

Control measures and the outcome of the measles epidemic of 1999 in the Eastern Highlands Province

JOYCE M. MGONE¹, CHARLES S. MGONE², TREVOR DUKE¹, DALE FRANK¹ AND WILLIAM YEKA²

Goroka Base Hospital, Eastern Highlands Province, Papua New Guinea and Papua New Guinea Institute of Medical Research, Goroka

SUMMARY

In the Eastern Highlands Province (EHP) of Papua New Guinea (PNG) measles outbreaks have occurred regularly every 3 to 4 years since 1980. The latest was between September 1998 and March 2000. Between July 1999 and March 2000 314 children with measles were reviewed at Goroka Base Hospital. The majority of these children were very young: 55% were under 1 year and 27% under 6 months. The median age of the measles cases was 11 months (range 10 days to 13 years). 40% of the children had a verifiable history of having received at least one dose of measles vaccine. The majority were vaccinated during the epidemic and included many children who either were below 6 months of age or who developed measles within 2 weeks of vaccination. Measles complications occurred in 82% of the children, the most common being pneumonia. Serious complications, particularly severe pneumonia, were more common among the unvaccinated children than in those who had received at least a single dose of the measles vaccine. No deaths occurred among 82 children who had received measles vaccine more than 2 weeks before the onset of clinical measles, compared with 10 deaths in 206 children who had never been vaccinated against measles or were vaccinated in the 2 weeks before presentation (p=0.067). The overall case fatality was 4%: 14% among the hospital-acquired and 2.5% in community-acquired measles. Improvement in the measles vaccination coverage and supplementary vaccination campaigns are required to prevent measles outbreaks in PNG. Intensified measles vaccination campaigns, such as the one conducted in EHP in 1999, are recommended during epidemics to minimize deaths due to measles and to rapidly control outbreaks. The efficacy of measles vaccination can only be measured in total mortality, not in the prevention of clinical measles.

Introduction

Measles continues to be a major health problem worldwide with about 45 million reported cases annually (1). In developing countries about 1 million children die of the disease each year (2,3) and despite the availability of an efficient and cost-effective vaccine, measles still accounts for 9.5% of 12.2 million children who die before the age of 5 years (4,5). According to the National Health Plan of Papua New Guinea (PNG) for 1974-1978, prior to the 1980s measles was not considered as an important health problem in PNG (6). Since then it has become a major

cause of morbidity and mortality in many parts of the country including the Eastern Highlands Province (EHP). Analysis of paediatric ward admissions to Goroka Base Hospital (GBH) shows that epidemics have occurred at regular intervals of 3 to 4 years with major outbreaks in 1982, 1986, 1988-1989 and 1992. In the major epidemic of 1992 there were 539 measles admissions to GBH with a case fatality of 14% (7). Following the 1992 epidemic until 1995 only 2 sporadic cases were seen at the hospital. No cases of measles were seen in 1996 and 1997. Since many of the major health facilities in the province were reporting very few cases of measles between 1995 and

¹ Goroka Base Hospital, PO Box 392, Goroka, EHP 441, Papua New Guinea

² Papua New Guinea Institute of Medical Research, PO Box 60, Goroka, EHP 441, Papua New Guinea

1998 and 6 years had gone by without any outbreak, it was wrongly assumed that measles was under control and was no longer a major problem.

Although the Expanded Program on Immunization recommended measles vaccine for worldwide use in 1974, it was not until 1982 that it was introduced into the immunization program of PNG (8). Since its routine introduction and despite various immunization campaigns, the coverage has remained low throughout the country. For example, the national and EHP coverage for measles vaccination between 1994 and 1995 were 35% and 8% respectively (9). This is well below the recommended 80% vaccination coverage for achieving a reduction in measles transmission and below the national target coverage level of 70%. Despite the poor vaccination coverage, the low incidence of measles since the previous epidemic of 1992 and the virtual absence of cases since 1995 gave a false sense of security to many health workers and administrators. In August 1998 measles cases started to appear in increasing numbers from various districts in the province and by the end of 1998 a total of 18 had been admitted to GBH with a case fatality of 5%. To prevent a major epidemic and minimize deaths from severe measles as had happened in previous epidemics, control measures were planned. These included conducting an intensified measles vaccination campaign. However, due to logistic and financial constraints the vaccination campaign did not take place until October 1999. Before this, monthly flying vaccination clinics to remote villages of Lufa District in EHP were conducted from April to September 1999, and in October 1999 these flying clinics extended to Obura-Wonenara District. There had been no vaccinations for any antigens done in the latter district in the 12 months before October 1999. During these clinics all children between the age of 4 months and 14 years were vaccinated. This delivered vaccines to over 2000 children. Towards the end of November 1998 all health workers in the EHP were notified of the measles epidemic by a circular letter outlining measures to be undertaken in order to control it and minimize deaths. This included an information sheet on the clinical

criteria for the diagnosis of measles and its management. All health workers were instructed to give measles vaccination to all children above 4 months and a second dose to every child who had been previously vaccinated; to administer 200,000 IU of vitamin A to all measles cases; and to admit to hospital all cases with severe measles. Severity was defined as the presence of pneumonia, gastroenteritis with dehydration, ear discharge, convulsions, difficulty in feeding or malnutrition. Additionally, a study was conducted to define the characteristic features of the affected patients and determine the outcome of the illness. This paper outlines the results of that study.

Material and Methods

From July 1999 to March 2000 all children with the clinical diagnosis of measles who were seen at GBH children's outpatient clinic and in the ward were recruited into the study. Using a standardized questionnaire, demographic and clinical information was recorded. This included the age of the patients, date of birth, place of residence, vaccination history, presence of measles complications and the final outcome of the illness. The measles vaccination history was verified from the child health record book (CHRB). To facilitate this, all suspected cases of measles seen at the outpatient department were reviewed and those with complications admitted and the outcome recorded. An isolation room for measles admissions was set up to minimize nosocomial transmission and to provide supplemental oxygen if required. All non-measles admissions over 2 months of age were given measles vaccine if they had not had two previous doses. All cases were managed according to the standard management protocols. In addition to the standard guidelines, children with severe pneumonia were managed according to a protocol that is currently being used in the GBH paediatric ward (10). This requires pulse oximetry monitoring, oxygen therapy and randomization to treatment with either chloramphenicol alone or benzylpenicillin and gentamicin. Children with severe pneumonia are hospitalized throughout the course of illness until clinical recovery and resolution of hypoxaemia.

Results

Between July 1999 and March 2000 a total of 314 children with measles (199 males and 115 females; male-female ratio 1: 0.58) were recruited into the study. The majority (298 children) were from EHP. Other provinces represented were Simbu 11, Southern Highlands 1, Morobe Province 1 and other unspecified provinces 3. The Districts in EHP where cases came from were Goroka 72, Lufa 62, Ungai-Bena 57, Henganofi 50, Okapa 32, Daulo 19, Kainantu 5 and Obura-Wonenara 1. The median age of measles cases was 11 months (range 10 days to 13 years). The age and sex distributions of these patients are shown in Table 1. 174 (55%) of the children had measles at or before the age of 1 year and 84 (27%) within the first 6 months of life.

TABLE 1

AGE AND SEX DISTRIBUTION OF THE MEASLES CASES

Age in months	Males N (%)	Females N (%)	Total N (%)
0-3	10 (3)	5 (2)	15 (5)
4-6	45 (14)	24 (8)	69 (22)
7-9	36 (11)	16 (5)	52 (17)
10-12	22 (7)	16 (5)	38 (12)
13-18	29 (9)	18 (6)	47 (15)
19-24	17 (5)	12 (4)	29 (9)
≥25	40 (13)	24 (8)	64 (20)
Total	199 (63)	115 (37)	314 (100)

Vaccination status was categorized according to the time between the first dose of measles vaccine and the onset of measles. In the first analysis all children who received the first dose of measles vaccine within 14 days of onset of measles were considered as unvaccinated. 14 days was chosen as the cut-off point to exclude those who may have been vaccinated while incubating measles. The age of vaccination is shown in Table 2. 126 children (40%) gave a history of having received at least one dose of measles vaccine that could be verified in the CHRB (Table 2). However, among these, 32 (25%) had received their first vaccination before the age of 6

months and 44 (35%) within 2 weeks of the onset of measles. Only 40 children (32%) had received two doses of measles vaccine. 162 children gave a history of not having been vaccinated at all and the vaccination status in 26 was unknown.

TABLE 2

VACCINATION STATUS ACCORDING TO AGE OF IMMUNIZATION

Age in months	First dose N (%)	Second dose N (%)
0-5	32 (25)	2 (2)
6-9	54 (43)	6 (5)
10-12	15 (12)	9 (7)
13-18	9 (7)	11 (9)
≥19	4 (3)	2 (2)
Unknown	12 (10)	10 (8)
Total	126 (100)	40 (32)

Measles complications occurred in 259 children (82%). Pneumonia accounted for 75% of all complications. Among the children with measles complications, 59 had a verifiable history of having received at least one dose of measles vaccine given more than 14 days before the onset of measles (Table 3), 188 had not been vaccinated or were vaccinated within 14 days of the onset of measles and in 12 the vaccination history was unknown. Among the 55 children with uncomplicated measles 22 had a verifiable history of vaccination given more than 14 days before the illness, 19 were either not vaccinated or vaccinated within 14 days of the onset of measles and the history of vaccination was unknown in 14 children. The mean interval between vaccination and onset of measles among those who were vaccinated but developed measles within 14 days was 6.5 days. Among those with an unknown history of measles vaccination there were 2 children with severe pneumonia, 4 each with moderate pneumonia and gastroenteritis and 2 with unspecified complications. When those vaccinated within 14 days of onset of measles were considered as not vaccinated, the vaccination rate was 54% among the children who did not develop complications and 24% in those who had complications (Mantel-Haenszel $\chi^2 = 15.36$, 1 df, $p < 0.001$).

TABLE 3

PATTERN OF THE OBSERVED MEASLES COMPLICATIONS ACCORDING TO VACCINATION GIVEN MORE THAN 2 WEEKS BEFORE ONSET OF MEASLES

Complication	Vaccination status		Total	Statistical significance	
	Vaccinated	Unvaccinated		Mantel-Haenszel χ^2	p value
	>2 weeks before onset of measles				
	N	N			
Severe pneumonia	9	44	53	3.89	0.05
Moderate pneumonia	16	87	103	12.32	<0.001
Mild pneumonia	11	22	33	0.53	NS
Gastroenteritis	15	23	38	2.87	NS
Acute otitis media	7	11	18	1.13	NS
Unspecified	1	1	2	-	-
Total	59	188	247		

Note: In 12 children with complications of measles the vaccination history was unknown
 NS = not statistically significant

Analysis was also done according to the immunization status irrespective of the time interval between the first dose of measles vaccination and the onset of measles. This is shown in Table 4. In this group measles complications were also more common among the unvaccinated than the vaccinated children, vaccination rates being 68% and 40%

respectively among those who did not and those who did develop complications (Mantel-Haenszel $\chi^2 = 11.66$, 1 df, $p < 0.001$). In both categories used for defining the vaccination status the statistical significance in the differences between the vaccinated and unvaccinated children was largely attributed to the differences in the incidences of severe and

TABLE 4

PATTERN OF THE OBSERVED MEASLES COMPLICATIONS ACCORDING TO VACCINATION GIVEN AT ANY TIME BEFORE THE ONSET OF ILLNESS

Complication	Vaccination status		Total	Statistical significance	
	Vaccinated (including	Unvaccinated		Mantel-Haenszel χ^2	p value
	≤ 2 weeks before onset of measles)				
	N	N			
Severe pneumonia	16	37	53	4.58	0.03
Moderate pneumonia	37	66	103	3.61	0.06
Mild pneumonia	16	17	33	0.40	NS
Gastroenteritis	19	19	38	0.78	NS
Acute otitis media	8	10	18	0.01	NS
Unspecified	2	0	2	-	-
Total	98	149	247		

Note: In 12 children with complications of measles the vaccination history was unknown
 NS = not statistically significant

TABLE 5

COMPLICATIONS AND IMMUNIZATION STATUS IN 36 PATIENTS WITH HOSPITAL-ACQUIRED MEASLES

Complication	Immunization status			
	Vaccinated	Vaccinated within 2 weeks of measles onset	Unvaccinated	Unknown
Severe pneumonia	2 (6%)	4 (11%)	8 (22%)	0 (0%)
Moderate pneumonia	1 (3%)	4 (11%)	7 (19%)	0 (0%)
Gastroenteritis	3 (8%)	0 (0%)	0 (0%)	0 (0%)
None	5 (14%)	0 (0%)	1 (3%)	1 (3%)

moderate pneumonia, which were far more frequent in the unvaccinated children.

238 children required admission to the hospital including 36 who acquired measles while in the ward. 16 (44%) of the children with hospital-acquired measles had not been vaccinated at all and 8 (22%) were vaccinated within 2 weeks of the onset of measles. Moderate and severe pneumonia were the most common complications in the hospital-acquired measles patients, especially among those who had received no vaccination (Table 5). There were 10 deaths among the admitted cases (5 each in the nosocomial and community-acquired measles) with an overall case fatality of 4%. The case fatality among the hospital-acquired measles was 14% in comparison with 2.5% among the community-acquired measles (Fisher's exact test, $p = 0.01$). All deaths in the hospital-acquired measles cases occurred among the previously unvaccinated children. No deaths occurred among 82 children who had received measles vaccine more than 2 weeks before the onset of clinical measles, compared with 10 deaths in 206 children who had never been vaccinated against measles or were vaccinated in the 2 weeks before presentation (Fisher's exact test, $p = 0.067$).

Discussion

Measles epidemics occur in situations where, against a background of low herd immunity, the number of susceptible individuals increase until they are sufficient to trigger and sustain an outbreak. Since the secondary attack rate of measles is very high (80%), once cases occur transmission is rapid

and continues until the proportion of susceptible individuals falls to 3-7% (11). The epidemic then ceases and the pool of susceptible individuals quickly increases again resulting in another epidemic within 2-3 years from the previous one. To prevent this a very high vaccination coverage and low susceptibility levels are required (12). In the Eastern Highlands Province of Papua New Guinea measles outbreaks have been occurring regularly at least since 1982 when measles admission records have been kept at the Papua New Guinea Institute of Medical Research and Goroka Base Hospital. Although the interval between the previous and the most recent epidemic was unusually prolonged (6 years), most of the other features of the outbreak were similar. These included very young age of the affected children, predominance of pneumonia as a complication of measles and a higher case fatality among children with hospital-acquired than with community-acquired measles.

In the current study the median age of children who had measles was 11 months, with 55% of them being at or below 1 year and 27% at or below 6 months of age. In a study conducted in 1989 at the same hospital among admitted measles patients a similar age distribution pattern was observed in which the mean and median ages of the patients were 17 and 10 months respectively (8). The predominance of measles infection at a young age is typical of many developing countries and is attributed mainly to the rapid loss of maternal antibodies (13-19). Other factors that favour an early age of contracting measles in developing countries are high level exposure to the virus due to overcrowded conditions and

family and social structures that may allow children to come into contact with each other frequently. The predominance of measles infection at a young age has great impact on the management and outcome of the disease. Young age of measles infection is associated with increased morbidity and mortality. The young age of infection also has an important bearing in determining the optimal and the most cost-effective age of giving measles vaccination.

In the current study measles complications were very common, the majority of these being pneumonia. They occurred more frequently among the non-vaccinated than the vaccinated children. Most of the vaccinated children had received only the first dose of measles vaccine. Many of them had been vaccinated in response to the outbreak and were either under the age of 6 months, which is the recommended age of routine measles vaccination in Papua New Guinea, or developed measles within 2 weeks of vaccination. The finding that complications were less frequent in even recently vaccinated children confirms that a single dose of measles vaccine, even when given close to the time of exposure, was highly beneficial. Besides reducing the number of susceptible individuals, immunization during an epidemic also reduces measles complications. Notably absent among the complications were acute central nervous system (CNS) complications, including convulsions and encephalitis. However, subacute sclerosing panencephalitis (SSPE), a late CNS complication of measles, occurs at a very high frequency in EHP (20,21). Recently we have shown that the incidence of SSPE in EHP has remained very high and is of public health concern (21).

Nosocomial measles is associated with a higher case fatality than community-acquired measles (8). In the current study, the case fatality in hospital-acquired measles was approximately 6 times higher than in community-acquired measles. This may be attributed to the higher infective dose of measles in hospital-acquired cases and the weakened condition of children who are already sick enough to be admitted to hospital. Complications were very common among the children with hospital-acquired measles and these contributed to the higher mortality. However, the overall measles case fatality of

4% among the admitted children in the current epidemic is much lower than that of 17% in the epidemic of 1989 (8) and 14% in 1992 (7). Although this may be attributed to the overall improvement in health care delivery, it is most likely to have been largely due to the institution of vaccination during the epidemic and to the improvement of the management of severe pneumonia cases. Vaccination can prevent or attenuate measles even when given within 72 hours of the exposure (22,23). Therefore the efficacy of measles vaccination should be measured in total mortality, not just in the prevention of clinical measles.

Despite the introduction of routine measles vaccination in Papua New Guinea since 1982, measles outbreaks still take place unabated. This is mainly due to low vaccination coverage. In Latin America and the United Kingdom, measles control has been achieved through mass vaccination programs, administered regardless of vaccination history, to preschool and school-age children. In the United States of America similar achievements have occurred by maintaining high coverage over a prolonged period with a two-dose measles vaccine schedule (12). Although mass vaccination can interrupt endemic measles within a very short time, such a strategy will not prevent reintroduction of measles or outbreaks. To prevent outbreaks very high routine vaccination coverage that is augmented by supplementary vaccination campaigns is required. In the Americas, an aggressive three-component approach consisting of catch-up, keep-up and follow-up vaccination programs has been adopted. Catch-up campaigns are one-off, nationwide vaccination programs that target all children aged 9 months to 14 years regardless of history of measles illness or vaccination status. Keep-up programs are routine services aimed at vaccinating more than 90% of each successive birth cohort. Follow-up vaccination programs are the subsequent nationwide immunization campaigns that are conducted every 2-5 years particularly targeting all children born since the catch-up campaign (24). However, in countries like Papua New Guinea where the coverage is low it may be more important first to improve the existing vaccination delivery services and reduce 'missed opportunities'. This should be accompanied by focusing on identified risk-groups such as those living in

remote areas with inadequate immunization facilities and low vaccination coverage and in areas where such services are frequently interrupted by law and order problems or tribal and clan conflicts. It is unfortunate that in many parts of the country it may not be possible even to attain the 70% national target coverage set to be achieved by the year 2000. Therefore there is a need for special efforts to be introduced to reduce the disease burden caused by measles. Currently these should include an early and rapid response of measles vaccination campaigns at the onset of measles outbreaks.

ACKNOWLEDGEMENTS

We thank Dr Samuel Maima, Dr Simon Konae and all the nursing staff of GBH Children's Outpatient Clinic for their help in recruiting the patients.

REFERENCES

- 1 **World Health Organization.** Expanded Programme on Immunization Information System. Report No 95.2:WHO/EPI/CEIS. Geneva: World Health Organization, 1995.
- 2 **Aaby P, Clements CJ.** Measles immunization research: a review. *Bull World Health Organ* 1989;67:443-448.
- 3 **Ndikuyeze A, Cook A, Cutts FT, Bennett S.** Priorities in global measles control: report of an outbreak in N'Djamena, Chad. *Epidemiol Infect* 1995;115:309-314.
- 4 **World Health Organization.** Global Programme for Vaccines and Immunization. Using Surveillance Data and Outbreak Investigations to Strengthen the Measles Immunization Programme. Geneva: World Health Organization, 1996.
- 5 **World Health Organization.** Global Programme for Vaccines and Immunization. Progress of Vaccine Research and Development and Plan of Activities - 1996. Geneva: World Health Organization, 1996.
- 6 **Papua New Guinea Department of Public Health.** Papua New Guinea National Health Plan 1974-1978. Port Moresby: Department of Public Health, 1974:244.
- 7 **Goroka Base Hospital.** Annual Report 1992. Goroka: Goroka Base Hospital, 1992.
- 8 **Coakley KJ, Coakley CA, Spooner V, Smith TA, Javati A, Kajoi M.** A review of measles admissions and deaths in the paediatric ward of Goroka Base Hospital during 1989. *PNG Med J* 1991;34:6-12.
- 9 **Papua New Guinea Department of Health.** Papua New Guinea National Health Plan 1996-2000. Port Moresby: Department of Health, 1996:151.
- 10 **Duke T, Mgone J, Frank D.** Hypoxaemia in children with severe pneumonia in Papua New Guinea. *Int J Tuberc Lung Dis* 2000, in press.
- 11 **de Quadros CA, Olive JM, Hersh BS, Strassburg MA, Henderson DA, Bradling Bennett D, Alleyne GA.** Measles elimination in the Americas. Evolving strategies. *JAMA* 1996;275:224-229.
- 12 **Heath T, Burgess M, McIntyre P, Catton M.** The national measles surveillance strategy. The National Centre for Disease Control Measles Elimination Advisory Committee. *Commun Dis Intell* 1999;23:41-50.
- 13 **Al Karim OA, Salih MAM.** Morbidity and mortality from measles in an urban community of the Sudan. *Ann Trop Paediatr* 1981;1:227-230.
- 14 **World Health Organization Expanded Programme on Immunization.** Seroconversion after measles vaccination - Tanzania. *Wkly Epidemiol Rec* 1981;30:234-237.
- 15 **Bhaskaram P, Radhakrishna KV, Madhusudan J.** Seroepidemiological study to determine age for measles vaccination. *Indian J Med Res* 1986;83:480-486.
- 16 **Eghafona NO, Ahmad AA, Odama LE, Onuora C, Gosham LT, Emejuaiwe SO, Woghiren EI.** The levels of measles antibodies in Nigerian children aged 0-12 months and its relationship with maternal parity. *Epidemiol Infect* 1987;99:547-550.
- 17 **Rogers S, Sanders RC, Alpers MP.** Immunogenicity of standard dose Edmonston-Zagreb measles vaccine in highland Papua New Guinean children from four months of age. *J Trop Med Hyg* 1991;94:88-91.
- 18 **Garenne M, Aaby P.** Pattern of exposure and measles mortality in Senegal. *J Infect Dis* 1990;161:1088-1094.
- 19 **Aaby P, Bukh J, Kronborg D, Lisse IM, da Silva MC.** Delayed excess mortality after exposure to measles during the first six months of life. *Am J Epidemiol* 1990;132:211-219.
- 20 **Lucas KM, Sanders RC, Rongap A, Rongap T, Pinai S, Alpers MP.** Subacute sclerosing panencephalitis (SSPE) in Papua New Guinea: a high incidence in young children. *Epidemiol Infect* 1992;108:547-553.
- 21 **Takasu T, Mgone JM, Mgone CS, Komase K, Miki K, Kokubun Y, Nishimura T, Marcus J, Asuo P, Alpers MP.** A continuing high incidence of subacute sclerosing panencephalitis in the highlands of Papua New Guinea. Abstract in Programme and Abstracts of the Thirty-fourth Annual Medical Symposium of the Medical Society of Papua New Guinea, Port Moresby, 7-11 Sep 1998:41-42.
- 22 **Centers for Disease Control.** Measles prevention: recommendations of the Immunization Practices Advisory Committee (ACIP). *Morb Mortal Wkly Rep* 1989;38:1-18.
- 23 **Centers for Disease Control.** Measles outbreak - Washington, 1989: failure of delayed postexposure prophylaxis with vaccine. *Morb Mortal Wkly Rep* 1990;39:617-619.
- 24 **World Health Organization.** Measles progress towards global control and regional elimination, 1990-1998. *Wkly Epidemiol Rec* 1998;73:389-396.