ESTIMATES OF DISEASE BURDEN DUE TO LAND-SNAKE BITE IN SRI LANKAN HOSPITALS

A Kasturiratne[1], A Pathmeswaran[1], MMD Fonseka[2], DG Lalloo[3], S Brooker[4] and HJ de Silva[2]

Departments of [1]Community and Family Medicine, [2]Medicine, Faculty of Medicine, University of Kelaniya, Ragama, Sri Lanka, [3]Clinical Research Group, Liverpool School of Tropical Medicine, and [4]Department of Infectious and Tropical Diseases, London School of Hygiene and Tropical Medicine, UK

Abstract. Snake bite is a common cause of hospital admission in Sri Lanka. Despite this, there have been no countrywide studies or national estimates of disease burden due to snake bites in Sri Lankan hospitals. We assessed the disease burden due to snake bite in our hospitals and estimated the frequency of admissions due to bites by different snake species. Sri Lanka was divided into four zones based on climate and topography. Hospital morbidity and mortality data, which are available on an administrative district basis, were collated for the four zones. A survey of opinion among specialist physicians (the Delphi technique) was used to estimate the proportion of bites by different species, and requirements for anti-venom (AV) and intensive care facilities for management of snake bites in hospitals in each of the four zones. A study of hospital admissions due to snake bites in seven selected hospitals was also performed to validate the opinion survey. There was a clear difference in the incidence of hospital admissions due to snake bites in the different zones. Estimates of hospital admissions due to bites by different species also varied considerably between zones. These trends corresponded to estimates of requirements of AV and other supportive health care. Health care planning using data based on environmental information, rather than merely on political boundaries, could lead to targeted distribution of AV and intensive care requirements to manage snake bites.

INTRODUCTION

Snake bites are common in Sri Lanka. In the year 2000, about 37,000 patients were treated for snake bite in government hospitals, an apparent ten-fold increase from 3,820 recorded in 1985 (Ministry of Health, 2000). The number of hospital deaths from snake bite over this period increased from 132 to 194. Although the hospital case fatality rate has declined dramatically from 3.5% in 1985 to 0.5% in 2000 (Ministry of Health, 2000), there has been an increase in the recorded population mortality rate from 8.3 to 10.1 per 1,000,000 population. The current low hospital case fatality rates have been confirmed by independent studies (Premawardhena *et al*, 1999; Seneviratne *et al*, 2000). These trends can be explained by a variety of factors, such as an increased public awareness of the availability of effective treatment for snake bites that encourages more victims, both seriously envenomed and non-envenomed, to seek hospital treatment early (Makita, 2003), and improvements in reporting, accessibility to medical care, availability of anti-venom (AV) and intensive care facilities in some hospitals situated in areas where snake bites are common (Kularatne, 2000). However, it is widely accepted that these improvements are not uniform throughout the country, and a better allocation of resources could result in further improvements in the management of envenoming due to snake bites.

Of the many species of snakes in Sri Lanka, only 6 are medically important: the Russell's viper (*Daboia russelli russelli*) (RV), cobra (*Naja naja*), the kraits (*Bungarus caeruleus* and *Bungarus ceylonicus*), saw-scaled viper (*Echis carinatus*) (SSV) and hump-nosed viper (*Hypnale*

Correspondence: HJ de Silva, Department of Medicine, Faculty of Medicine, University of Kelaniya, PO Box 6, Thalagolla Road, Ragama, Sri Lanka.
Tel: +95-11-2958039, +95-11-2958337; Fax: +94 11 2955280
E-mail: hjdes@sltnet.lk

hypnale) (HNV). Most of the morbidity and mortality is caused by the highly venomous Russell's viper, cobra, and krait bites (de Silva and Aloysius, 1983; de Silva and Ranasinghe 1983). Other species are either mildly venomous or non-venomous, where bites never cause systemic envenoming or death.

Hospital data alone do not represent the total disease burden due to snake bites. However, reliable data on the frequency of snake bite admissions to hospitals and the distribution of biting species in different parts of the country would help to effect improvements in the distribution of resources, such as, AV and equipment for basic life support, to the island's hospitals. There have been no country-wide hospital studies or national estimates to provide such data. Clinical impressions (based mainly on dissimilar clinical presentations of bites due to different species), with some supportive evidence from small hospital based studies, indicate that there is geographic variation in the distribution of hospital admissions due to bites of medically important snakes within the country (de Silva and Aloysius 1983; de Silva and Ranasinghe, 1983; Ratnapala *et al*, 1983). This is most likely to be due to varying ecological conditions, since the distribution of an individual species is influenced by factors, such as, climate, rainfall, altitude, vegetation, and its preference for a particular prey (de Silva, 1990). Studies on the distribution of bites by medically important snakes are hampered by difficulties in definitive species identification, because the snake is often not brought to hospital (Premawardhena *et al*, 1999; Seneviratne *et al*, 2000). In addition to the low proportion of snakes brought to hospital, there is differential killing of snakes (Makita, 2003). This is due partly to cultural and religious beliefs (cobras are rarely killed by Buddhists and Hindus) and partly to the snakes' biting habits (kraits often bite sleeping victims during the night making capture difficult). The ideal method for identifying biting species would be immunodiagnosis, but this is not affordable for a developing country like Sri Lanka.

The aims of our study were to assess disease burden due to snake bite and estimate the frequency of admissions following bites by different venomous species to hospitals in geographically defined zones of the island.

MATERIALS AND METHODS

Setting

Sri Lanka consists mainly of plains, with highlands confined to the central region. The island is divided into three ecological zones, wet, intermediate and dry, on the basis of annual rainfall (de Silva, 1990; Panabokke, 1996). Differences in rainfall patterns have led to much diversity in the flora and fauna of these zones (de Silva, 1990). For purposes of our study, we divided the island into four zones (Z1 to Z4) based on climate and topography (Survey Department, 1988; de Silva, 1990) (Fig 1). Z1 was the land area within the wet zone above an altitude of 900 meters. Z2 was the area of the wet zone below 900 meters, Z3 the intermediate zone, Z4 the dry zone. Each of the country's 25 administrative districts was allocated to one of these four zones because hospital morbidity and mortality data on snake bites is available on a district basis. When parts of a district fell into two ecological zones (6 of the 25 districts), the whole district was placed in one zone taking into consideration the relative land area and population distribution in each zone, using Geographic Information Systems (International Water Management Institute, Colombo, Sri Lanka).

Data sources

Morbidity and Mortality. The number of admissions and deaths due to snakebite for all government hospitals for the year 2000 were obtained from the Medical Statistics Unit of the Ministry of Health. Government hospitals in Sri Lanka report their in-patient morbidity and mortality statistics to the medical statistician on a quarterly basis. The diagnosis is coded using the 10th revision of the International Classification of Diseases that has been used by the medical statistician since 1996. The code T 63.0 was taken as snake bite. The data from the 25 administrative districts were collated to arrive at the number of hospital admissions and deaths due to snake bite for each of the four zones.

Opinion survey. Estimates of the pattern of snake bite admissions to government hospitals were obtained from a group of specialist physicians with experience in treating snake bites in hospitals in different parts of the country using the Delphi technique (Jones and Hunter, 1995). The information was collected using a structured, pre-tested questionnaire which asked physicians to estimate, for each hospital they worked in, the relative proportions of bites by different species of snakes, the percentage of snake bites admissions that needed treatment with AV, the percentage of admissions that needed intensive care, and the average length of hospital stay.

The survey of physicians was conducted in two phases. During the first phase, physicians were interviewed either in person or over the telephone by two of the authors (HJdeS and MMDF) who have considerable experience in snake bites and its management. These physicians were selected deliberately to represent hospitals in all parts of the country. Each physician was asked about the hospital to which they were currently attached as well as the hospitals where they had worked during the past 10 years as specialist physicians, provided that they had served in that hospital for a period of at least one year. The data obtained were used to calculate point and interval estimates for each of the variables for the four zones. Point estimates were based on the median. During the second phase, the summary figures for each zone were reported back to at least 3 physicians for each of the four zones. They were already involved in the survey and had recent experience in that particular zone, either currently working there or having had worked there within the past two years. In most instances, the physicians unanimously agreed with the estimates. In the few instances where there were disagreements the estimates were modified to arrive at a consensus.

Hospital survey. In order to validate the opinion survey, we performed a study of hospital admissions due to snake bites in seven selected hospitals (Fig 1). Hospital records of snake bite admissions over a six-month period were surveyed. The biting species was confirmed only in cases where it was documented that the dead snake had been brought to hospital.

RESULTS

Hospital-derived morbidity and mortality figures for snake bites in the different zones are given in Table 1.

During the first phase of the expert opinion survey, 37 physicians (40% of the total of 91 specialist general physicians working in government hospitals in Sri Lanka) were interviewed. Thirty-six (85%) of the 42 hospitals manned by specialist general physicians in the country were included (Fig 1), and 3, 39, 11, and 21 expert opinions were obtained for Zones 1, 2, 3 and 4, respectively. Sixteen of the 37 physicians took part in the second phase of the survey. Estimates of the numbers of snake bite admissions due to different species for each zone are shown in Table 2. These were calculated using the agreed point estimates (obtained as percentages) and number of hospital admissions due to snake bites for each zone. The pattern of distribution

Table 1
Hospital derived morbidity and mortality due to snake bites for the year 2000.

Zone	Population[a]	Snake bite cases	Snake bite deaths	Incidence[b]	Mortality rate[c]	Case fatality rate
1	737,000	303	0	0.4	0	0
2	10,197,000	13,196	54	1.3	5.3	0.4
3	3,471,000	9,682	44	2.8	12.7	0.5
4	4,772,000	13,900	96	2.9	20.1	0.7
Total	19,177,000	37,081	194	1.9	10.1	0.5

[a]Estimated population for 2000; [b] Per 1,000 population; [c] Per 1,000,000 population
Source: Medical Statistics Unit and Population Division, Ministry of Health

Table 2
Distribution of snake bites due to different species by zone shown as point and interval estimates expressed as percentages [estimated numbers].

Zone	HNV	RV	KRT	CBR	SSV	MV	Total
1	85% (80-90) [250]	0%	0%	0%	0%	15%(10-20) [50]	300
2	65% (60-70) [8,600]	25% (20-30) [3,200]	0%	5% (1-10) [700]	0%	5% (1-10) [700]	13,200
3	50% (45-55) [4,800]	30% (25-35) [2,900]	10% (5-15) [1,000]	5% (1-10) [500]	0%	5% (1-10) [500]	9,700
4	5% (1-10) [600]	50% (45-55) [6,600]	30% (25-35) [4,200]	5% (1-10) [600]	5% (1-10) [600]	10% (5-15) [1,300]	13,900
Total[a]	14,200 (35-45%)	12,700 (30-40%)	5,200 (10-20%)	1,800 (1-10%)	600 (1-2%)	2,600 (1-10%)	37,100

HNV - Hump-nosed viper; RV - Russell's viper; KRT - Kraits; CBR - Cobra; SSV - Saw-scaled viper; MV - Mildly / non-venomous snakes

[a] Obtained by summing up the estimated numbers in the four zones (calculated point and interval estimates given as percentages).

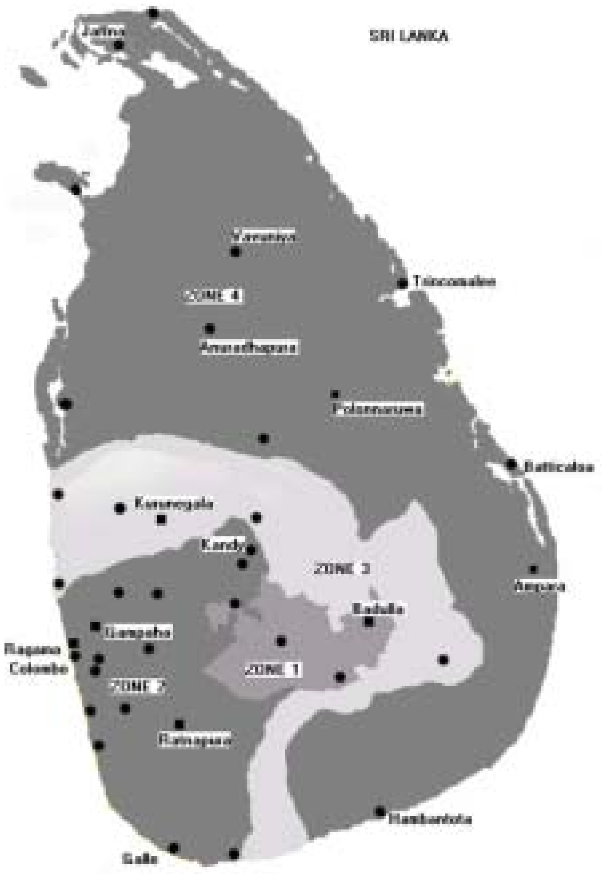

Fig 1–Map of Sri Lanka showing the four zones (● denotes locations of hospitals included in the opinion survey, ■ denotes hospitals where patient records were also surveyed).

of bites by individual species varied considerably between the different zones. The results of the survey of hospital records are shown in Table 3. The offending snake was definitely identified in 20-41% of cases in different hospitals. The proportion of krait and cobra bites were lower than the proportions estimated in the expert opinion survey, but there was reasonable agreement with regard to the rank order of the biting species for the respective hospitals.

Estimates of the average length of hospital stay for snake bite victims was 2-3 days for those who did not require AV, 5-6 days for those who received AV, and 8-10 days for those who needed intensive care treatment. These estimates were used to calculate hospital burden due to snake bite for each zone, expressed as patient-days (Table 4). Based on the total number of hospital beds available in the country (57,027)

Table 3

Results of the hospital snake bite survey.

Hospital (Zone)	Total number of snake bites (n)	Identified snake bites n (%)	HNV survey n (%)	HNV estimate (%)	RV survey n (%)	RV estimate (%)	Krait survey n (%)	Krait estimate (%)	Cobra survey n (%)	Cobra estimate (%)	Mildly venomous survey n (%)	Mildly venomous estimate (%)
Polonnaruwa (4)	268	93 (34.7)	7 (7.5)	<5	63 (67.7)	50-60	14 (15.1)	25-35	2 (2.2)	5	7 (7.5)	5-10
Ampara (4)	218	65 (29.8)	8 (12.3)	5	38 (58.5)	35-45	17 (26.2)	40-50	0	5	2 (4.6)	5
Badulla (3)	141	29 (20.6)	17 (58.6)	45-55	11 (37.9)	30-40	1 (3.4)	5-10	0	5	0	5
Kurunegala (3)	533	109 (20.5)	58 (53.2)	45-55	43 (39.4)	25-35	5 (4.6)	5-15	2 (1.8)	5-15	1 (0.9)	<5
Ratnapura (2)	170	47 (27.6)	30 (63.8)	55-65	13 (27.7)	30-35	0	0	1 (2.1)	5-10	3 (6.4)	5
Gampaha (2)	239	98 (41)	65 (66.3)	60-70	31 (31.6)	20-30	0	0	2 (2)	5	0	5
Ragama (2)	186	61 (32.8)	44 (72.1)	60-70	13 (21.3)	25-35	0	0	2 (3.3)	5	2 (3.3)	<5

(Ministry of Health, 2000), the overall hospital bed occupancy rate due to snake bites was 0.6%.

Estimates of AV requirements are also given in Table 4. Here, the estimated proportion of snake bite victims requiring AV was used to calculate the number of AV vials required based on the conservative assumption that, on average, each snake bite victim with evidence of envenoming should receive at least 10 vials of AV. This is the initial dose recommended by the Sri Lanka Medical Association Expert Committee on Snake bites, and is generally adhered to. By this method it was estimated that the minimum total requirement of AV for the entire country for the year 2000 was 143,750 vials [estimated cost: Rs.100 million (US$ 1 million)] at a cost of Rs.700 per vial (annual total recurrent health budget is Rs.19 billion). The shelf life of AV used in Sri Lanka during the survey (Haffkine Laboratories, Mumbai, India) is 5 years. The Medical Supplies Division (MSD) of the Ministry of Health is the sole supplier of AV to government hospitals. The average number of vials of AV issued from the central stores annually during the six years from 1996 to 2001 was approximately 120,000 (source: MSD, Ministry of Health, Sri Lanka). A reliable breakdown of the amount of AV supplied to individual hospitals and districts is not available.

DISCUSSION

We have shown geographical variation in the incidence of hospital admissions due to snake bites. These data are likely to be underestimates as they are dependant on the reporting system and would miss snake bite cases that do not reach formal care. The incidence of hospital admissions due to snake bites was high in the dry (Zone 4) and intermediate zones (Zone 3), and lowest in the high altitude area above 900 meters (Zone 1). The dry and intermediate zones of our country are largely rural, with farming areas and jungle in close proximity to each other. This would make the likelihood of contact between man and snake high and explain the high incidence of snake bite there.

Hospital case fatality rates due to snake bites were low overall. Despite differences in the

Table 4
Estimated hospital burden due to snake bites.

Zone	No. of cases	Proportion of patients requiring AV	No. of AV vials required[a]	Hospital patient-days	ICU patient-days
1	300	0%	0	900	0
2	13,200	20%	26,400	37,620	2,640
3	9,700	35%	33,950	31,040	1,940
4	13,900	60%	83,400	59,770	5,560
Total	37,100		143,750	129,330	10,140

[a]Average number of vials required per patient considered as 10.

estimated distribution of biting species, rates were more or less similar in the different zones. No case fatalities due to snake bites were reported from zone 1, and doctors working in hospitals in that zone reported that almost the entire supply of AV supplied to them goes unutilized. In contrast, doctors working in some areas of the dry zone (notably hospitals in the northern areas which were affected by civil conflict) reported having to use lower doses of AV than recommended due to a lack of resources. The similar case fatality rates in Zones 3 and 4, where a high proportion of bites are estimated to be due to highly venomous snake species, and Zone 2, where snake bites are mainly due to HNV may seem surprising. However, 6 of the 7 tertiary care hospitals in Sri Lanka are situated in Zone 2, and they accept transfers of patients from hospitals all over the island. Patients with snake bites who develop severe complications are very likely to be transferred to these hospitals when resources at local hospitals are inadequate or overwhelmed. This may lead to selection bias in admissions resulting in higher mortality rates. A similar situation in hospital case fatality rates has been observed for myocardial infarction and maternal mortality (Ministry of Health, 2000).

Estimates of hospital admissions due to bites of different snake species also indicate a variation between zones. This is of particular interest, as it has not been studied previously. Nearly all snake bites in Zone 1 were estimated to be either due to mildly venomous snakes or the HNV. This is corroborated by the fact that there were no hospital deaths due to snake bites in this zone, and AV is rarely used. Nearly two-thirds of snake bites admitted to hospitals in Zone 2 and half the bites in Zone 3 were estimated to be due to the HNV, which rarely causes systemic envenoming or death (Sellahewa and Kumararatne, 1994; Premawardhena *et al*, 1998). In contrast, more than three-quarters of the snake bites admitted to hospitals in Zone 4 were estimated to be due to the highly venomous RV and Kraits. These zonal variations are in general agreement with data from smaller studies done earlier in hospitals situated in the wet and dry zones of the country (de Silva and Ranasinghe, 1983; Sellahewa and Kumararatne, 1994; Premawardhena *et al*, 1998, 1999; Seneviratne *et al*, 2000; Kularatne, 2000). The zonal snake bite pattern also corresponded with the estimated requirement of AV and other facilities (including intensive care facilities) in hospitals situated in the respective zones (Table 3), *ie* high in Zone 4, lower in Zone 2, and lowest in Zone 1.

For the country as a whole, bites requiring hospitalization were estimated to be most commonly due to the HNV (35-45%) and RV (30-40%), followed by the bites of kraits (10-20%) and cobras (1-10%). Admissions due to bites of the SSV were estimated to account for 1-2% of all snake bites, but were confined to hospitals in the north and north-western parts of the dry zone. Mildly venomous snakes were estimated to account for 1-10% of all bites admitted to hospital. We note, that if the snake is not brought to hospital, it is impossible to differentiate between the bite of a mildly venomous snake and a 'dry' bite (a bite which does not result in envenoming) of a highly venomous species.

We used the Delphi technique to arrive at our estimates. The Delphi technique is a consensus method commonly used in health services research (Jones and Hunter, 1995). It is intended for use in judgement and forecasting situations in which model based statistical methods are not practical or possible because of the lack of appropriate data, and where some form of human judgement is necessary. The key features are anonymity, iteration, controlled feedback and the statistical aggregation of a group response. Another feature of the technique is that the number of panellists required is small (usually 7 to 12) (Rowe and Wright, 1999). We felt that this was an appropriate method for us to use given the inadequacy of national data on snake bites and the other limitations in countries such as ours.

The approach we used does have shortcomings. The use of physicians' opinions to estimate the relative importance of biting species is subject to individual bias. We believe that the differences in clinical presentation between the bites of different species would have reduced such bias; for example, bleeding tendency and renal impairment following Russell's viper bites, severe local swelling without significant systemic envenoming following hump-nosed viper bites, and neurotoxicity with ventilatory failure but minimal local reaction following krait bites (de Silva and Aloysius, 1983; Ratnapala *et al*, 1983). To cover as many hospitals in as many parts of the island as possible, we had to depend on 10-year recall. We have attempted to reduce potential error by confirming group estimates in the second phase of the survey with physicians who were either currently working in those zones or had worked there within the last two years. We also performed a study of hospital admissions due to snake bite in seven selected hospitals in an attempt at validating the opinion survey. This confirmed the low proportion of snakes brought in with the victims to hospital, and as was to be expected, also showed a low frequency of bites due to kraits and cobras. Because direct identification of the offending snake is an uncommon occurrence in our hospitals, and there is differential killing of snakes in this country (Makita, 2003), hospital surveys based solely on direct identification are unlikely to give a true picture regarding the importance of different biting species. Nevertheless, results of this survey and the physicians' opinions did show reasonable agreement when the rank order of the biting species was considered for individual hospitals (Table 3). The reliability of our data could have been greatly improved by using immunodiagnosis; not doing so is a limitation of this study. We were unable to account fully for transfers between hospitals, although we do not believe that this would have significantly affected the overall validity of our findings.

In conclusion, our results indicate a geographical variation in the incidence of hospital admissions due to snake bites and the biting species. This variation was reflected in the estimated requirement of facilities. Environmental data can be used to develop zone maps that identify areas of ecological similarity, that are better able to define broad areas of epidemiological similarity than political boundaries (Brooker *et al*, 2002). Health care planning using data based on environmental information, rather than relying solely on political boundaries, could lead to targeted distribution of resources to manage snake bites. Clearly, more reliable national data on snake bites and the resulting morbidity and mortality are necessary. We already have advanced plans to measure the community burden of snake bites in Sri Lanka.

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