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High mortality from snakebite in south-eastern Senegal

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Abstract

Over 24 years, from 1976 to 1999, we conducted a prospective study of overall and cause-specific mortality among the population of 42 villages of south-eastern Senegal. Of 4228 deaths registered during this period, 26 were caused by snakebite, 4 by invertebrate stings and 8 by other wild or domestic animals. The average annual mortality rate from snakebite was 14 deaths per 100 000 population. Among persons aged ≥ 1 year, 0·9% (26/2880) of deaths were caused by snakebite and this cause represented 28% (26/94) of total deaths by accidents. We also investigated the snake fauna of the area. Of 1280 snakes belonging to 34 species that were collected, one-third were dangerous and the proportion of Viperidae, Elapidae and Atractaspidae was 23%, 11% and 0·6%, respectively. The saw-scaled viper *Echis ocellatus* was the most abundant species (13·6%). Other venomous species were *Causus maculatus* (6·5%), *Naja katiensis* (5·5%), *Bitis arietans* (2·7%), *Elapsoidea trapei* (2·4%), *Naja nigricollis* (1·2%), *Naja melanoleuca* (1·1%), *Atractaspis aterrima* (0·4%), *Dendroaspis polylepis* (0·3%) and *Naja haje* (0·1%).

Keywords: snakes, snakebites, animal bites, arthropod stings, vital statistics, accidents, *Echis ocellatus*, Senegal

Introduction

Recent estimates indicate that up to 5 million snakebites, scorpion stings and anaphylactic reactions to insect stings may occur each year worldwide, causing over 100 000 human deaths (WHO, 1995). In Africa, where few data are available, there is a wide range of uncertainty about the number of snakebites and deaths occurring each year. Classically, mortality estimates were low, about 1000 deaths per year for the whole continent (WHO, 1995). However, high mortality has been reported from several areas of northern Nigeria (PUGH & THEAKSTON, 1980), and, from a limited number of studies, it has been recently suggested that up to one million snakebites causing over 20 000 deaths may occur each year in Africa (CHIPPAUX, 1998).

In Senegal, long-term demographic and health surveillance was initiated in the 1970s in villages of the Bandafassi area, one of the most remote and traditional areas of the country. Over 24 years, a continuous study of the levels and causes of deaths in this population has been carried out. Here we examine the incidence of deaths caused by animals and we present the results of further investigations on the herpetological fauna of this area where snakebites are an important cause of death.

Methods

Study area and population

The Bandafassi study area is located in the Sudan savannah of south-eastern Senegal, between latitudes 12°30′–12°46′ N and longitudes 12°16′–12°31′ W. Rains are concentrated over a 6-month period from May to October, and annual rainfall averaged 1100 mm during the study period. The population comprises 10 509 inhabitants (our 2000 census) belonging to 3 ethnic groups (Bedik, Fula Bande and Mandinka Niokholonko) who live in 42 villages and hamlets (PISON *et al.*, 1997). This is one of the remotest areas in Senegal, with a low density of population (about 13 inhabitants per square kilometre) and a low impact of traditional agricultural practices on the natural savannah vegetation. The main activities are cultivation of cereals (sorghum, maize), peanuts and cotton, and cattle breeding. There is one small dispensary within the study area but access to health care is always difficult for most villages and almost impossible during the rainy season where the rare tracks are impassable.

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Assessment of the rates and causes of mortality

The demographic surveillance was initiated in 1970 in Mandinka Niokholonko villages (9 villages, 16% of the present population of the study area). In 1975, it was extended to Fula Bande villages (25 villages, 59% of the study population) and in 1980, 8 more villages were added (Bedik villages, 25% of the study population). The data collection system has been presented in detail elsewhere (PISON & LANGANEY, 1985; PISON *et al.*, 1997). In brief, at the beginning of the study, a map of each village was drawn and compounds were located, numbered, and identified by the name of the head of the compound and the name of its lineage. A list of all persons living in each compound was established and further surveys were made for collecting genealogies, marriage, birth and circumcision group histories, establishing an historical calendar, and then estimating the age of each villager. Once each year, usually in February or March, all villages or hamlets were visited and information on events (births, deaths, marriages, migrations) that had occurred since the previous visit was collected. For each death which occurred among the study population, the cause and circumstances were investigated by questioning bereaved relatives. The verbal autopsy technique with a standardized questionnaire was used for deaths of children (0–14 years) and a simplified open questionnaire was used for adult deaths. The causes of deaths were determined from the responses to these questionnaires and from any available medical information. The mortality data presented in this article cover the 24-year period 1976–99.

Snake fauna study

Snakes are abundant in the area and are systematically killed by the villagers without any distinction between venomous and non-venomous species. To investigate the snake fauna, we selected 7 villages belonging to the study area (Bandafassi, Boundoucoundi, Ibel, Landieni, Nathia, Ndebou) or located in its periphery (Mako: 12°51′ N, 12°21′ W). During one year, from March 1993 to February 1994, a 100-litre formol can was placed in the villages under the responsibility of the chief or another person in the community. We asked the villagers to bring for conservation in the formol the snakes that were killed during their usual activities. No specific field collection was organized. At the end of the survey, the cans were returned to Dakar where all collected specimens were identified.

Results

During 1976–99, 26 deaths due to snakebite occurred in the study population, and 12 additional deaths attributable to wild or domestic animals were reported (dogs, 4 cases; bees, 2 cases; spider, 1 case; unidentified arthropod, 1 case; stripped ground squirrel, 1 case; lizard, 1 case; cow, 1 case; sheep, 1 case). The average annual mortality rate from snakebite was 0·14 deaths per 1000 inhabitants. The youngest person who died from snakebite was a 2-year-old boy, and the oldest person was a woman aged 81 years. Among persons aged ≥1 year, almost 1% of deaths were caused by snakebite and this cause represented 28% of total deaths by accident. Mortality from snakebite did not differ significantly according to age-group or season of the year (Table 1). It was higher in males than in females. According to ethnic group, highest rates were observed among Bedik and Fula Bande.

Table 2 shows the results of snake collections. Of 1280 snakes collected, 781 (61·3%) were Colubridae, 292 (22·8%) Viperidae, 136 (10·6%) Elapidae, 41 (3·2%) Boidae, 11 (0·9%) Leptotyphlopidae, 8 (0·6%) Typhlopidae, and 7 (0·6%) Atractaspidae. Of the 34 species identified, the most abundant was the highly venomous saw-scaled viper *Echis ocellatus* which represented 12·9% of all specimens collected. Six other venomous species represented more than 1% of the snakes collected, the most dangerous being the puff adder *Bitis arietans* and the spitting cobra *Naja nigricollis*. Among the rare species, the most dangerous was the black mamba *Dendroaspis polylepis* (4 specimens collected).

Discussion

The mortality data presented in this paper derive from a prospective community-based surveillance system established to monitor child and adult survival where cause of deaths was attributed through combinations of interviews with bereaved relatives and—when available (rarely)—reviews of clinical notes related to the terminal event. From our experience in different areas of Senegal (TRAPE *et al.*, 1998), we believe that few deaths remain undetected with this surveillance system, and that accidental deaths are accurately diagnosed through interviews with bereaved relatives. For these reasons, we believe that the true figures of snakebite and accidental mortality in our study population are very close to the estimates presented in this paper.

Snakebites are frequent in many tropical regions, but there are wide variations in their incidence and the resulting number of deaths. The annual mortality of 14 per 100 000 population in our study area is one of the highest reported. Among the Waorani Indians of Amazonian Ecuador, 4·9% of all deaths were attributable to snakebites (LARRICK *et al.*, 1978). In Asia and Oceania, high rates of mortality due to snakebites have been reported from parts of Burma (SWAROOP & GRAB, 1954; AUNG-KHIN, 1980), Philippines (WATT *et al.*, 1987) and Papua New Guinea (LALLOO *et al.*, 1995). In Africa, it has long been presumed that mortality was low, with about 1000 deaths per year for the whole continent (SWAROOP & GRAB, 1954; WHO, 1995). However, in the 1970s, studies in Nigeria revealed that snakebite was a major cause of death in several regions of the country and that annual mortality reached up to 60 per 100 000 population in villages of the Benue valley (WARRELL & ARNETT, 1976; PUGH *et al.*, 1979; PUGH & THEAKSTON, 1980). From these data and those of other studies in several African countries, it has been recently suggested that up to one million snakebites causing over 20 000 deaths may occur each year in Africa (CHIPPAUX, 1998).

The high mortality from snakebites in Bandafassi is associated with the high prevalence of the saw-scaled viper *E. ocellatus* which was the most abundant snake species in our study area. This association was also observed in northern Nigeria where *E. ocellatus* (previously termed *E. carinatus* before revised taxonomic classification) was responsible for the majority of bites and deaths among populations of the Benue and Niger valleys (WARRELL *et al.*, 1977; PUGH *et al.*, 1979). This small viper (maximum length: 382 mm among the 174 specimens collected in Bandafassi area) has a wide range in the Sudan savannah of West Africa and is replaced by *E. leucogaster* in the Sahel (ROMAN, 1972; HUGHES, 1976).

Mortality from snakebite in Bandafassi was higher in males than in females. However, this difference was

Table 1. Mortality due to snakebite, accidents and all causes, Bandafassi study area, Senegal, 1976–99

	Number of deaths			Annual mortality (/1000)		
	Snakebite	All accidents	All causes	Snakebite	All accidents	All causes
Age-group (years)						
<1	0	1	1348	0·00	0·14	183·3
1–4	3	14	1125	0·13	0·59	47·8
5–14	8	20	276	0·18	0·44	6·1
15–39	6	27	398	0·09	0·41	6·1
40–59	6	18	427	0·21	0·64	15·2
≥60	3	14	654	0·25	1·19	55·4
Total	26	94	4228	0·14	0·52	23·3
Gender						
Male	17	57	2102	0·19	0·65	23·9
Female	9	37	2126	0·10	0·40	22·8
Ethnic group						
Bedik	8	34	947	0·18	0·78	21·8
Mandinka	2	7	705	0·07	0·24	23·7
Fula Bande	16	53	2576	0·15	0·49	23·8
Season						
May–July (rains)	5	19	1126	0·11	0·42	24·7
Aug–Oct (rains)	9	30	1213	0·20	0·65	26·4
Nov–Jan (dry)	6	22	993	0·13	0·48	21·9
Feb–Apr (dry)	6	23	896	0·13	0·52	20·1
Period						
1976–89	16	52	2457	0·18	0·57	26·9
1990–99	10	42	1771	0·11	0·47	19·6

Table 2. The snake fauna collected in seven selected villages in the Bandafassi area of Senegal (March 1993–February 1994)

Family and species	Number (%) of specimens
Typhlopidae	
Typhlops lineolatus Jan, 1863	8 (0·6%)
Leptotyphlopidae	
Leptotyphlops boueti (Chabanaud, 1917)	2 (0·2%)
Leptotyphlops sp.	1 (0·1%)
Rhinoleptus koniagui (Villiers, 1956)	8 (0·6%)
Boidae	
Python sebae (Gmelin, 1788)	19 (1·5%)
Python regius (Shaw, 1802)	22 (1·7%)
Colubridae	
Lamprophis fuliginosus (Boié, 1827)	70 (5·5%)
Lamprophis lineatus (Duméril, Bibron & Duméril, 1854)	103 (8·0%)
Philothamnus irregularis (Leach, 1819)	22 (1·7%)
Prosymna meleagris (Reinhardt, 1843)	37 (2·9%)
Lycophidion semicinctum Duméril, Bibron & Duméril, 1854	57 (4·5%)
Grayia smithii (Leach, 1818)	5 (0·4%)
Haemorrhois dorri (Lataste, 1888)	74 (5·8%)
Afronatrix anoscopus (Cope, 1861)	1 (0·1%)
Meizodon coronatus (Schlegel, 1837)	34 (2·7%)
Crotaphopeltis hotamboeia (Laurenti, 1768)	46 (3·6%)
Telescopus variegatus (Reinhardt, 1843)	11 (0·9%)
Rhamphiophis oxyrhynchus (Reinhardt, 1843)	24 (1·9%)
Dromophis praeornatus (Schlegel, 1837)	8 (0·6%)
Psammophis elegans (Shaw, 1802)	44 (3·4%)
Psammophis sibilans (Linnaeus, 1758)	142 (11·1%)
Dasypeltis fasciata A. Smith, 1849	106 (8·3%)
Dasypeltis scabra (Linnaeus, 1758)	1 (0·1%)
Atractaspidae	
Atractaspis aterrima Günther, 1863	5 (0·4%)
Amblyodipsas unicolor (Reinhardt, 1843)	2 (0·2%)
Elapidae	
Naja katiensis Angel, 1922	70 (5·5%)
Naja nigricollis Reinhardt, 1843	16 (1·2%)
Naja melanoleuca Hallowell, 1857	14 (1·1%)
Naja haje (Linnaeus, 1758)	1 (0·1%)
Elapsoidea trapei Mane, 1999	31 (2·4%)
Dendroaspis polylepis Günther, 1864	4 (0·3%)
Viperidae	
Echis ocellatus Stemmler, 1970	174 (13·6%)
Causus maculatus (Hallowell, 1842)	83 (6·5%)
Bitis arietans (Merrem, 1820)	35 (2·7%)
Total	1280 (100%)

All specimens were identified by 2 of the authors (J.-F. T. and Y. M.) and deposited at the Laboratoire de Paludologie of IRD in Dakar. A publication giving full meristic data of these specimens is in preparation.

observed only for older children and adolescents (8 deaths vs 1 death among boys and girls aged 5–19 years, respectively). Among adults, the same number of deaths occurred in men and women (7 deaths each among men and women aged ⩾20 years). Young girls spend more time in the villages for domestic activities than young boys but adults of both sexes are equally involved in agricultural work in the surrounding bush where the risk of snakebite is highest. Interestingly, there was no important seasonal variation in the distribution of snakebite mortality. In regions of Africa where there is a long dry season, many snake species have their maximum activity beginning with the first rains and lasting during the whole rainy season. In our study, mortality was highest during the second trimester of the rainy season, when vegetation was high, but a significant mortality was observed also during the dry season and there was no clear relationship with sowing and harvesting periods. The important vegetation of the study area all year round combined with the low population density may explain in part these findings. However, comparison of our data with those of hospital studies in north-east Nigeria (HARRIES *et al.*, 1984) and western Burkina Faso (LANKOANDE SALIFOU, 1981) suggests that the seasonality of snakebites may decrease considerably between isohyets 600 mm and 1200 mm in the savannah of West Africa despite relatively low differences (8–6 months) in the length of the dry season.

Arthropod bites were also a frequent cause of death in this study, with a mortality rate about 300 times higher than in France. Interestingly, 2 deaths were attributed to the bite of non-venomous small animals: the stripped ground squirrel *Xerus erythropus* and the Geckonidae lizard *Hemitheconyx caudicinctus*. Both animals are feared by populations of most regions of Senegal since their bite has the reputation of being 'always fatal', possibly related to a high incidence of septicaemia when the wound is not disinfected (PELTIER *et al.*, 1941; CISSE & KARNS, 1978).

The study area is located in the vicinity of Niokolo-Koba national park where large mammals and reptiles are numerous, including buffaloes, hippopotomi, lions, leopards, crocodiles and a small population of elephants. No death was caused by these animals. By contrast, cases of rabies following dog bites and accidents with cattle were the main causes of death attributable to large animals.

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Book Review

Infectious Disease (2nd edition). B. A. Bannister, N. T. Begg and & S. H. Gillespie. Oxford: Blackwell Science Ltd, 2000. vi+506pp. Price £29.50. ISBN 0-632-05319-4.

The book is aimed at senior medical students and junior doctors, but will be valuable to public-health and primary-care practitioners as an infectious diseases resource. It will also be useful to other health professionals involved with infection control and travel medicine. Infectious diseases are evolving rapidly and the authors of this second edition have updated the book to include several new pathogens, the introduction of HAART (highly active antiretroviral therapy) and describe the routine laboratory use of modern molecular techniques.

The contents have been divided into 5 main sections which include: infection; pathogens and antimicrobial agents (which covers the nature and pathogenesis of infection and then details classification and diagnosis); and finally anti-microbial chemotherapy. The second section details infectious diseases by organ system and also covers childhood diseases. The smallest section covers genital infections and sexually transmitted disease and birth-related infections. Infections including tuberculosis, sepsis and pyrexia of unknown origin are covered in a single grouping and are defined as infections involving more than one system. The final section covers environmental, travel-associated and infections in the immunocompromised.

The subject material is both comprehensive and covers enough detail for the understanding of the scope of infection in clinical practice, but is of less value for reference purposes.

One of the outstanding features of the book is the quality and quantity of illustrations included. The authors have produced a visually appealing layout with many useful and colourful diagrams, charts and tables which can be found on most pages. The authors have included many clinical images of high quality including radiographic material, which are well labelled. There are numerous epidemiological graphs, distribution maps of diseases and parasite life-cycles. The quantity and quality of illustration encourages the reader to continue browsing through all the chapters.

The writing style is clear and well structured, and the use of case studies helps put the material into a clinical context.

This book is very good value for students and anyone dealing with infectious diseases who need background reading. It sets a quality benchmark of illustrations, which other publishers should strive to follow.

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