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Reviews/Analyses

Snake-bites: appraisal of the global situation

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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

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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 (150km 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*

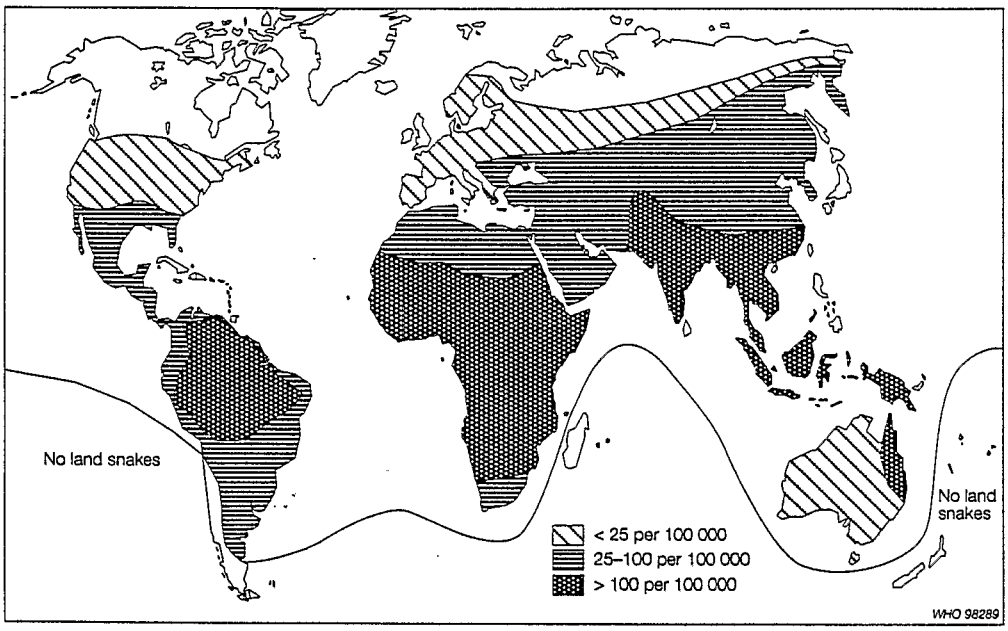
[a] Hospital records.

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

	Population ($\times 10^6$)	Total number of bites	No. of envenomations	No. of deaths
Europe	730	25 000	8 000	30
Middle East	160	20 000	15 000	100
USA and Canada	270	45 000	6 500	15
Central and South America	400	300 000	150 000	5 000
Africa	760	1 000 000	500 000	20 000
Asia	3 500	4 000 000	2 000 000	100 000
Oceania	20[a]	10 000	3 000	200
Total	5 840	5 400 000	2 682 500	125 345

[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.

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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.

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