month-old children fell from 61% in 1990 to 15% in 1993. A community survey of measles after an outbreak in 1993 showed that among children < 5 years of age, the mean monthly attack rate was 37 per 1000 (95% CI, 32–43) and the mean case fatality rate was 7·4%. Measles incidence was highest (77/1000/month) in children aged 9–11 months and fell among children > 3 years of age. Incidence rates were high (56/1000/month) among 6–8-month-old children, but only 3 deaths occurred in this age group. Measles vaccine efficacy, estimated by comparing attack rates in unvaccinated and vaccinated children, was 71% (95% CI, 59–80%). Extrapolation of the results to the city population indicated that an estimated 19000 cases and > 1000 measles-associated deaths occurred in 1993. This preventable morbidity and mortality, in a city where coverage was formerly among the highest in Africa, shows the need for sustained global commitment to preventive health care.

INTRODUCTION

The World Summit for Children and the World Health Assembly have established a goal to reduce measles deaths by 95% and cases by 90% compared with pre-immunization levels by 1995 [1]. Many high and middle income countries have achieved this goal; the USA was apparently free of any indigenous transmission of measles in November 1993 [2], and measles incidence is at an all-time low in the Caribbean and Central America, and in several European countries [3]. However, in many low income countries of sub-Saharan Africa, where measles case fatality ratios are highest, the reported incidence of measles is as high or higher than it was in 1990 (World Health Organization, unpublished data). Here, we report a measles outbreak in N'Djamena, the capital of Chad, and an analysis of the incidence and case fatality of measles, that illustrates the need for a reappraisal of where and how global resources are spent on measles control.

* For correspondence and reprints.

MATERIALS AND METHODS

The setting

N'Djamena has a population of 576249 (preliminary results of the census, 1993), divided in 'quartiers' (neighbourhoods) which in turn comprise 'carrés', or blocks of about 25 compounds. N'Djamena has 11 health centres (9 public and 3 run by religious organizations) and 8 government social centres which provide preventive care including vaccination. In 1988, the estimated proportion of children who were fully vaccinated with the complete series of childhood vaccines (1 dose of BCG, 3 doses of oral polio vaccine, 3 doses of diphtheria-tetanus-pertussis vaccine, and 1 dose of measles vaccine) was 65%, and in 1990, an estimated 61% of 12–23-month-old children received measles vaccine. Since then, in parallel with the deteriorating socioeconomic and political situation, vaccine coverage has declined precipitously. Only 3% of 12–23-month-old children were fully vaccinated and 18% vaccinated against measles in a 1991 coverage survey, and 7% and 15% respectively in 1993. In October 1993, we conducted a retrospective survey at the end of an outbreak to determine the age-specific incidence and case fatality ratios of measles in the city.

Survey methods

The study population comprised children born between 1 September 1988 and 30 September 1992, i.e. those aged 12–60 months at the time of the survey or who had died. We conducted a modified two-stage cluster sample survey. At the first stage, 50 carrés were selected with Probability Proportional to Estimated Size (PPES) sampling, according to the population of each carré. At the second stage, in each carré selected, a list of compounds was made and a starting compound selected using a random number table. All households in the compound were visited. After completing the compound, interviewers then proceeded to the nearest compound until at least 100 eligible children had been registered in each cluster.

In each household with an eligible child, the mother was asked about the child's history of measles before and during 1993, and measles vaccination status (confirmed by a vaccination record when available). Data were also collected on sex, age and socio-economic variables including parental education, number of rooms in the house, electricity connection and type of water supply.

Data analysis

We defined measles as the occurrence of a fever, rash and either a cough, conjunctivitis or coryza, and measles-related deaths as those occurring within 1 month of measles. We estimated measles incidence rates per person month during the epidemic period of 1 February to 30 June 1993, using the statistical package STATA (Stata Corporation 1993). Standard errors of estimates, allowing for cluster sampling, were calculated using the formula of Snedecor and Cochran [4], adapted for use with rates. We used Poisson regression to examine relationships between measles incidence rates and other factors, and logistic regression to examine relationships between case fatality ratios and other factors.

Vaccine efficacy was defined as: $(1-\mathrm{ARV}/\mathrm{ARU})\times 100$, where ARV and ARU are the attack rates among vaccinated and unvaccinated children respectively. Children with a reported history of measles prior to the epidemic period, and those vaccinated prior to age 9 months, were excluded from the analysis of vaccine efficacy. There were too few children vaccinated prior to age 9 months to derive a separate estimate of efficacy for these children. For children with a record of the date of vaccination, the potential onset of protection was taken to be 14 days after the vaccine was given. We estimated vaccine efficacy first excluding and then including children with only a verbal history of vaccination, taking them as having been vaccinated at 9·7 months, the median age at vaccination for those with records. Estimates of overall vaccine efficacy used age-stratified Mantel–Haenszel techniques [5].

RESULTS

We registered 4987 children in the survey. Of these, 925 had a history of measles prior to 1993, and 883 cases of measles were reported between 1 January and the time of interview, of which 12 did not meet the case definition and were excluded. Of the remaining cases, 824 (95%) occurred during the period of the epidemic, of which 61 (7·4%) resulted in death. The outbreak peaked in April, with 263 cases (Fig. 1).

Incidence of measles

Age-specific measles incidence rates were highest among children aged 9–11 months, with an average of 77 (95% confidence interval (CI), 61–98) cases per 1000 children per month (Table 1). Children aged 6–8 and 12–23 months had attack rates of 56 and 53/1000/month respectively, and incidence declined rapidly after 3 years of age.

Incidence rates were highest in the poorer households, i.e. those with fewer rooms, no electricity, and no piped water supply, and in those with lower parental education (data not shown). Reported incidence was slightly higher in females (rate ratio 1·1, $P = 0·1$).

Case fatality

The overall case fatality ratio (CFR) was 7·4% (Table 1). CFR were highest (8·7%) in children aged 12–35 months, and lowest in children aged 48–60 months (4·8%) and 6–8 months (4·4%). As expected, CFR were highest in children whose mothers were less well educated and of lower socio-economic status (data not shown). CFR were somewhat higher in boys than girls (odds ratio adjusted for all other factors = 1·4, 95% confidence interval 0·8–2·4). There were no deaths among 23 cases with documented measles vaccination, but the CFR among children with an undocumented history of vaccination was the same as that of unvaccinated children. Approximately three-quarters of cases had sought care at a health centre, but there was no significant difference in case-fatality among those who did or did not seek care (5·9% *vs.* 8·0% respectively).

Vaccine efficacy

A record of measles vaccination was available for 543 children (11%), the median age of vaccination being 9·7 months. A further 1062 children (21%) had a verbal history of vaccination, and the remaining 3370 children (68%) were said

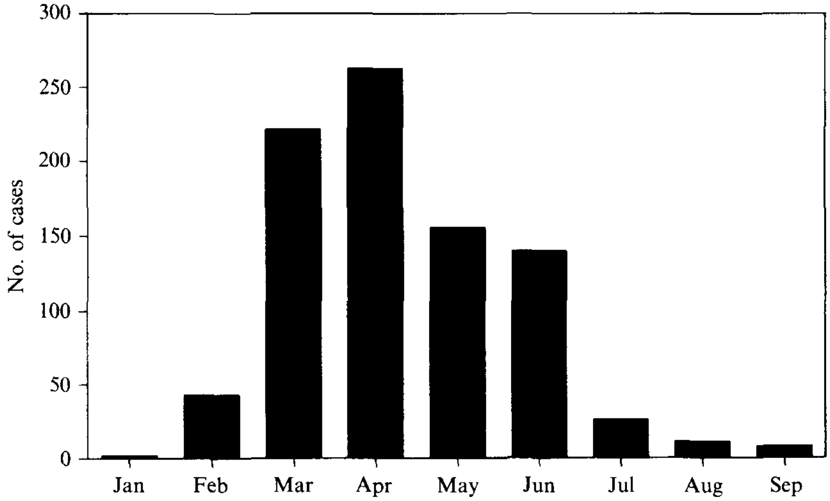

Fig. 1. Measles cases by reported month of onset, N'Djamena, Chad, 1993.

Table 1. *Age-specific measles incidence and case fatality ratios, 1993 measles epidemic, N'Djamena, Chad*

Age group (months)	Person months at risk	Number of cases	Number of deaths	Case fatality ratio (%)	Incidence rate per 1000 person-months	95% Confidence Interval
0–5	330	0	0	0	0	—
6–8	1225	68	3	4·4	56	41–75
9–11	1139	88	6	6·8	77	61–98
12–23	4868	257	22	8·6	53	44–64
24–35	5017	225	20	8·9	45	38–54
36–47	4891	123	7	5·7	25	20–31
48–60	4958	63	3	4·8	13	10–17
0–60	22428	824	61	7·4	37	32–43

to be unvaccinated. The overall vaccine efficacy, adjusted for child's age at the time of the survey, was 71% (95% CI, 59–80%) if only documented vaccination was accepted, and 67% (95% CI, 60–73%) if children with a verbal history of vaccination were included.

DISCUSSION

A large measles outbreak occurred in N'Djamena city in 1993, when estimated measles vaccine coverage was only 15%. Measles incidence rates were highest in children aged < 3 years, as expected in a poorly vaccinated community in a developing country [6]. Measles incidence and case fatality ratios were highest among the poorer families. Extrapolating from the incidence and case fatality ratios observed in this study to the estimated population < 5 years of age in N'Djamena, 19042 (16469–22130) cases and over 1000 measles-associated deaths may have occurred during the epidemic. Annual measles epidemics have occurred in N'Djamena after vaccine coverage fell. This morbidity and mortality is potentially preventable, and is of particular concern given that vaccine coverage in N'Djamena was once among the highest in Africa.

Estimated measles vaccine efficacy was somewhat low at *c.* 70%. Since the estimate of vaccine efficacy relied on mothers' ability to diagnose measles, false positive diagnoses would lower the observed efficacy [7]. Other studies have shown varying specificity of diagnosis, but the use of a clinical case definition, relatively short recall period, and the occurrence of an outbreak should have reduced, though not eliminated, the likelihood of misclassification [8]. Low vaccine efficacy may have contributed to this outbreak, but the major problem was failure to vaccinate rather than vaccine failure.

Improving the vaccination programme in N'Djamena and throughout Chad is a high priority for child health care in this country. Although attack rates among children aged 6–8 months, and so below the age for routine vaccination, were high, case fatality ratios were no higher than in older age groups. Forty-two percent of cases and 46% of measles-associated deaths occurred among children aged 9–23 months, the target age group for vaccination, and most of the morbidity and mortality that occurred in N'Djamena could be prevented if current vaccination policies were implemented effectively. There is doubt about whether new vaccines or new programmes are needed for measles control [9], and mass campaigns have been heralded as an additional strategy that will have maximum impact on interrupting transmission of measles virus [10]. However, it is possible that the search for 'new' solutions may obscure the fundamental problem of the inequitable use of global resources.

In N'Djamena, a small capital city, access to health facilities is relatively good, and health services have achieved high vaccination coverage in the past. Chad is ranked ninth poorest country in the world [11], and current problems arise from the deteriorating economic and political situation, which has led to low motivation of health workers, who were without salaries for a large part of 1993, and low utilization of health centres that lack essential drugs and equipment. This situation is common to many countries of West Africa [12, 13], and the recent devaluation of the CFA Franc in the West African Monetary Union will not improve the situation. In 1994, the United States allocated $128 million to improve the quality of services in the US public sector, in response to a measles epidemic that resulted in 130 deaths in 1989–90 [14], and the United Kingdom Department of Health spent £20 million to prevent an epidemic that, according to mathematical models, might have led to 50 deaths [15]. Yet, under current conditions of economic growth, many of the least developed nations are estimated to be able to afford $< 30\%$ vaccination coverage by the year 2000, even if they allocated 10% of their total health care budget to childhood immunization [16]. Rather than searching for new strategies for measles control, we need strategies to convince politicians to sustain support for health promotion in low income countries.

ACKNOWLEDGEMENTS

This study was financed by the Global Programme on Vaccines, World Health Organization.

REFERENCES

1. World Declaration on the survival, protection and development of children and plan of action for implementing the World Declaration on the survival, protection and development of children in the 1990s. World Summit for Children. United Nations. New York, 1990.
2. Morbidity Mortality Weekly Report. Absence of reported measles. United States. November 1993. MMWR 1993; **42**: 925–6.
3. Peltola H, Heinonen OP, Valle M, et al. The elimination of indigenous measles, mumps and rubella from Finland by a 12-year, two-dose vaccination program. N Engl J Med 1994; **331**: 1397–402.
4. Snedecor GW, Cochran WG. Statistical methods. Ames: Iowa State University Press, 1968: 515.
5. Rothman KJ. Modern epidemiology. Boston: Little, Brown and Company, 1986: 213.
6. Cutts FT, Markowitz LE. Successes and failures in measles control. J Infect Dis 1994; **170** (suppl 1): S32–S41.
7. Orenstein WA, Bernier RH, Hinman AR. Assessing vaccine efficacy in the field. Further observations. Epidemiol Rev 1988; **10**: 212–41.
8. Cutts FT, Brown DWG. The contribution of field tests to measles surveillance and control: a review of available methods. Rev Med Virol 1995; **5**: 35–40.
9. Katz SL, Gellin BG. Measles vaccine: do we need new vaccines or new programs? Science 1994: **265**: 1391–2.
10. Global Programme for Vaccines of the World Health Organization. Role of mass campaigns in global measles control. Lancet 1994; **344**: 174–5.
11. World Bank. World development indicators. In: World Development Report 1993. Investing in Health. Oxford: Oxford University Press, 1993: 231.
12. Malfait P, Jataou IM, Jollet M-C, Margot A, De Benoist A-C, Moren A. Measles epidemic in the urban community of Niamey: transmission patterns, vaccine efficacy and immunization strategies, Niger, 1990 to 1991. Pediatr Infect Dis J 1994; **13**: 38–45.
13. Ndumbe PM. Do vaccines reach those who most need them? Cameroon. In: Cutts FT, Smith PG, Eds. Vaccination and world health. Chichester: John Wiley, 1994: 225–38.
14. Bernier RH, Orenstein W, Hutchins S, Zell ER. Do vaccines reach those who most need them? United States. In: Cutts FT, Smith PG, Eds. Vaccination and world health. Chichester: John Wiley, 1994: 213–25.
15. Miller E. The new measles campaign. BMJ 1994; **309**: 1102–3.
16. Rosenthal G. The economic burden of sustainable EPI: implications for donor policy. Resources for Child Health Project. Feb. 1990. Arlington: John Snow Inc, 1990.