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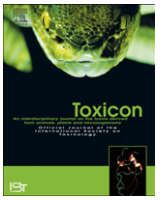

Estimate of the burden of snakebites in sub-Saharan Africa: A meta-analytic approach

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ABSTRACT

Snakebites represent an important neglected public health problem in many developing countries. There is a lack of epidemiological data, which would be very useful for the organisation of snakebite management and provision of antivenom. An extensive literature search for the years 1970–2010 was performed. Data were analysed using meta-analysis to take into account the heterogeneity between the studies and their respective weight. Incidence, mortality and population at risk were estimated after stratification according to the environment (urban or rural) and survey methodologies (national, hospital or community studies). The incidence of snakebite was inversely correlated with population density. The number of envenomings was estimated at 314,078 [CI95% = 251,513–377,462], of which 95% occurred in rural areas. The remainder occurred in cities. The annual mortality was estimated at 7,331 [5,148–9,568], of which 97% occurred in a rural environment. The annual number of amputations ranged from 5,908 to 14,614. The population most at risk was young men engaged in agricultural or pastoral labours. Household surveys indicated that actual incidence and mortality were likely 3–5 times higher. The difference maybe explained by treatment seeking behaviour. However, incidences and mortalities reported here reflect the number of patients who attend modern health facilities, giving underestimated figures of the burden of snakebites in sub-Saharan Africa but realistic current requirements for antivenoms.

1. Introduction

Although data on incidence and mortality from snakebites in Africa are underestimated, recent evaluations have shown that snakebites represent an important but neglected public health problem among poor rural populations in many developing countries (Harrison et al., 2009; Warrell, 2010). It has been claimed that one million snakebites occur every year in Africa, primarily in sub-Saharan Africa, resulting in 100,000 to 500,000 envenomings and 10,000 to 30,000 deaths (Chippaux, 1998a; Kasturiratne et al., 2008). However, incidence and mortality data are inaccurate due to the lack of reliable epidemiological and health data. Although frequent, venomous animal aggressions are usually not reported. Therefore, it is impossible to define budgets and allot funds for envenoming management and health staff training (Chippaux, 2008). As a result, envenoming is not considered by health authorities who state that therapeutic solutions are unavailable and resources are inaccessible (Stock et al., 2007; Williams et al., 2010). In addition, the high cost of antivenoms and their short shelf life discourage users from keeping sufficient stocks, which in turn reduces requests for antivenom. Moreover, health staff's ignorance regarding the directions for use causes disappointing results, which dissuade them from employing antivenoms in the future. Manufacturers hesitate to produce antivenoms that they are not sure they could sell. This vicious

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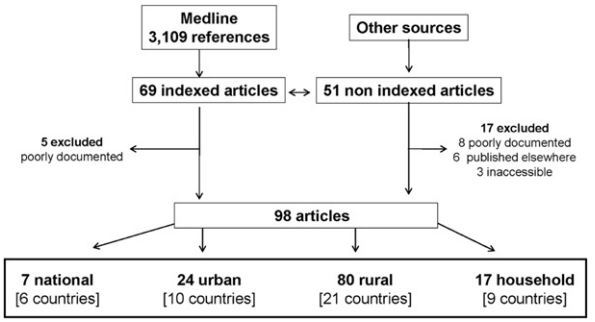

Fig. 1. Diagram of the steps of the literature review.

cycle has resulted in the reduction of antivenom accessibility, particularly in Africa, where the sale of antivenom has declined from approximately 200,000 vials per annum in the 1980s to less than 20,000 at the beginning of the years 2000 (Chippaux, 1998b, 2002c).

To address this important public health problem, several measures were suggested (Stock et al., 2007; Chippaux, 2008). One was to specify the epidemiologic burden of envenoming to better estimate the requirements for antivenoms and to ensure their distribution in sufficient quantity to areas in need. Several attempts at evaluating snakebite incidence were made (Chippaux, 1998a; Kasturiratne et al., 2008; Swaroop and Grabb, 1954). The two most recent papers reported high incidences of snakebites, but their results were disputed by some authors who regard them as incomplete and skewed (Warrell, 2010; Simpson, 2010). According to these critics, the methods used for data collection were not specified, and/or the extrapolations were not justified.

We urgently need an estimator of the burden of snakebites in sub-Saharan Africa in order to define strategies of management (antivenom supply, health personnel training). Lacking consistent data in this area and before the health authorities of African countries organise a reliable case report system, literature analysis remains the main source of information. Here, the data reported in the literature are analysed according to the method used for data collection and geographical occurence, and generalisation of the results is discussed according to environmental and socio-economic factors. The heterogeneity of the observations may be taken into account using estimation models by meta-analyse.

The goal is to describe as precisely as possible the epidemiological characteristics of snakebites in sub-Saharan Africa to assist antivenom manufacturers and health authorities in giving tools for the implementation of and defining better strategies for snakebite management.

2. Materials and methods

The search for epidemiological studies on snakebites in Africa was performed through a systematic interrogation of Medline with the following words: Africa AND snake* AND [envenom* OR antiven*]. The final enquiries were made on December 7th, 2010. The references of selected articles were searched to find publications in non-indexed journals, thesis and conference proceedings, as well as available clinical reports and grey literature. This survey was completed by systematic searching of non-indexed tropical medicine journals and congress proceedings in English, French, Italian, Spanish, Portuguese and German for the last 40 years.

In the selected literature, data were obtained using three main approaches: national health reporting system (NHRS), hospital records (HR) and household surveys (HHS). The NHRS gathers reports from all public health centres (both hospitals and dispensaries). However, in most countries, envenomings (following both snakebites and scorpion stings) are reported together with trauma and other violent events and, sometimes, poisonings. The HR were obtained from health centres either retrospectively or prospectively; prospective studies generally provide more precise and reliable information, especially on snakebite management. Finally, the HHS used standardised questionnaires administered to the whole population or a sample of the population of selected localities aiming at questioned villagers on snakebites that they or their relatives experienced during past years. HHS provide three basic types of information, namely incidence (morbidity) rates, case fatality rates (mortality) and therapeutic-seeking behaviour (either traditional or modern medicine). Moreover, they permit the definition of the population at risk. Epidemiological follow-up can also be performed in demographic surveillance system (DSS) areas in which epidemiological and health events are systematically reported, particularly causes of death through standardised verbal autopsy (Setel et al., 2006). These studies contributed to the validation of the HHS methodology (Guyavarch and Chippaux, 2005).

The articles that did not specify basic methodological criteria (locality of the study, method of data collection, period and duration of the study, criteria of selection of the subjects, clinical diagnosis, and severity of envenoming) were excluded from the corresponding analysis. When the number of inhabitants in the study area was not specified in the article, demographic information was obtained from national or United Nations (www.un.org/esa/population and http://unstats.un.org/unsd/demographic/) official documents for the period of study. When hospital catchment area was not given by the authors, it has been estimated from the regional population. Lastly, results already mentioned in other articles were excluded.

The data were analysed following meta-analyse technique using the Comprehensive Meta Analysis v. 2·2·050 software (Biostat®, Englewood, NJ, USA; Borenstein et al., 2009). In addition, the data were stratified according to the level at which the data were collected (national, urban hospitals, rural health centres and community). Cities were defined by the number of inhabitants (>500,000) and the presence of a reference hospital. Regarding incidence and mortality, data were also stratified according to the geographic origin, i.e. West African studies performed from Senegal to Nigeria *versus* East African studies from Cameroon to Djibouti and South Africa. Analyses were performed under the random-effects model allowing that the true effect is not identified and could vary from study; such a model takes into account both within-study errors in estimating the effect in each study and variations in the true effects across studies.