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The epidemiology of snake bite in Central Province and National Capital District, Papua New Guinea

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Abstract

Snake bite is an important medical problem in some areas of Papua New Guinea and appears to be most common in the Central Province and National Capital District. The overall incidence for Central Province is 215·5 per 100 000 population, but Kairuku subprovince has an incidence of 526 per 100 000, which is amongst the highest in the world. The clinical pattern of envenoming also varies within the Province, suggesting that different species of snake may be responsible for bites in different areas. Most envenomed patients are bitten during daylight on the lower limb and are rarely able to describe the snake. The mortality rate in Central Province is 7·9 per 100 000; most patients die from ventilatory failure due to severe neurotoxicity. Mortality might be reduced by increased use of compression bandaging as a first aid measure, earlier treatment with antivenom and earlier referral to hospital.

Keywords: snake bite, epidemiology, Papua New Guinea

Introduction

Central Province and National Capital District (NCD) lie on the south-west coast of Papua New Guinea (PNG), surrounding the capital, Port Moresby (Fig. 1). The area

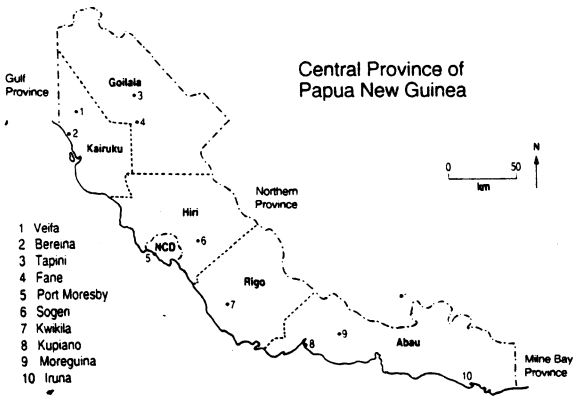

Figure 1: Health centres and subprovinces within Central Province, Papua New Guinea

was one of the first contacted by western explorers in the late 18th century and snake bite has been recognized as a significant health care problem in PNG since then; the many myths and legends surrounding snake bite in this region indicate its importance to the population (RILEY, 1925; WILLIAMS, 1936). Despite reports of snake bite as the main cause of death in some isolated communities in PNG (GAJDUSEK, 1977), few studied the problem until the work of Campbell in the 1960s. He identified the major biting species in the region: taipan (*Oxyuranus scutellatus canni*), death adder (*Acanthophis* sp.) and Papuan black snake (*Pseudechis papuanus*), and described clinical syndromes associated with envenoming by each of these species (CAMPBELL, 1966, 1967a, 1967b, 1969). Central Province and the NCD have the highest incidence of snake bite in the country (D.G. Lalloo, unpublished observations) but, although numbers of hospital admissions have been documented, only one recent study has attempted to make estimates of the incidence in the general population (CURRIE *et al.*, 1991). As part of a large clinical study of snake bite, we attempted to define accurately its incidence and mortality rates throughout Central Province and National Capital District and to examine its epidemiology in this region.

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Methods

Incidence

Figures were gathered from health centres throughout Central Province and from Port Moresby General Hospital in PNG. Health centres treating patients with snake bite were identified from centralized records of disease code upon discharge from the years 1987–1991. Copies of the monthly discharge notification for these centres were reviewed and details of the patients' age, sex, month of admission, admission number and survival were recorded. The 5 health centres treating large numbers of patients were visited. Numbers and details of patients were cross-checked against those from the central records. Case notes for 1990 and 1991 were checked for mention of signs consistent with envenoming and details were entered on standard forms. Data for hospital patients were obtained from intensive care unit and medical ward records from 1987 to February 1990 (only inpatients could be identified for this period as casualty records were no longer available) and from a prospective study of all suspected snake bite patients admitted or observed as outpatients for 1990–1992.

The annual incidence of snake bite during a period of 5 years in each of the 5 subprovinces within Central Province was calculated using admission figures from individual health centres (including patients bitten in subprovinces who had presented directly to the hospital) and preliminary figures from the 1990 population census. Incidence rates for NCD were calculated from hospital figures after exclusion of patients who had been referred or who had come directly to hospital from Central Province.

Mortality rates

Deaths occurring in each health centre were recorded. Examination of all death certificates issued for the 5 years period identified deaths in hospital and some deaths occurring in the periphery. Numbers were cross-checked by looking at casualty records for 'dead on arrival' and at admission books to identify patients dying in hospital. Details and the mode of death of each case were recorded from clinical records.

Circumstances of the bite

Clinical features, geographical location and time of the bite were recorded from health centre records. Clinical features in envenomed patients from each of the 5 major health centres were compared. More detailed clinical information and further details of the circumstances of the bite were recorded for patients presenting to hospital. The variation in snake bite admissions to the hospital was

compared with rainfall figures for the area around Port Moresby (provided by the National Meteorological Office).

Results

Incidence

The numbers of patients admitted to each major health centre and to Port Moresby General Hospital for the years 1987–1991 are shown in Table 1. The mean number of cases admitted per year varied markedly between health centres, from 2·2 in Tapini to 111·0 in Veifa. Incidence of snake bites in each of the 5 subprovince areas within Central Province are shown in Table 2. There was a marked variation in annual incidence between subprovinces: the incidence in Kairuku was 25 times greater than that in Goilala subprovince.

Table 1. Admissions following snake bite in Central Province, Papua New Guinea, 1987–1991

Year	Health Centres										
	Bereina	Veifa	Kwikila	Kupiano	Moreguina	Iruna	Sogeri	Tapini	Others	Total	PMGH[a]
1987	14	83	62	18	18	7	3	0	1	206	–[b]
1988	16	143	59	17	25	13	4	1	2	280	–[b]
1989	8	107	47	10	37	5	5	5	0	224	–[b]
1990	34	140	46	21	23	1	4	4	2	275	98
1991	34	82	45	24	20	8	3	1	9	226	112
Total	106	555	259	90	123	34	19	11	14	1211	–
Mean	21·2	111	51·8	18	24·6	6·8	3·8	2·2	2·8	242·2	105

[a]Port Moresby General Hospital (excluding referred patients).
[b]Figures for non-envenomed patients not available.

Table 2. Annual snake bite incidence in Central Province, Papua New Guinea

	Subprovinces					Central Province	National Capital District
	Kairuku	Rigo	Abau	Hiri	Goilala		
Mean annual admissions	154	53·5	49·5	33	4·5	303	59·5
Population	29266	30353	30515	28638	21812	140584	193242
Annual incidence/100 000 population	526·2	176·3	162·2	115·2	20·6	215·5	30·8

Patients and pattern of clinical signs

The mean age of patients admitted to health centres was 25·0 years; 8·5% were under the age of 10 years. Males generally predominated and the overall sex ratio was 1·39:1, although in Veifa there was a male to female ratio of 0·87:1. Although the proportion of patients with signs of envenoming (excluding lymphadenopathy alone) was similar in the 4 bigger health centres (between 27·9% and 33·3%), there were major differences in the patterns of clinical signs (Table 3). Only one-third of patients in Bereina and Veifa had prolonged blood clotting times, compared to up to 80% in health centres to the south of Port Moresby. The incidence of neurotoxicity was similar in different centres but only 6% of patients in Veifa required eventual intubation in Port Moresby General Hospital, compared with 30% of envenomed patients from Kwikila. The mean length of stay in hospital or health centre was longer for patients from Kwikila than for those from Veifa (4·7 and 2·1 d respectively).

Circumstances of the bite

Detailed information was available for 335 patients (205 envenomed) seen in hospital. The incidence of snake bite was lowest in April and May and increased towards the end of the year, similarly to the pattern seen in health centres. No clear relationship to rainfall was seen (Fig.2). Most envenomed patients (89·4%) were bitten during the day, although 46% of non-envenomed patients were bitten after dark. All but 2 patients were bitten outside, most while tending their garden, on the way to the garden or walking in the bush; patients often described being bitten by a fast moving snake in long grass (Table 4). Only 57% of envenomed patients could give any form of description of the snake and only 16 patients (6·5%) gave a description that clearly identified the species of snake that had bitten them. These patients all described a dark snake with a reddish or orange streak on its back, consistent with the taipan. Only 2 envenomed patients and 8 non-envenomed patients (3%) killed and brought the snake with them to hospital. Most patients (86%) were bitten on the foot, ankle or lower leg, although 2 women were bitten on the buttocks whilst urinating in long grass. First aid measures were reported by 60·5% of patients, although this probably underestimates the frequency of use of both short-term tourniquets and traditional medication. Superficial cuts around the wound and on the bitten limb (34·7%) and tourniquets (32·1%) were the commonest methods used; no complication from excessively tight tourniquets was seen. The use of compression bandaging, the recommended first aid treatment for Australasian elapid bites (SUTHERLAND, 1979), was uncommon and had always been applied at a small aid post.

Mortality

Case fatality rates (Table 3) varied widely between health centres but the small number of reported deaths overall makes it difficult to draw conclusions from these figures. A mean of 6·5 patients died per year in Central Province health centres in 1990 and 1991; in Port Moresby General Hospital from 1987–1992, an annual

Table 3. Clinical signs in envenomed patients from different health centres in Papua New Guinea

	Health Centres				
	Bereina	Veifa	Kwikila	Kupiano	Moreguina
No. of patients	10	68	27	16	6
Local signs (%)	75·0	77·2	76·9	76·9	60·0
Neurotoxic signs (%)	100·0	81·3	88·0	68·8	70·0
Incoagulable blood (%)	33·3	33·3	80·0	71·4	60·0
Clinical bleeding (%)	16·7	31·7	70·4	56·3	16·7
Intubation (%)	10·0	5·9	29·6	26·3	16·7
Survival (%)	70·0	97·1	85·2	93·8	83·3
Mean length of admission (d)	–	2·1	4·7	3·3	4·0
Referral rate					
All bites (%)	4·4	3·6	27·5	26·7	4·7
Envenomed (%)	15·8	12·9	80·7	75·0	33·3

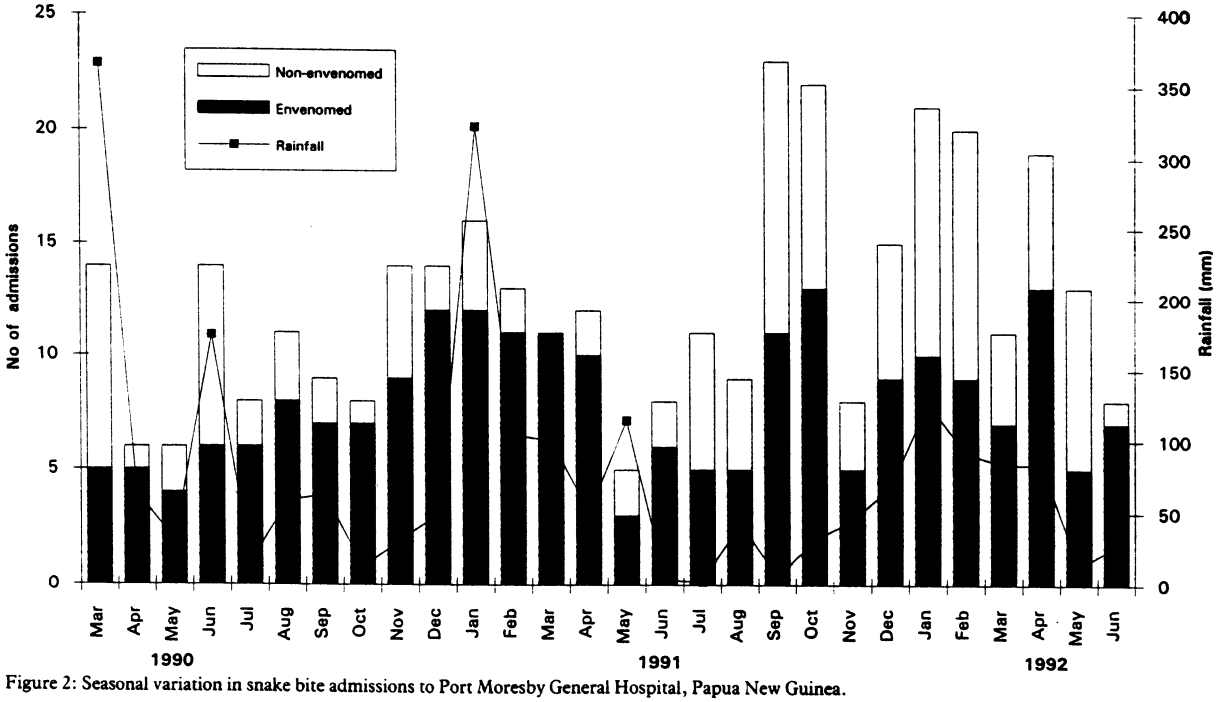

Figure 2: Seasonal variation in snake bite admissions to Port Moresby General Hospital, Papua New Guinea.

Table 4. Circumstances of snake bite, Papua New Guinea

Activity	No. of patients Envenomed	Non-envenomed
Near water	13 (7·2%)	3 (2·9%)
In garden	36 (20%)	18 (17·3%)
Near house	7 (3·9%)	7 (6·7%)
Toilet/urinating	8 (4·4%)	13 (12·5%)
Walking	64 (35·6%)	34 (32·7%)
In bush (e.g. collecting wood)	25 (13·9%)	17 (16·3%)
Chasing/playing with snakes	2 (1%)	2 (2%)
Hunting	7 (3·9%)	1 (1%)
Sleeping/sitting	7 (3·9%)	3 (2·9%)
Children playing	4 (2·2%)	1 (1%)
Other	7 (3·9%)	5 (4·8%)

mean of 2·4 patients were dead on arrival and 3·6 died as inpatients. Discussion with health centre personnel revealed that a substantial number of patients also died from snake bite before reaching medical help, but it proved impossible to quantify this. Using these figures, the annual population mortality was 3·7 per 100 000 for Central Province and NCD combined and 7·9 per 100 000 for Central Province alone; this underestimates the true rates. The overall case fatality rate for envenomed hospital inpatients from 1987 to mid 1992 was 4·4%; the particular vulnerability of children to snake bite is emphasized by the difference in case fatality rates for children aged under 10 years (10·0%) and adults (3·3%).

Mode of death

Descriptions of patients dying before reaching medical help or soon after arrival suggested respiratory paralysis as the cause of death. In health centres, most patients died within 12 h of the bite. The cause of death in 22 patients who died in Port Moresby General Hospital over 5½ years is shown in Table 5. The major causes of death were respiratory arrest, either just before or soon after arrival at hospital or while inadequately observed on the wards, and delayed intubation, aspiration and the development of pneumonia.

Table 5. Deaths following snake bite, Papua New Guinea

No.	Age (years)	Sex[a]	Coagulopathy[a]	Neurotoxicity[b]	Time to hospital (h)	Time to death after admission (h)	Circumstances
1	3	F	Y	Y	1·25	11	Delayed intubation, excessive bleeding, aspiration
2	30	F	Y	Y	3·5	96	Severe coagulopathy, renal failure, blocked endotracheal tube
3	–	M	Y	Y	4·5	40	Delayed intubation, aspiration, O_2 failure
4	7	M	Y	Y	–	24	Delayed diagnosis, probable intracerebral bleeding
5	14	M	Y	Y	1·75	45	Delayed intubation, aspiration
6	4	M	Y	Y	13	53	Cardiac arrest on ventilator
7	47	M	–	–	–	1	Cardio-respiratory arrest soon after arrival
8	35	M	Y	Y	12	60	Arrest on ward, anoxic brain damage
9	18	F	Y	Y	10	96	Ventilator malfunction, arrest
10	6	F	N	Y	–	24	Delay in ventilation, arrest, anoxic damage
11	–	M	N	Y	12	192	Respiratory arrest, slow response to resuscitation
12	9	M	N	Y	18	72	Respiratory arrest on ward, anoxic brain damage
13	55	M	Y	Y	14·5	288	Delayed intubation, aspiration, blocked endotracheal tube
14	24	F	Y	Y	4·5	0·5	Arrest 30 min after arrival
15	16	F	N	Y	46·5	0·5	Respiratory arrest on arrival
16	40	M	Y	Y	1·25	48	Cardiac arrest, uncertain cause
17	3	M	N	Y	1·25	24	Difficult intubation, anoxia
18	15	F	Y	Y	3·5	576	No antivenom, failure to get off ventilator
19	20	F	–	–	2·5	0·5	Asystole just after admission
20	7	F	–	Y	24	48	Probable anoxia on admission
21	10	M	Y	Y	4·75	0·5	Admitted with respiratory arrest
22	60	M	Y	Y	7·5	312	Sudden death

[a]F=female, M=male.
[b]N=no, Y=yes.

Discussion

This study demonstrated that snake bite was frequent in this region of PNG. The annual incidence for Central Province of 215 bites per 100 000 population was higher than that in many other parts of the world and the rate of 526 bites per 100 000 population seen in Kairuku subprovince is exceeded in only a few tropical regions, such as West Africa or French Guiana where studies have reported an incidence of up to 600 bites per 100 000 population (WARRELL & ARNETT, 1976; PUGH & THEAKSTON, 1980; CHIPPAUX & THEAKSTON, 1987). The true incidence may be even higher; patients bitten in a village may not present for medical attention, either because their symptoms are mild, as demonstrated in other parts of the tropics (REID & LIM, 1957), or because they are bitten in remote areas and either die or recover spontaneously before reaching medical help. However, some patients who reported a snake bite but developed no sign may not have been bitten by snakes. CAMPBELL (1969) reported an average of 112 patients each year admitted to Central Province health centres and Port Moresby General Hospital in 1962–1967, which suggests that the incidence of snake bite may be increasing. However, because the population has increased and a much larger proportion is now able to reach health care, it is difficult to be sure whether this apparent increase is real. Our finding of an incidence of envenoming of 62·6 per 100 000 for Central Province is broadly in agreement with the reported incidence of envenoming of 81·8 per 100 000 in rural Papua (CURRIE *et al.*, 1991), as that study excluded certain areas of Central Province. Some of the variation in incidence between subprovinces is easily explained. The large subprovince of Goilala includes the foothills of the Astrolabe range, reaching up to 4000 m. Few venomous snakes would be expected to live at altitudes above about 1500 m. However, Rigo, Abau and Kairuku have a similar population and Rigo and Kairuku occupy approximately the same land area, but the incidence of bites in Kairuku was 3 times that in Rigo. In the absence of other obvious differences, it seems most likely that this was due to differing densities and species of snake in the 2 regions.

The mean age and proportion of children bitten was similar to those found in previous studies (CAMPBELL, 1969; CURRIE *et al.*, 1991). Children accounted for 16% of envenomed patients but only 6·9% of non-envenomed patients; this may reflect a difference in behaviour patterns but probably indicates that their lower body weight makes them more vulnerable to the effect of the average dose of venom injected by a snake. Although males predominated, the male:female ratio was less than the 4:1 reported by CAMPBELL (1969); this might be because men hunt much less now as food is available commercially. In contrast to northern PNG, where most snake bites occur in the wet season (HUDSON & POMAT, 1988), no clear seasonal pattern emerged from our data, although bites were less common during the drier months in the middle of the year. Although SLATER (1968) and O'SHEA (1990) recorded that the taipan, death adder and Papuan black were most active at the beginning of the wet season, end of the wet season, and end of the dry season respectively, our data showed no evidence of this. Like CAMPBELL (1969) and CURRIE *et al.*, (1991), we found that most envenomed patients were bitten during the day. The taipan and the Papuan black snake are predominantly diurnal snakes and, although the death adder is nocturnally active, its habit of sleeping during the daytime on paths probably leads to most of the contact with humans. Bites at night are more likely to be by non-venomous snakes, as most species in this area are nocturnal, and patients are also more likely to misinterpret a scratch or a bite by an insect in unlit rural areas at night.

Few patients were bitten near their homes and so standard advice such as clearing long grass in the vicinity of dwellings is unlikely to have much impact on the frequency of snake bite in PNG. The tall kunai grass that covers much of the savannah area made it very difficult for snake bite victims to see the snake and very few snakes were killed. This problem of identification of the biting species is unique to PNG; in large studies of snake bite elsewhere, dead snakes have been brought in by patients in 40–50% of cases (WARRELL *et al.*, 1977; CHIPPAUX & THEAKSTON, 1987). In the absence of reliable visual identification, clinicians are forced to use more expensive polyvalent antivenom, and have difficulty deciding which patients should be referred to hospital. First aid measures were reported by only 60% of patients and traditional methods were surprisingly rare. Despite education campaigns, few patients used the compression immobilization method presently advocated in Australia (SUTHERLAND, 1979). Considerable efforts are required, both to educate the population and health staff and to overcome the practical problems of supplying suitable bandages to rural areas, before this method is likely to be of great value in this environment. As in most other studies of snake bite in the tropics, bites occurred most commonly on the foot or leg and the wearing of shoes is the intervention most likely to reduce the incidence of snake bite in PNG (CAMPBELL, 1969). Enzyme immunoassay of serum from envenomed patients admitted to Port Moresby General Hospital showed that taipans caused 83·2% of all cases. *Acanthophis* sp., *P. papuanus* and *P. textilis* were responsible for 10·8%, 4·2% and 1·8% of bites respectively (LALLOO *et al.*, 1994). Because of the bias induced by referral to hospital for treatment of severe neurotoxicity, these results cannot be extrapolated to the whole of Central Province. However, the difference in frequency and clinical pattern of bites between Kairuku and the health centres south of Port Moresby may suggest that different species of snake predominate in the 2 regions (TREVETT & LALLOO, 1992). The observation of less frequent severe neurotoxicity and incoagulable blood is consistent with the clinical pattern of bites by the Papuan black snake (LALLOO *et al.*, 1994). This species may cause most cases of envenoming in the Veifa region, while the taipan does so in Rigo. There is circumstantial evidence to support this. During this study, Veifa was the only place where Papuan black snakes were collected. The slightly higher rainfall and large areas of swamp would be consistent with the snake's reported preferences (SLATER, 1968). The low prevalence of the cane toad, thought to be responsible for the disappearance of the Papuan black snake from other areas of the Province, may also be relevant (CURRIE *et al.*, 1991; LALLOO *et al.*, 1994). Unfortunately, while it is clear that taipans are responsible for many bites in the Rigo area, the low referral rate from Veifa makes interpretation of immunoassay results difficult. Of 19 referred patients from this region, 15 were bitten by taipans, 2 by death adders and 2 by Papuan black snakes (CURRIE, 1992 and our unpublished observations). Only a study based in Veifa would resolve this question.

The annual mortality from snake bite in Central Province is 7·9 per 100 000 population. Higher rates have been reported from only a few countries such as Burma (15 per 100 000) and certain regions of Nigeria (up to 60 per 100 000) (SWAROOP & GRAB, 1956; PUGH & THEAKSTON, 1980). Most of the fatalities could be explained by the severe neurotoxicity and poor response to antivenom associated with taipan bites, and the absence of facilities for ventilation. This contrasts with envenoming by species in other tropical regions which frequently cause death by severe haemorrhage, shock or renal failure (WARRELL *et al.*, 1977; THEIN-THAN *et al.*, 1991). Our clinical studies suggested that earlier treatment with antivenom would have helped to reduce the incidence of severe neurotoxicity. A number of deaths could be attributed to a delay in referral. Earlier referral from health centres of patients with neurological signs might reduce mortality. However, patients died as soon as 2·5 h after the bite. If compression bandaging delays absorption of the venom and the onset of severe neurotoxicity, mor-

tality rates might be reduced; the case fatality rate among hospital inpatients was only 2·4% when patients reached hospital before the onset of respiratory involvement. Most of the deaths in hospital were potentially avoidable and were usually due to problems with the care of intubated patients, or inadequate observation of respiratory function. Education of the population and health care workers about the importance of first aid and early attendance at health centre or hospital together with the development of further medical and nursing expertise, particularly in the care of paediatric patients, might result in lower mortality.

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