An epidemiological study of snake bite envenomation in Papua New Guinea

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We report a study of 347 patients with snake bite envenomation in Papua New Guinea. The male: female ratio of the victims was 1.6:1 and their mean age was 24.5 years; 26% were children less than 15 years old. In all cases in which the bite site was known (334) the snake had bitten the extremities of the victim, with 71.3% of these bites being on the ankle or below. The patients came from three regions: urban Papua, rural Papua and (mostly rural) New Guinea. Snake bites occurred more frequently during the daytime in all regions, but this pattern was less obvious in New Guinea ($P = 0.004$), reflecting the predominance of the death adder *(Acanthophis antarcticus)* in New Guinea and of the taipan *(Oxyuranus scutellatus canni)* in Papua. Bites were commoner in the rainy season (November to April) in all groups, but this was less noticeable in rural Papua and New Guinea ($P = 0.004$). This may relate to seasonal activities of the rural population. The female:male ratio for patients from rural areas was higher for those 30 years of age and over than for those under 30 ($P = 0.034$), probably reflecting the increased gardening workload of older women. The incidence of envenomation and mortality rates after snake bite in Papua appear to have changed little over 25 years. However, increased relative numbers of taipans seem to be occurring in central Papua possibly related to the cane toad *(Bufo marinus)* and deforestation. We calculate the annual incidence of envenomation and the mortality rate per 100 000 to be 81.8 and 4.3, respectively, for rural central Papua, 21.8 and 2.1 for urban central Papua, and 3.0 and less than 1.0 for the Madang region of New Guinea. The importance of a standard management protocol and of improved first aid are emphasised.

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Over 20 years have passed since Campbell's pioneering work in central coastal Papua describing the important clinical and epidemiological features of snake bite in Australasia.[1] A recent study suggested that, at least in children, snake bites are becoming less frequent in subtropical Australia.[2] In addition, mortality from snake bite in Australia is decreasing.[3,4] We report here the results of an epidemiological study of serious snake envenomation in Papua New Guinea, and compare aspects of this study with Campbell's original data and with other studies.

Subjects and methods

Only cases of snake bite receiving antivenom were included in this study. Information was collated from three sources: (i) all patients who required antivenom during a 30-month prospective study of snake bite victims treated at Port Moresby General Hospital, beginning January 1987; (ii) patients treated with snake antivenom at Madang General Hospital between 1978 and 1988; and (iii) data sheets returned to the Commonwealth Serum Laboratories, Melbourne, for patients given antivenom in Papua New Guinea between 1983 and 1988.

The data sheets returned to the Commonwealth Serum Laboratories ($n = 103$) represent only a small proportion of the patients given antivenom in Papua New Guinea, even though the sheets are enclosed with the antivenom. They were cross-checked with information from the other two sources to avoid duplication.

Port Moresby General Hospital admits patients from rural central Papua (Central Province), as well as from its own urban region (National Capital District). The Madang General Hospital patients were mostly from rural areas of the Madang Province of New Guinea.

A database was established recording age, sex, month of bite, time of bite, site of bite and location within Papua New Guinea. Analysis was performed using the Statistical Package for Social Sciences (SPSS-X).

A log linear model was constructed to examine the relationships among the recorded parameters. For this analysis patients were grouped into three geographical regions; urban Papua (National Capital District including Port Moresby); rural Papua (Central Province and other regions); and New Guinea (Madang region and other regions, predominantly rural). Patients were classified as children (less than 15 years old) or adults. The time of bite was grouped as morning (6 a.m. to 12 p.m.), afternoon (12 p.m. to 6 p.m.), or night (6 p.m. to 6 a.m.). The season of bite was classified as rainy (November to April) or dry (May to October). Analysis of the log linear model was conducted using GLIM (Generalised Linear Interactive Modelling).[5]

Calculated projections of the 1980 Census figures[6] were used to determine incidence and mortality rates.

Results

Information was collected on 347 cases, with complete data available for 317 (91.4%). Table 1 gives a summary of the data.

TABLE 1: Summary of the data collected on snake bites with envenomation in Papua New Guinea

	No. (%) of bites ($n = 347$)
Sex of victim	
Male	215 (62.0%)
Female	132 (38.0%)
Age of victim	
< 15	90 (25.9%)
≥ 15	238 (68.6%)
Unknown	19 (5.5%)
Season of bite	
Rainy (November–April)	197 (56.8%)
Dry (May–October)	150 (43.2%)
Time of day of bite	
0600–1159	88 (25.4%)
1200–1759	193 (55.6%)
1800–0559	53 (15.3%)
Unknown	13 (3.7%)
Geographical region	
Urban Papua	75 (21.6%)
Rural Papua	208 (60.0%)
New Guinea	64 (18.4%)

Of the 208 cases from rural Papua, 188 (90%) were from Central Province. Of the

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64 cases from New Guinea, 48 (75%) were from the Madang region.

The patients' ages ranged from 2 to 67 years (mean 24.5, SD 13.8). One quarter were children under 15 years old. A higher proportion of the victims were men than would be expected from the 1980 Census (52% men in the Census; $\chi^2_1 = 13.79$, $P < 0.001$), and bites were commoner in the rainy season (November till April) ($P = 0.012$).

Fifty-six per cent of bites occurred during the afternoon, 25% during the morning and 15% at night. The mean and median times at which bites occurred were 1351 and 1400 hours, respectively.

The sites of bites are shown below (in 13 cases the site was unknown).

Bite site	*Number (n = 334)*	
Toe	33	(9.9%)
Foot	171	(51.2%)
Ankle	34	(10.2%)
Lower leg	72	(21.6%)
Upper leg	6	(1.8%)
Finger	11	(3.3%)
Hand	6	(1.8%)
Arm	1	(0.3%)

All bites occurred on the extemities. In 71.3% of patients the bite was on the ankle or below, and in only 5.4% was it on the upper limb.

The log linear model constructed to examine the relationships among the factors detailed in Table 1 generated a 72-cell table, cross classifying by age, sex, season, time of day and geographical region. When all first order interactions among these factors were analysed by means of GLIM, only the interactions between season and geographical region, and between time of day and geographical region were significant. Snake bites were commoner in the rainy season, but this pattern was less obvious for rural Papua and for New Guinea than for urban Papua ($\chi^2_2 = 11.22$, $P = 0.004$). More snake bites occurred during the day, but this was less noticeable for New Guinea than for urban and rural Papua ($\chi^2_4 = 15.08$, $P = 0.004$). The second order interaction between season, time of day and geographical region was not significant ($\chi^2_4 = 3.58$, $P = 0.47$).

Analysis of the constructed model showed no significant interaction between age and sex, but it was evident that the female:male ratio increased with age. We therefore examined the age groups less than 15, 15 to 29, and 30 years and over. The urban Papuan group was omitted because of a significant predominance of men in the Port Moresby population. The female:male ratios of the three age groups were 0.46:1.0, 0.54:1.0 and 0.91:1.0. The difference in sex ratios between those less than 30 and those 30 years and over was significant ($P = 0.034$).

TABLE 2: Incidence of envenomation and mortality rate

Region	Rate per 100 000 per year			
	Incidence (all ages)	Age specific incidence*	Mortality (all ages)	Age specifi mortality*
Central Papua — rural (Central Province†)	81.8	ND	4.3	ND
Central Papua — urban (National Capital District)	21.8	17.6	2.1	3.3
New Guinea (Madang Region)	3.0	ND	<1.0	ND

*Children <15 years old. † Excluding Goilala region. ND = not determined.

The prospective data from the 30-month Port Moresby study (together with unpublished data collected concurrently from rural Health Centres in Central Province), and the prospective data from Madang over the three years, 1985–1988, were used to calculate regional incidence rates for envenomation and mortality rates (Table 2).

Discussion

Interpretation of epidemiological data on snake bite is difficult because of the different criteria used in diagnosis. For example, when Campbell included suspected cases of snake bite he found a much higher proportion of nocturnal bites than when analysing only cases of venomous snake bite.[1] This probably reflects both increased diagnostic error at night and differences in the diurnal rhythms of various venomous and non-venomous snakes. By only including patients receiving antivenom we hoped to minimise error in diagnosis, and to look at the real morbidity of snake bite.

The patients in the Port Moresby and Madang Hospital studies all had signs of envenomation, and 233 out of 244 (95%) had serious envenomation (neurotoxicity and/or defibrination). This reflects both late presentation and the management protocol for snake bite and antivenom use in Papua New Guinea, as outlined in standard treatment manuals.[7] It is difficult, therefore, to compare this study with the recent Queensland epidemiological study of 218 children with suspected or confirmed snake bite.[2] In that study only nine children were seriously envenomed, and of the 14 cases who received antivenom five had no signs of envenomation.

From the results of a questionnaire distributed throughout Papua New Guinea, Bell recorded 34 deaths from snake bite in Papua New Guinea in 1971.[8] This compared with only 14 deaths from snake bite reported in the same year through hospital death certificates. Bell concluded that there were possibly over 200 snake bites each year in Papua New Guinea. Campbell calculated an average of 155.5 admissions per year in Papuan hospitals between 1961 and 1967 for snake bite or suspected snake bite, with 6.3 cases per 1000 total admissions.[1] However, during that time only between one and eight deaths from snake bite were notified each year in Papua. Campbell did not look at snake bite in New Guinea, but it is unlikely that snake bite fatalities in New Guinea account for the differences between Bell's and Campbell's figures. Rather, the differences relate to difficulties with diagnosis of snake bite and to underreporting in the many rural and remote areas of the country.

We are able to make some useful comparisons between the Papuan groups in our study and Campbell's study of 123 patients with venomous snake bite (111 of whom developed clinical envenomation).[1] The age distribution, time of bite, bite site and seasonal distribution are all very similar. The male:female ratio, however, was 4:1 in Campbell's study compared with 1.6:1 in our study. This reflects the urban majority (57%) in Campbell's study, with male urban population predominance being greater at that time. Over the six years of his study beginning in 1959 Campbell recorded 61 cases of urban (National Capital District) envenomation, giving a rough annual urban envenomation rate of 30 per 100 000. This is similar to the 22 per 100 000 in our study. The mortality rate of envenomed patients in Campbell's study was 6.8%. The mortality rate for the patients in our study who were treated at Port Moresby General Hospital was 6.3% (unpublished data). Over the 30-month period, 56 patients required intubation and ventilation and snake bites accounted for 52% of the patients requiring ventilation in the Intensive Care Unit (unpublished data).

The year round activity of snakes in the tropics is well known,[9] and this explains the lesser seasonal snake bite variation in our

study compared with that in the Queensland (subtropical) study.[2] The reason for the significant seasonal difference when comparing urban Papua with rural Papua and (predominantly rural) New Guinea remains uncertain. The lower peak during the rainy season in the rural areas may reflect reduced time spent outdoors by rural dwellers in the "wet" season.

The significant decrease in daytime bite prevalence in New Guinea relates to the distribution of venomous snakes within the country. In the central Papuan region the taipan *(Oxyuranus scutellatus canni)* now predominates, with the death adder *(Acanth is antarcticus)* also present.[10] In New Gu...ea, separated from Papua by rugged mountain ranges, there are no taipans, and the death adder predominates.[11] The taipan is most active in the middle of the day, while the death adder, although often encountered asleep near walking paths during daytime, is active at night. It should be noted that Campbell described the Papuan black snake *(Pseudechis papuanus)* as the commonest venomous snake in Papua.[12] Papuan black snakes are now rare and the last positive identification we are aware of from Central Province was in 1977. How much previous misidentification occurred remains uncertain.[13] The demise of frog-eating elapids, such as the black snakes and the death adder, may well be related to the introduction of the poisonous cane toad *(Bufo marinus).* The cane toad was introduced to Port Moresby from F ul in the late 1940s (Dr J Menzies, personal communication), and it is now widely distributed in Central Province. Taipans prey on mammals and not on frogs, so that the presence of cane toads together with deforestation and increasing open habitats gives them a selective advantage. It is therefore likely that the increase in relative numbers of taipans in coastal Queensland[9] is also occurring in coastal Papua. This is a sobering thought considering that the number of mouse LD_{50} doses per average venom yield is higher for the taipan (and the inland taipan, *Oxyuranus microlepidotus)* than for any other snake.[14]

The increased female:male ratio of snake bite victims 30 years of age and older in rural areas probably reflects the greater involvement of older women in gardening. Gardens are often some kilometres from the village, and bush tracks are often overgrown. It is of interest that the strong male predominance in children in our study (69% boys) is similar to the Queensland study (71% boys),[2] and probably relates to the behaviour patterns of boys.

That 71% of bites were on the ankle or below confirms Campbell's conclusion that "the unshod rural dweller or the unshod worker in rural areas, who has to move through the grass of the savanna woodland, is the person at particular risk from snake bite in Papua."[1] The Australian elapid snakes with the longest fangs are the taipan (up to 13 mm) and the death adder (average, 6.2 mm). Fairley described the fangs of a death adder penetrating an ordinary shoe, but felt boot leather to be adequate protection.[15] In our study, of only two known expatriate victims, one was an American tourist who was unaware of the speed of Australasian elapid snakes. He was bitten on the finger while attempting to pick up a snake.

While it may be unrealistic to expect footwear to become popular, it is encouraging that "local" versions of pressure bandages are commonly applied in Papua New Guinea.[16] This includes "bush" ropes and grass, rubber and available clothing such as the lap-lap (sarong). The importance of adequate first aid[17] becomes even greater when long delays are common before the patient reaches a health facility. More work is needed on the appropriate use of bush materials for effective first aid, but already adapted versions of the pressure-immobilisation technique[18] in Motu and Melanesian pidgin have been disseminated. Unfortunately wound laceration is still widely practised.[19] This is a combination of traditional therapy (with bamboo or stone) and residual teachings from the colonial days (often used razor blades are used).

Although the population is small, the incidence and mortality rates of snake bite in both urban and rural Papua are considerable. The annual mortality rate is similar to that in Burma (over 3.3 per 100 000),[20] greater than that in southern Africa (0.53 per 100 000),[21] but less than that in north-eastern Nigeria (60 per 100 000) and parts of Equador.[22]

Improved first aid should help decrease mortality, but the limited technical and health staff resources available in Papua New Guinea, together with transport difficulties, will remain major obstacles. Under such circumstances the use of locally devised standard management protocols is essential. Improved reporting of local experience with snake bite should help in the validation and revision of such protocols.

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References

1. Campbell CH. A clinical study of venomous snake bite in Papua [MD Thesis]. Sydney: The University of Sydney, 1969: 50-67.
2. Jamieson R, Pearn J. An epidemiological and clinical study of snake-bites in childhood. *Med J Aust* 1989; 150: 698-702.
3. Sutherland SK, Lovering KE. Antivenoms. Use and adverse reactions over a 12-month period in Australia and Papua New Guinea. *Med J Aust* 1979; 2: 671-674.
4. Pearn J. Snakebite victims. In: Pearn J, Covacevich J, eds. Venoms and victims. Brisbane: The Queensland Museum, 1988: 87-88.
5. Payne, CD. The GLIM system. Release 3.7 Manual, Oxford: Numerical Algorithms Group, 1985.
6. Papua New Guinea Department of Health. Papua New Guinea National Health Plan 1986–1990. Port Moresby: Department of Health, 1986: Appendix II.
7. Papua New Guinea Department of Health. Standard treatment for common illnesses of adults in Papua New Guinea. 4th ed. Port Moresby: Department of Health, 1989: 108-112.
8. Bell CO. Dangerous flora and fauna. In: Diseases and health services of Papua New Guinea. Port Moresby: Department of Health, 1973: 325-330.
9. Shine R, Covacevich J. Ecology of highly venomous snakes: the Australian genus Oxyuranus (Elapidae). *J Herpetology* 1983; 17: 60-69.
10. Currie B, Hudson B, Vince J. Snake bite and snake identification. *Trans R Soc Trop Med Hyg* 1988; 82: 655.
11. Hudson BJ, Pomat K. Ten years of snake bite in Madang Province, Papua New Guinea. *Trans R Soc Trop Med Hyg* 1988; 82: 506-508.
12. Campbell CH. The Papuan black snake *(Pseudechis papuanus)* and the effect of its bite. *PNG Med J* 10: 117-121.
13. Currie B, Vince J, Naraqi S. Snake bite in Papua New Guinea. *PNG Med J* 1988; 31: 195-198.
14. Broad AJ, Sutherland SK, Coulter AR. The lethality in mice of dangerous Australian and other snake venom. *Toxicon* 1979; 17: 661-664.
15. Fairley NH. The present position of snake bite and the snake bitten in Australia. *Med J Aust* 1929; 1: 296-313.
16. Currie B, Naraqi S, Kevau I. Snakebite in Papua New Guinea — rising costs and unanswered questions. Abstracts of the 23rd Annual Medical Symposium of the Medical Society of Papua New Guinea, September 4–5, 1987.
17. Sutherland SK, Coulter AR, Harris RD. Rationalisation of first-aid measures for elapid snakebite. *Lancet* 1979; 1: 183-186.
18. Sutherland SK. First-aid for snake bite in Australia. 3rd ed. Melbourne: Commonwealth Serum Laboratories, 1985.
19. Currie B, Fitzmaurice M, Oakley J. Resolution of neurotoxicity with anticholinesterase therapy in death-adder envenomation. *Med J Aust* 1988; 148: 522-525.
20. Myint-Lwin, Warrell DA, Phillips RE, et al. Bites by Russell's viper *(Vipera russelli siamensis)* in Burma: haemostatic, vascular and renal disturbances and response to treatment. *Lancet* 1985; 2: 1259-1264.
21. McNally SL, Reitz CJ. Victims of snakebite. A 5-year study at Shongwe Hospital, Kangwane, 1978–1982. *S Afr Med J* 1987; 72: 855-860.
22. Warrell DA. Injuries, envenoming, poisoning and allergic reactions caused by animals. In: Weatherall DJ, Ledingham JGG, Warrell DA, eds. Oxford textbook of Medicine. 2nd ed. Oxford: Oxford University Press, 1987: 6.67-6.68.

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