Reviews/Analyses

Snake-bites: appraisal of the global situation

J.-P. Chippaux[1]

The true global incidence of envenomations and their severity remain largely misunderstood, except for a few countries where these accidents are rare or are correctly reported. Nevertheless, this information is essential for drawing up guidelines for dealing with snake-bites, to plan drug supplies, particularly antivenin, and to train medical staff on snake-bite treatments. Since the comprehensive review by Swaroop & Grab in 1954 no global survey has been carried out on snake-bite epidemiology. The present article is an attempt to draw the attention of health authorities to snake envenomations and urges them to prepare therapeutic protocols adapted to their needs.

Introduction

Snake-bites are not systematically reported in most countries. Moreover, very few countries possess a reliable epidemiological reporting system capable of providing precise data on snake-bites. Instead, scientific reports and publications have to be used to assess the magnitude of the problem posed by snake-bites. The data thus obtained are generally more precise and reliable but often cover limited geographical areas or deal with special aspects. From these data, and taking into account the activities practised by a given population and the proportion living in rural zones, estimates have been made of the number of snake-bites, their severity, and mortality due to envenomations. These evaluations are summarized in this article, by region. The values are speculative, but minimal, and highlight the necessity of performing more precise investigations.

As discussed below, two methods can be used to estimate the incidence (total number of snake-bites), morbidity (number of envenomations), case fatality rate (number of deaths among envenomed people), and mortality from snake-bites (number of deaths due to envenomation among the general population).

• *The household survey.* This is carried out by visiting every family in a village (or a randomized sample of a population) and questioning them about their snake-bite histories. The results obtained provide information on the incidence of snake-bites in a community and data on treatment sought or the circumstances of bites.

• *Hospital records or health authority statistics.* These can provide data on snake-bite morbidity, case fatality rate, and mortality. However, in some locations, hospitals are few and far between and hospitalized cases may represent a low proportion of total snake-bites. Also, data from some locations may be inaccurate.

A distinction is made between hazardous snake-bites, which occur when humans encounter a snake, and "illegitimate" snake-bites inflicted by an animal kept in captivity or during snake handling. In industrialized countries the frequency of illegitimate snake-bites is increasing (*14*, *66*, *76*, *81*), while hazardous snake-bites occur mainly in developing countries especially among rural active people, chiefly while they are working in the fields. For example, illegitimate bites represented 21% of the total snake-bites in Utah, USA, during the early 1990s (*70*).

The incidence of bites is high in warm regions, where snakes are abundant and economic activities are mainly agricultural. In most developing counties, up to 80% of people bitten by snakes (*13*, *98*) consult first traditional practitioners and only subsequently resort to modern medicine, thus accounting for the long delays before they receive proper treatment. Notified cases, data on which are used to determine morbidity, therefore cover only a small proportion of the true numbers. In some areas the high morbidity from snake-bites should denote a high prevalence of venomous species, notably in populous regions. High mortality and/or case fatality rates mean that treatment of envenomations is not adequate. There are

[1] Director, Centre de Recherches sur les Meningites et les Schistosomiases, B. P. 10887, Niamey, Niger. Requests for reprints should be sent to Dr Chippaux at this address.

Reprint No. **5891**

many reasons for the high mortality rate, e.g. scarcity of health facilities, unavailability of drugs and antivenins, poor training of health workers on snake-bite management, and long delays before starting treatment. Each location has to be examined individually to determine the particular reasons which prevail there.

Snake-bite incidence and severity

Europe and the Middle East

In Europe, snake-bites are relatively rare (Table 1). The snakes involved belong to the *Vipera* genus, represented in Europe by a few species that are not among the most venomous: *V. aspis* (asp viper), *V. ammodytes* (sand viper), *V. berus* (common viper), and *V. latastei* (Lataste's viper). In Great Britain, there are approximately 200 hospitalizations a year from snake-bites but no deaths have been reported since 1975 (*75*, *111*). In France, the number of cases is higher. Chippaux et al. reported an annual incidence of approximately 5 cases per 100000 residents in the *Département* of Yonne (150 km south of Paris) (*17*) and similar incidences have been reported elsewhere in the country (*7*). The annual incidence for the whole of France is about 2.5 per 100000 inhabitants; however, the annual morbidity is rather less than 0.5 per 100000 people and the case fatality rate is about 0.3% (*42*). In Switzerland, the morbidity is very low, corresponding to approximately 0.1 case per 100000 residents per year (*100*). In rural areas of southern Europe rates are higher. In Spain (*33*) and Italy (*71*) the annual incidence of snake-bites can reach 5 per 100000 people. In Italy, the morbidity is about 1 per 100000 per year with a case fatality rate of 0.1–0.6%, and the annual mortality from snake-sites ranges from 0.01 to 0.04 per 100000 people (*4*).

In Europe (population, ca. 730 million), the annual number of snake-bites could reach 25000, of which 8000 involve an envenomation. About 90% of envenomed patients are hospitalized and about 30 deaths could result every year.

In the Middle East, the snake species involved in bites are more dangerous than in Europe: *V. lebetina* (Levantine viper), *V. xanthina*, *V. palestinae* (Palestine viper) or their cognates (*1*, *28*, *35*, *63*). Although data are lacking, the incidence of snake-bites appears to be low, and as in North Africa, scorpion stings are more frequent events. *Cerastes* spp., a rather common Viperidae in North Africa and in Middle East, are not very dangerous, although the venom can provoke local necrosis. In the Middle East (population, ca. 160 million), the annual number of snake-bites could be as high as 20000, with about 15000 envenomations per year; probably not much than 60% of those bitten attend hospital and the mortality can be estimated at 100 deaths every year.

Americas

In Canada and the USA (population, ca. 270 million), the annual incidence of snake-bites, particularly in the USA, is similar to that observed in Europe. According to Parrish (*65*) and Russell (*81*), approximately 45000 snake-bites occur each year in North America. Of these bites about 10000 are inflicted by venomous species, 6500 require medical intervention, and approximately 15 individuals thus bitten die each year. The case fatality rate is very low in view of the high toxicity of the venom of some of the species of snakes (e.g. *Crotalus* spp.). The implementation of adequate treatment is probably the reason for this low case fatality rate. The deaths that do occur are mainly due to delayed or insufficient treatment or to people refusing therapy.

Table 1: **Annual incidence and severity of snake-bites in Europe**

Country	Morbidity (per 100000)	Mortality (per 100000)	Case fatality rate (%)	Ref.
Finland	4.1	0.02	0.5	*96*
France	0.4 (0.1–2.6)[a]	0.005	0.1–0.3	*7*, *17*, *20*, *42*, *48*
Great Britain	0.1	0.0001	—	*75*, *111*
Italy	1	0.01–0.04	0.1–0.6	*4*, *71*
Israel	3–5	0.029	1.3	*29*, *36*, *64*
Jordan	—	—	—	*1*
Poland	—	—	1.1	*104*
Spain	1.5–4	0.008–0.02	0.6–1.8	*34*
Sweden	2.6		—	*67*
Switzerland	—	—	0.1	*100*

[a] Hospital records.

In Central and South America, the prevalence of snake-bites is significantly higher (Table 2), with Crotalidae being responsible for most envenomations, provoking oedema, necrosis, and haemorrhages. In savanna areas of South America, the bite of *Crotalus durissus terrificus* (tropical rattlesnake) provokes neurotoxic envenomations associated with mild inflammation, severe rhabdomyolisis, and renal failure, while in Central America, the bite of *C. durissus durissus* induces severe local oedema and necrosis but no neurotoxicity or rhabdomyolisis. Recent studies showed that the use of antivenin has contributed to a significant improvement in envenomation prognosis. Nevertheless, in Ecuador, for example, the case fatality rate ranges from 5.4% for envenomations treated in hospital (*46*) to 6.3% in some bush areas (*109*); the annual snake-bite morbidity has been evaluated to be 30 per 100000, with the associated mortality being 1.8 per 100000 per year (*109*). In Costa Rica, the current average annual morbidity and mortality reported by health services is about 20 per 100000 and 0.4 per 100000, respectively (*34, 79*); however, in the 1970s, mortality was around 0.5 per 100000 (*6*). Some surveys in forest areas have found a high incidence of snake-bites, especially among Indians (*19, 21, 51*). In Brazil, the notified annual morbidity from snake-bites is about 15 per 100000 people mainly from *Bothrops* spp. The reported incidence of envenomation for the whole of Brazil is about 20000 cases per year, e.g. 15 per 100000 population (*41*). Mortality from snake-bites in São Paulo State, where available data are probably more relevant, reaches 0.04 per 100000 (*52*). However, Cruz-Rocha et al. (*25*) demonstrated that the real incidence in Amazonas State was at least six times greater than the notified value. The case fatality rate is less than 1% in the south of the country (*10*) and 1.3% in the Amazon area (*25*); the annual mortality rate in the Amazon basin is about 1.1 per 100000 people.

On the basis of values reported in the literature (*6, 29, 34, 83*), the annual incidence of snake-bites in Central and South America (population, ca. 400 million) should be at least 300000; a total of 150000 envenomations are reported every year, 65% of which are treated in hospital. The annual number of deaths from snake-bites could exceed 5000 and their distribution is probably uneven.

Africa

In Africa, the prevalence of snake-bites (Table 3) is underestimated by health authorities, mainly because the reporting system is inaccurate. Moreover, the poor organization of health facilities in many countries complicates the management of patients and accounts for the great variation in the case fatality rate (*15*). Bites occur especially in plantations (*16, 99*). In industrial plantations the snake-bite incidence can be as high as ten times that in closed village plantations, largely because the industrial plantations attract more venomous snake species because of the abundance of prey they contain. In banana plantations mainly *Causus maculatus* (spotted night adder), an aggressive adder not really harmful to healthy adults, is involved. In palm tree plantations or in rubber plantations, black cobras (*Naja melanoleuca*) and green mambas (*Dendroaspis* spp.) are frequent. In forest regions, the gaboon vipers and their cognates (*Bitis* spp.) are especially responsible for numerous bites in village plantations and in rice fields. In savanna areas, the most abundant snakes are *Echis* spp. These Viperidae are probably responsible for the greatest number of accidents and deaths by envenomation in Africa (*112*). Towns also are not spared venomous

Table 2: **Annual incidence and severity of snake-bites in the Americas**

Country	Incidence (per 100000)	Morbidity (per 100000)[a]	Mortality (per 100000)	Case fatality rate (%)	Ref.
Brazil	350–450[b] (forest)	6.8–192	0.4 (South) 0.4–5 (North)	0.4–6.5 —	*10, 25, 41, 52, 54, 68, 78*
Colombia	—	—	1.6	—	*56*
Costa Rica	—	20–35	0.2–1.2	2.3–3.3	*6, 34, 79, 83*
Ecuador	>1000[b] (forest)	16–28	—	5.4	*46, 51, 107, 109*
French Guyana	45–590[b]	75	1.5	2.2	*19, 21*
Venezuela	—	—	—	6.5	*27*
USA	0.7–15	0.5–5	0.005–0.01	0.1–1.6	*65, 70, 81, 82*

[a] Hospital records.
[b] Household surveys.

snakes and snake-bites occur in the capital cities of African countries (*16*, *57*). In some rural regions, during the rainy season, envenomations involve up to 10% of hospitalized patients. In Nigeria, a study in the Benue valley estimated that the annual incidence of snake-bites was up to 600 per 100000 inhabitants and that the case fatality rate was 12.3%, mainly from *Echis ocellatus* bites (*73*). In the North Province of Cameroon, *E. ocellatus* is also responsible for a high morbidity (*55* and J.-P. Chippaux, personal data, 1994). A survey in a rural area of Senegal showed that the annual mortality from snake-bites was 11.7 per 100000 inhabitants (*69*). In Benin, the overall incidence can reach 450 bites per 100000 in some rural areas, with 5.9% lethality (*13*), while notifications give annual morbidity and mortality as 70 per 100000 and 1 per 100000, respectively (*30*, *31*); less than 30% of patients treated in health centres are admitted to hospital. In rural Kenya, snake-bite incidence exceeds 150 bites per 100000 and mortality is estimated to be 6.7 per 100000 (*98*); however, about 70% of patients do not attend health centres.

In Africa (population, ca. 760 million), probably 1 million snake-bites occur every year involving 500000 envenomations, of which 40% are hospitalized. It is likely that about 20000 deaths per year occur as a result, although less than 10000 are reported by health services.

Asia

In Asia, there is a wide variation in the incidence of snake-bites (Table 4), according to human activities and the snake species involved. In Japan, the general incidence of snake-bites is approximately 1 case per 100000 people; the case fatality rate is less than 1% and the overall mortality is about 0.5 per 100000. Nevertheless, the morbidity is more important in the south of the country, where it can reach up to 340 cases per 100000 residents (*85*) with a 0.7% case fatality rate (*45*). The incidence of snake-bites depends on human activities and snake behaviour (*108*). In the south of Japan, as in China (Province of Taiwan) and in south China, *Trimeresurus* spp. are responsible for at least half of the bites (*85*, *90*, *92*). *T. flavoviridis* (habu), one of the most common species, is encountered in human settlements (*39*); however, a control programme has been implemented successfully, leading to a decrease in the annual incidence of bites from about 300 to 150 per 100000 inhabitants (*106*). In the Republic of Korea, the incidence of *T. flavoviridis* bites remains unknown but quite low. The case fatality rate is about 5% from *Agkistrodon blomhoffi* bites (*88*). More than a half of the snake-bites that are hospitalized in Malaysia are caused by *Calloselasma rhodostoma* (*89*); and in Sri Lanka, the overall annual mortality rate of bites from this species exceeds 5.6 per 100000 and in some places can reach 18 per 100000 (*90*). About 40% of recorded deaths involve *Vipera russelli* (Russell's viper), while 35% involve *Naja naja* (common cobra). Less than 25% of patients are treated in hospital and only 43% of deaths are reported to health authorities (*90*, *95*). In Asia, the mortality due to snake-bites seems to be highest in Myanmar, where 70% of the bites involve *V. russelli* (*3*, *61*); however, these data for Myanmar may simply be a reflection of the better reporting system in this country, where the reporting of snake-bite deaths has been obligatory for many years. In India, data are fragmentary because less than 40% of snake-bite patients attend

Table 3: **Annual incidence and severity of snake-bites in Africa**

Country or area	Incidence (per 100000)	Morbidity (per 100000)[a]	Case fatality rate (%)	Ref.
Benin	216–653[b]	39–315	1.8–4.1	*13*, *30*, *31*
Burkina Faso	—	40–70	5–11.7	*50*, *80*
Chad	—	10 (urban)	—	*57*
Cameroon	—	75–200	5–10	*55*, J. P. Chippaux, personal data
Congo	125–430[b]	20	1–6.6	*11*
Côte d'Ivoire	—	130–400	2–28	*16*, *18*
Ghana	—	21	—	*103*
Kenya	150[b]	1.9–67.9	2.6–9.4	*24*, *59*, *77*, *98*
Liberia	420	170	—	*99*
Natal	—	100	—	*23*
Nigeria	48–603[b]	100–120	2.1–16	*36*, *40*, *63*, *72*, *73*, *112*
South Africa	—	34	—	*58*
Zimbabwe	—	3.5	1.8–4.8	*9*, *43*, *62*

[a] Hospital records.
[b] Household surveys.

public hospital (*87*). *Echis carinatus* (the carpet or saw-scaled viper) occurs in both India and Pakistan, where it is responsible for a large number of snake-bite cases, reaching 95% of envenomations in the State of Jammu (*5*). *V. russelli* also are frequently encountered in India and throughout south-east Asia. In Maharashtra State, in India, the annual incidence of severe envenomation is about 70 per 100000 inhabitants and the mortality rate is about 2.4 per 100000 per year (*32*).

In Asia (population, ca. 3500 million) as a whole there may be up to 4 million snake-bites each year, of which almost 50% are envenomed. Approximately half of the victims reach hospital and the annual number of deaths resulting can be estimated at 100000.

Oceania

In Australia, the estimated annual incidence of snake-bites ranges from 3 to 18 per 100000 (*114*) with the average mortality rate being 4 per 100000 per year (*101*). Most of bites are due to *Pseudonaja* spp., which are involved in about a half of deaths, as well as *Notechis* spp. and *Oxyuranus* spp., which together are responsible of nearly all the deaths from snake-bites in Australia. Bites occur during the warm months in the south of Australia and all year round in the tropical north of the country. In Papua New Guinea, the mortality from snake-bites in the Central Province is estimated at over 7.9 per 100000 inhabitants (*49*).

Most of the Pacific islands are free from venomous snakes except sea snakes, whose venom is neurotoxic, but which are not aggressive.

From the whole of Oceania (population, ca. 20 million), more than 10000 snake-bites and 3000 envenomations are reported every year. Most individuals involved (70%) are hospitalized and 200 people die from such bites every year.

Conclusion

It appears from the fragmentary epidemiological data presented in this article that snake-bites remain a public health problem in most countries, even if it is difficult to be precise about the actual numbers involved. The global figures given by Swaroop & Grab (*102*) over 40 years ago were greatly underestimated. The true incidence of and mortality from snake envenomations could exceed 5 million per year, with an associated mortality level of 125000 persons per year. About 2.5 million people are envenomed each year, half of whom request medical care, and probably more than 100000 individuals suffer from severe sequelae (Table 5).

The global disparity in the epidemiological data for snake-bites reflects the variation of health reporting accuracy and the great diversity of ecological and economic conditions throughout the world (Fig. 1). Agricultural activities are associated with most of the bites. The snake species involved can be very dangerous because of the toxicity of their venom or abundance in areas close to human settlements. Finally, health facilities and availability of antivenin have to be considered in implementing the treatment of envenomations. Clearly in developing countries, where snake-bites are the most prevalent, none of the required conditions for their correct manage-

Table 4: **Annual incidence and severity of snake-bites in Asia and Oceania**

Country or area	Incidence (per 100000)	Morbidity (per 100000)[a]	Mortality (per 100000)	Case fatality rate (%)	Ref.
Australia	3–18	—	0.03	—	*101, 114*
China	—	—	—	0.5–1.1	*93*
China (Province of Taiwan)	32–300	80	0.25	2.1–2.7	*92*
Hong Kong Special Administrative Region of China	—	—	—	1.2	*12, 22*
India	66–163	1.4–68	1.1–2.4	1.7–20	*5, 32, 37, 47, 84, 87*
Indonesia	—	—	—	2.5	*44*
Japan	10–500	0.2–120	—	0.8–1	*2, 45, 85, 108*
Malaysia	400–450	130–300	0.1–0.2	0.4–1	*53, 74, 89, 97*
Myanmar	35–200	35	3.3	10	*3, 60*
Nepal	—	—	—	5.2	*39*
New Guinea	215–526	3–82	7.9	1–9.6	*26, 49*
Philippines	—	—	0.8–54	54	110, 113
Republic of Korea	—	—	—	4.9	88
Sri Lanka	—	45–60	5.6–18	4–22	90, 94–96
Thailand	—	10	0.9	1.5–6.6	*8, 85, 86, 110*

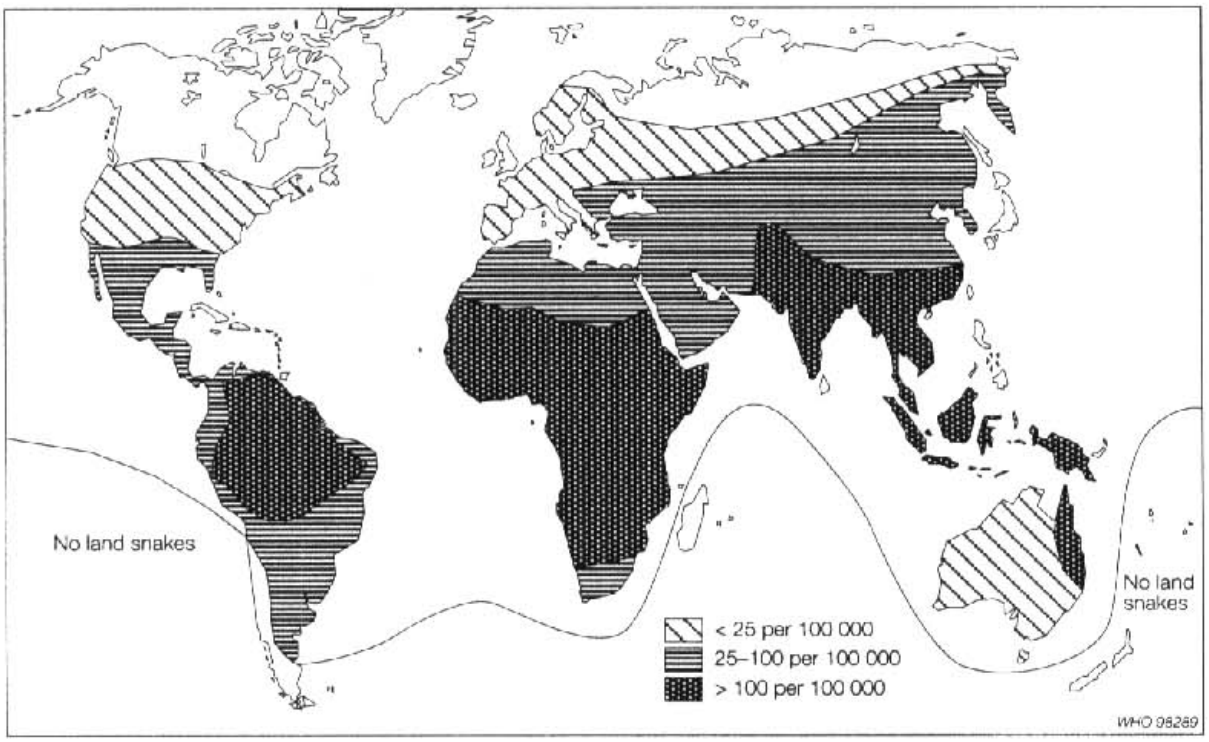
[a] Hospital records.

Table 5: **Global evaluation of snake-bites**

	Population ($\times 10^6$)	Total number of bites	No. of envenomations	No. of deaths
Europe	730	25000	8000	30
Middle East	160	20000	15000	100
USA and Canada	270	45000	6500	15
Central and South America	400	300000	150000	5000
Africa	760	1000000	500000	20000
Asia	3500	4000000	2000000	100000
Oceania	20[a]	10000	3000	200
Total	5840	5400000	2682500	125345

[a] Population at risk.

Fig. 1. **Map showing the global distribution of snake-bite morbidity.**



ment is fulfilled. In most developing countries, lack of medical attention, specially antivenin therapy, leads to high mortality levels. Considerable effort will be needed to develop studies on snake-bite epidemiology and improve the distribution and use of antivenin.

Acknowledgements

Dr J. White and Dr. J.M. Gutierrez made useful comments on snake-bite epidemiology and clinical features. I am grateful to Dr J. Williamson for his help during the preparation of the manuscript.

Résumé

Les morsures de serpent: Situation mondiale

L'incidence et la gravité des morsures de serpent dans le monde sont mal connues. Cette information permettrait pourtant une meilleure prise en charge du traitement et une prévision adéquate de l'approvisionnement en médicaments et en sérums antivenimeux.

A partir des données de la littérature, en tenant compte des aspects démographiques propres à

chaque région, nous avons évalué le nombre de morsures (incidence), le nombre d'envenimations (morbidité), le nombre de décès rapportés au nombre de cas (létalité) ou à la population générale (mortalité). Dans les pays tempérés, les morsures de serpent constituent un événement rare, alors que dans les pays tropicaux ou équatoriaux, l'incidence des morsures de serpent peut être très élevée. En outre, dans les pays développés, une grande proportion des morsures se produit lors de la manipulation des serpents. En revanche, dans les pays en développement, la majorité des accidents survient au cours d'activités agricoles.

Ainsi, le nombre annuel de morsures de serpent dépasse 5 millions, dont 4 millions pour l'Asie, 1 million pour l'Afrique, 350 000 pour les Amériques. Environ la moitié sont suivies d'envenimations. Le nombre de décès est voisin de 125 000 par an, dont 100 000 en Asie, 20 000 en Afrique et 5000 dans les Amériques. En Europe, au Proche-Orient, ainsi qu'en Océanie et en Australie, moins de 350 décès au total sont recensés chaque année. Des séquelles graves surviennent chez 100 000 patients. D'un pays à l'autre on constate une grande disparité des données épidémiologiques concernant les morsures de serpent. Cela tient, d'une part, au recueil des informations épidémiologiques et, d'autre part, à la grande diversité écologique et économique entre les régions. Il faut remarquer que ce sont les pays où les serpents sont les plus abondants et les espèces les plus venimeuses que, par ailleurs, les infrastructures sanitaires sont les plus rudimentaires et la disponibilité en sérums antivenimeux la plus faible.

References

1. **Amr ZS, Amr SS.** Snakebites in Jordan. *Snake*, 1983, **15**: 81–85.
2. **Araki Y, Tomihara Y.** Hime-habu (*Trimeresurus okinavensis*) bites in Okinawa during last 4 years (1985–1988). *Snake*, 1989, **21**: 103–107.
3. **Aung-Khin M.** The problem of snake bites in Burma. *Snake*, 1980, **12**: 125–127.
4. **Beer E.** Fatalities due to viper-bite in Italy in the years 1951–1991. Paper presented at: *First International Congress on Envenomation Treatment, Institut Pasteur, Paris, 7–9 June1995*: 137.
5. **Bhat RN.** Viperine snake bite poisoning in Jammu. *Journal of the Indian Medical Association*, 1974, **63**: 383–392.
6. **Bolanos R.** [Poisonous snakes and reptiles in Central America]. San Jose, University of Costa Rica, 1984 (in Spanish).
7. **Bouquier JJ et al.** Les piqûres de vipères chez l'enfant. Étude de 43 cas. *Archives françaises de Pédiatrie*, 1974, **31**: 285–296.
8. **Buranasin P.** Snakebites at Maharat Nakhon Ratchasima Regional Hospital. *Southeast Asian journal of tropical medicine and public health*, 1993, **24**: 186–192.
9. **Blaylock RS.** Snake bites at Triangle Hospital January 1975 to June 1981. *Central African journal of medicine*, 1982, **28**: 1–10.
10. **Cardoso JLC.** Hospital Vital Brazil: 50 years of clinical experience at Instuto Butantan, São Paulo. Paper presented at: *First International Congress on Envenomation Treatment, Institut Pasteur, Paris, 7–9 June 1995*: 151.
11. **Carme B et al.** Les morsures de serpent au Congo. Estimation de la morbidité à Brazzaville et en zone rurale de la région du Pool et du Mayombe. *Annales de la Société belge de Médecine tropicale*, 1986, **66**: 183–189.
12. **Chan TY, Critchley JA.** An epidemiological study of the snake bites in the New Territories East, Hong Kong. *Annals of tropical medicine and parasitology*, 1994, **88**: 219–221.
13. **Chippaux JP.** Snakebite epidemiology in Benin (West Africa). *Toxicon*, 1988, **27**: 37.
14. **Chippaux JP.** Evaluation des risques d'accidents en élevage de serpents venimeux exotiques. *Bulletin de la Société Herpétologique de France*, 1982, n° **21**: 6–25.
15. **Chippaux JP et al.** Therapeutic approach to snake bite in tropical Africa. In: Bon C, Goyffon M, eds. *Envenomings and their treatments*. Lyon, Fondation Marcel Mérieux, 1996: 247–253.
16. **Chippaux JP, Bressy C.** L'endémie ophidienne des plantations de Côte d'Ivoire. *Bulletin de la Société de Pathologie Exotique*, 1981, **74**: 458–467.
17. **Chippaux JP, Bry D, Goyffon M.** Un type d'enquête sur les envenimations vipérines dans un département français: l'Yonne. *Bulletin de la Société Herpétologique de France*, 1995, **75/76**: 57–61.
18. **Chippaux JP et al.** Epidémiologie des morsures de serpents en Afrique de l'Ouest. *Etudes médicales*, 1981, n° **2**: 117–137.
19. **Chippaux JP, Galtier J, Lefait JF.** Epidémiologie des envenimations en Guyane française. *Bulletin de la Société de Pathologie Exotique*, 1984, **77**: 206–215.
20. **Chippaux JP, Goyffon M.** Les morsures accidentelles de serpent en France métropolitaine. *Nouvelle Presse médicale*, 1989, **18**: 794–795.
21. **Chippaux JP, Theakston RD.** Epidemiological studies of snake bite in French Guiana. *Annals of tropical medicine and parasitology*, 1987, **81**: 301–304.
22. **Cockram CS, Chan JC, Chow KY.** Bites by the white-lipped pit viper (*Trimeresurus albolabris*) and other species in Hong Kong. A survey of 4 years' experience at the Prince of Wales Hospital. *Journal of tropical medicine and hygiene*, 1990, **93**: 79–86.
23. **Coetzer PW, Tilbury CR.** The epidemiology of snakebite in northern Natal. *South African medical journal*, 1982, **62**: 206–212.

24. **Coombs MD et al.** Snake bites in Kenya: a preliminary survey of four areas. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, 1997, **91**: 319–321.
25. **Cruz-Rocha MA et al.** Incidence of accidents caused by poisonous snakes in twenty-four municipal districts of Amazonas State. *Journal of venomous animals and toxins*, **3**: 253.
26. **Currie BJ et al.** An epidemiological study of snake bite envenomation in Papua New Guinea. *Medical journal of Australia*, 1991, **154**: 266–268.
27. **Dao LL.** [Poisoning in the State of Lara]. *Gaceta medical de Caracas*, 1971, **79**: 383–410 (in Spanish).
28. **Efrati P.** Symptomatology, pathology and treatment of the bites of viperid snakes. In: Lee CY, ed. *Snake venoms*. Berlin, Springer Verlag, 1979: 956–988.
29. **Fan HW, Cardoso JLC.** Clinical toxicology of snake bites in South America. In: Meier J, White J, eds. *Handbook of clinical toxicology of animal venoms and poisons*. Boca Raton, FL, CRC Press, 1995: 667–688.
30. **Fayomi EB et al.** Les accidents dus aux serpents en milieu rural ouest africain: quelle attitude thérapeutique adopter aujourd'hui? *Médecine d'Afrique noire*, 1987, **34**: 971–984.
31. **Fayomi EB, Fourn L, Favi PM.** Analyse des cas de morsures de serpent déclarés par les formations sanitaires publiques au Bénin de 1993 à 1995. *Médecine d'Afrique noire*, 1997, **44**: 591–595.
32. **Gaitonde BB, Bhattacharya S.** An epidemiological survey of snake bite cases in India. *Snake*, 1980, **12**: 129–133.
33. **Gonzales D.** Epidemiological and clinical aspects of certain venomous animals of Spain. *Toxicon*, 1982, **20**: 925–928.
34. **Gutierrez JM.** Clinical toxicology of snakebite in Central America. In: Meier J, White J, eds. *Handbook of clinical toxicology of animal venoms and poisons*. Boca Raton, FL, CRC Press, 1995: 645–665.
35. **Hadar H, Gitter S.** The results of treatment with Pasteur antiserum in cases of snakebites. *Harefuah*, 1959, **56**: 257–261.
36. **Harries AD, Chugh KS, Ngare B.** Snake bite: frequency of adult admissions to a general hospital in north-east Nigeria. *Annals of tropical medicine and parasitology*, 1984, **78**: 665–666.
37. **Hati AK et al.** Epidemiology of snake bite in the district of Burdwan, West Bengal. *Journal of the Indian Medical Association*, 1992, **90**: 145–147.
38. **Hayashi Y, Tanaka H.** Invasive behaviour of a venomous snake, Habu, *Trimeresurus flavoviridis*, into residential area. *Japanese journal of experimental medicine*, 1982, **52**: 209–211.
39. **Heap BJ, Cowan GO.** The epidemiology of snake bite presenting to British Military Hospital Dharan during 1989. *Journal of the Royal Army Medical Corps*, 1991, **137**: 123–125.
40. **Idoko A, Ikwueke K.** Snakebite in the tropics: experience in Makurdi, Nigeria. *Tropical and geographical medicine*, 1984, **36**: 175–180.
41. **Jorge MT, Ribeiro LA.** [Epidemiology and clinical picture of accidents with the tropical rattle snake, (*Crotalus durissus terrificus*)]. *Revista Instituto Medica Tropicale, São Paulo*, 1992, **34**: 347–354 (in Portuguese).
42. **Jouglard J.** Experience of envenomation at the Marseille Poison Centre. Paper presented at: *First International Congress on Envenomation Treatment Institut Pasteur, Paris, 7–9 June 1995*. 47.
43. **Kasilo OM, Nhachi CF.** A retrospective study of poisoning due to snake venom in Zimbabwe. *Human experimental toxicology*, 1993, **12**: 15–18.
44. **Kawamura Y, Chinzei H, Sawai Y.** Snakebites in Indonesia. *Snake*, 1975, **7**: 73–78.
45. **Kawamura Y, Sawai Y.** Habu (*Trimeresurus flavoviridis*) bites on the Amani islands in 1985. *Snake*, 1989, **21**: 108–110.
46. **Kerrigan KR.** Venomous snakebite in eastern Ecuador. *American journal of tropical medicine and hygiene*, 1991, **44**: 93–99.
47. **Kulkarni ML, Annees S.** Snake venom poisoning: experience of 633 cases. *Indian pediatry*, 1994, **31**: 1239–1243.
48. **Lagraulet J, Pays JF.** Les problèmes posés par le traitement des morsures de vipères en France. *Bulletin et Mémoires de la Société de Médecine de Paris*, 1984, **4**: 104–108.
49. **Lalloo DG et al.** The epidemiology of snake bite in Central Province and National Capital District, Papua New Guinea. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, 1995, **89**: 178–182.
50. **Lankoandé Salifou T.** Envenimations par morsures de serpents. *Médecine d'Afrique noire*, 1981, **28**: 143–146.
51. **Larrick JW, Yost JA, Kaplan J.** Snake bite among the Waorani Indians of Eastern Ecuador. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, 1978, **72**: 542–543.
52. **Lebrao ML, Ribeiro LA, Jorge MT.** Evaluation of deaths by accidents with venomous snakes in the State of São Paulo, 1988/1989. *Revista de Associaçao Medica Brasileira*, 1995, **41**: 343–347.
53. **Lim TW.** Epidemiology of snakebites in Malaysia. *Snake*, 1980, **12**: 119–124.
54. **Magalhaes De O.** [Anti-snake compaign in Minais Gerais]. *Memorias do Instituto Oswaldo Cruz*, 1958, **56**: 291–372. (in Portuguese).
55. **Manent P, Mouchon D, Nicolas P.** Envenimation par *Echis carinatus* en Afrique: étude clinique et évolution. Indication du sérum antivenimeux. *Médecine tropicale*, 1992, **52**: 415–421.
56. **Marinkelle CJ.** Accidents by venomous animals in Colombia. *Industrial medicine and surgery*, 1966, **35**: 988–992.
57. **Markwalder KA.** Treatment of unidentified viper bites. *British medical journal*, 1980, **281**: 648.
58. **McNally SL, Reitz CJ.** Victims of snakebite. A 5-year study at Shongwe Hospital, Kangwane, 1978–1982. *South African medical journal*, 1987, **72**: 855–860.

59. **Mwangemi PM.** Current concepts on poisonous snake bites. A reappraisal. *East African medical journal*, 1976, **53**: 657–659.
60. **Myint-Lwin 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.
61. **Naing S.** Clinical profile of viper bite cases, Divisional Hospital, Magwe (1981–82). *Burmese medical journal*, 1985, **31**: 195–203.
62. **Nhachi CF, Kasilo OM.** Snake poisoning in rural Zimbabwe. A prospective study. *Journal of applied toxicology*, 1994, **14**: 191–193.
63. **Onuaguluchi GO.** Clinical observation on snakebite in Wukari, Nigeria. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, 1960, **54**: 265–269.
64. **Paret G et al.** *Vipera palestinae* snake envenomations: experience in children. *Human and experimental toxicology*, 1997, **16**: 683–687.
65. **Parrish HM, Khan MS.** Bites by foreign venomous snakes in the United States. *American journal of medical science*, 1966, **251**: 150–155.
66. **Parrish HM.** Incidence of treated snakebites in the United States. *Public health reports*, 1966, **81**: 269–276.
67. **Persson H, Irestedt B.** A study of 136 cases of adder bite treated in Swedish hospitals during one year. *Acta medica Scandinavica*, 1981, **210**: 433–439.
68. **Pierini SV et al.** High incidence of bites and stings by snakes and other animals among rubber tappers and Amazonian Indians of the Juruá valley, Acre State, Brazil. *Toxicon*, 1966, **34**: 225–236.
69. **Pison G, Trape JF.** Mortality by snake bite in Africa. A case study in rural Senegal. Paper presented at: *First International Congress on Envenomation Treatment, Institut Pasteur, Paris, 7–9 June 1995.* 183.
70. **Plowman DM, Reynolds TL, Joyce SM.** Poisonous snakebite in Utah. *Western journal of medicine*, 1995, **16**: 547–551.
71. **Pozio E.** Venomous snake bites in Italy: epidemiological and clinical aspects. *Tropicalli medicina e parasitologia*, 1988, **39**: 62–66.
72. **Pugh RN et al.** Bites by the carpet viper in the Niger Valley. *Lancet*, 1979, **2**: 625–627.
73. **Pugh RN, Theakston RDG.** Incidence and mortality on snake bite in savanna Nigeria. *Lancet*, 1980, **2**: 1181–1183.
74. **Reid HA.** Epidemiology of snake bite in North Malaya. *British medical journal*, 1963, **1**: 992–997.
75. **Reid HA.** Adder bites in Britain. *British medical journal*, 1976, **2**: 153–156.
76. **Reid HA.** Bites by foreign venomous snakes in Britain. *British medical journal*, 1978, **1**: 1598–1600.
77. **Resti C, Bosiosi E, Dal Lago A.** Snake bite and snake envenoming in Tharaka, Kenya: utilising a standard protocol (SP) in a rural hospital. Paper presented at: *Primo Congresso Nationale della Societa Italiana di Medicina Tropicale, Palermo, 19–22 October 1994.*
78. **Ribeiro LA et al.** [Accidents involving snakes in the State of São Paulo]. *Revista da Associaçao Medica Brasileira*, 1993, **39**: 4–7 (in Portuguese).
79. **Rojas G, Bogarin G, Gutierrez JM.** Snakebite mortality in Costa Rica. *Toxicon*, 1997, **35**: 1639–1643.
80. **Roman B.** *Serpents de Haute Volta.* Ouagadougou, Centre National de la Recherche Scientifique et Technique, 1980.
81. **Russell FE.** Snake venom poisoning in the United States. *Annual review of medicine*, 1980, **31**: 247–259.
82. **Russell FE, Carlson RW, Osborne AH.** Snake venom poisoning in the United States. *Journal of the American Medical Association*, 1975, **233**: 341–344.
83. **Russell FE et al.** Snakes and snakebite in Central America. *Toxicon*, 1997, **35**: 1469–1522.
84. **Saha SG, Hati AK.** Study on snakebites in a subsidiary health centre in West Bengal. *Snake*, 1983, **15**: 86–90.
85. **Sawai Y.** Snakebites in Asia. *Snake*, 1973, **5**: 29–75.
86. **Sawai Y.** Epidemiological study on snakebites in the Asian areas. *Snake*, 1980, **12**: 115–118.
87. **Sawai Y, Honma M.** Snake bites in India. *Snake*, 1975, **7**: 1–16.
88. **Sawai Y, Lah KY.** Snakebites in the South Korea. *Snake*, 1978, **9**: 39–47.
89. **Sawai Y et al.** Study on sea snakes and the bites in Malaysia, Thailand and Hong-Kong. *Snake*, 1978, **9**: 48–62.
90. **Sawai Y et al.** Study on deaths due to snakebite in Anuradhapura District, Sri Lanka. *Snake*, 1984, **16**: 7–15.
91. **Sawai Y, Tseng CS.** Snakebites on Taiwan. *Snake*, 1969, **1**: 9–18.
92. **Sawai Y, Tseng CS, Kuo TP.** Snake bites in Kao Hsiung Prefecture, Taiwan. *Snake*, 1970, **2**: 13–17.
93. **Shanghai Vaccine and Serum Institute.** [*Agkistrodon halys* bite treated with specific antivenom. Observations of 530 cases]. *Chinese medical journal*, 1976, **2**: 59–62 (in Chinese).
94. **Silva De A.** Snakebites and antivenom treatment in Sri Lanka. *Snake*, 1980, **12**: 134–137.
95. **Silva De A.** Snakebites in Anuradhapura District. *Snake*, 1981, **13**: 117–130.
96. **Silva De A, Ranasinghe L.** Epidemiology of snakebite in Sri Lanka: a review. *Ceylon medical journal*, 1983, **28**: 144–154.
97. **Singh KI.** Ecology of land snakes and epidemiology of snake bites in Malaysia. *Snake*, 1980, **12**: 37–44.
98. **Snow RW et al.** The prevalence and morbidity of snake bite and treatment-seeking behaviour among a rural Kenyan population. *Annals of tropical medicine and parasitology*, 1994, **88**: 665–671.
99. **Stahel E.** Epidemiological aspects of snake bites on a Liberian rubber plantation. *Acta tropica*, 1980, **37**: 367–374.
100. **Stahel E, Wellauer R, Freyvogel TA.** [Envenomations by native vipers (*Vipera berus* and *Vipera aspis*). A retrospective study of 113 patients]. *Schweizerische medizinische Wochenschrift*, 1985, **115**: 890–896 (in German).

101. **Sutherland SK, Leonard RL.** Snakebite deaths in Australia 1992–1994 and a management update. *Medical journal of Australia*, 1995, **163**: 616–618.
102. **Swaroop S, Grab B.** Snakebite mortality in the world. *Bulletin of the World Health Organization*, 1954, **10**: 35–76.
103. **Swiecicki AW.** Snakes and snake bite in the Western Region, Ghana. *Journal of tropical medicine and hygiene*, 1965, **68**: 300–304.
104. **Szyndlar Z.** [Herpetofauna of the Western Bieszczady Mountains]. *Acta zoologica Cracovia*, 1980, **24**: 299–336 (in Polish).
105. **Tallquist H, Österland K.** [Viper bites]. *Nordisk medicin*, 1962, **68**: 1073–1076 (in Norwegian).
106. **Tanaka H et al.** Improvement of control methods of habu (*Trimeresurus flavoviridis*), the venomous snake on the Amami Islands studied by a research group from 1977 to 1979. *Snake*, 1985, **17**: 96–111.
107. **Theakston RDG et al.** Snake venom antibodies in Ecuadorian indians. *Journal of tropical medicine and hygiene*, 1981, **84**: 199–202.
108. **Tomari T.** An epidemiological study of the occurrence of habu snake bite on the Amami Islands, Japan. *International journal of epidemiology*, 1987, **16**: 451–61.
109. **Touzet JM.** [Bites by poisonous snakes among the community of indigenous people in San Pablo de Kantesyia and data on reptile fauna and local amphibians] *Publicación de Museo Ecuatoriano Ciencias Naturales*, 1986, **7**: 163–190 (in Spanish).
110. **Trishnananda M.** Incidence, clinical manifestation and general management of snake bites. *Southeast Asian journal of tropical medicine and public health*, 1979, **10**: 248–250.
111. **Warrell DA.** Snake bite and snake venoms. *Quarterly journal of medicine*, 1993, **86**: 351–353.
112. **Warrell DA, Arnett C.** The importance of bites by the saw scaled or carpet viper (*Echis carinatus*): epidemiological studies in Nigeria and a review of the world literature. *Acta tropica*, 1976, **33**: 307–341.
113. **Watt G et al.** Bites by the Philippine cobra (*Naja naja philippinensis*): an important cause of death among rice farmers. *American journal of tropical medicine and hygiene*, 1987, **37**: 636–639.
114. **White J.** Treatment of snake bite in Australia. In: Bon C, Goyffon M, eds. *Envenomings and their treatments*. Lyon, Fondation Marcel Mérieux, 1996: 247–253.