

Protection against Snake Bites by Sleeping under a Bed Net in Southeastern Nepal

François Chappuis,* Sanjib K. Sharma, Nilhambar Jha, Louis Loutan, and Patrick A. Bovier

Travel and Migration Medicine Unit, and Department of Community Medicine, Geneva University Hospitals, Geneva, Switzerland;
Department of Medicine, and Department of Community Medicine, B. P. Koirala Institute of Health Sciences, Dharan, Nepal

Abstract. Snake bites in persons while they are asleep indoors are associated with a high risk of fatal outcome in southeastern Nepal. The preventive impact of sleeping under a bed net was assessed in four villages in a case-control study. A case was defined as a person with a history of snake bite that occurred indoors while asleep. Cases were matched with controls by village, type of household, sex, and age category. Of the 11,176 households visited, 56 cases, including 13 (23%) with a fatal outcome and 56 controls were included in the analysis. Sleeping under a bed net was a strong protective factor (odds ratio = 0.02, 95% confidence interval = 0.007–0.07, $P < 0.0001$), whereas the place of sleeping in the household and the use of a cot were not associated with the risk of snake bite. These findings provide further support for use of bed nets in this region.

INTRODUCTION

Up to four million snake bites occur each year in Asia, resulting in 100,000 deaths per year.¹ Incidence is particularly high in rural areas of warm regions where snakes are abundant. In Nepal, where more than 20,000 snake bites and a resulting 1,000 deaths occur annually,² most bites occur in the Terai, the southern lowland agricultural plain characterized by a hot tropical climate. Of the 22 venomous snake species living in Nepal, several highly venomous species are found in the Terai including *Naja naja* (common cobra), *Ophiophagus hannah* (king cobra), *Bungarus caeruleus* (common Indian krait), *Bungarus fasciatus* (banded krait) and *Daboia russelii* (Russell's viper, restricted to western Nepal).^{2,3} Bites by Elapidae (cobras and kraits) are characterized by severe neurotoxicity, which may rapidly lead to respiratory paralysis and death.

We recently conducted a community-based survey in five eastern Terai villages that showed a high annual incidence (1,162/100,000) of snake bites and annual mortality rate (162/100,000) caused by snake bites. An increased risk of death was associated with reports of bites occurring inside the house while victims were resting between midnight and 6:00 AM.⁴ These fatalities were likely to be due to common kraits, which often enter houses at night in search of food.⁵ They bite human victims sleeping on the floor, a common sleeping behavior among Hindus in the rural Indian sub-continent.^{6–9} We hypothesized that bed nets, which are used in this region to protect against malaria and other vector-borne diseases, may act as a physical barrier that prevents venomous snakes from biting humans while asleep.

We took advantage of a large community-based intervention study, the aim of which was to decrease case-fatality rate of snake bites, to conduct a nested case-control study to assess the impact that sleeping under a bed net had on the risk of snake bites occurring indoors during sleep in southeastern Nepal.

MATERIALS AND METHODS

The case-control study was conducted in 4 village development committees (VDCs) in southeastern Nepal (Chulachuli,

Itahara, Kerabari, and Rajghat). All VDC households were visited by 15 teams of trained interviewers in November and December 2003. All individuals with a history of snake bite that occurred indoors while asleep were included as cases. For each case, the interviewers identified one control who lived in the same VDC in the same type of house and of the same sex and age category (0–9, 10–19, 20–29, 30–44, and ≥ 45 years of age). Controls were included in the study if they did not report any history of snake bite indoors while asleep and were living in the household at the time the case was bitten. In the field, the interviewer visited the household(s) of the same house type nearest to the case's residence until he could find an individual who met all criteria required for classification as a control. Information on demographic characteristics, conditions of sleep at the time of bite for cases and at a corresponding time for controls, and outcome of the bite (for cases) were recorded on a standardized questionnaire. The head of household responded to the questionnaire if the case or control was less than 15 years of age or if the case was no longer living. Ethical clearance for this study was obtained from the B. P. Koirala Institute of Health Sciences Ethical Review Board in March 2003. Informed consent was obtained from all participants.

Odds ratios (ORs) with 95% confidence intervals (CIs) were used to determine the size of the association between the exposure (e.g., use of bed net) and outcome (snake bite) in an unmatched-pair analysis. We then performed a matched-pair analysis to ensure that the matched variables were not significant confounders.¹⁰

RESULTS

A total of 57 cases, of whom 13 (23%) had a fatal outcome, and 57 controls were recruited from the 11,176 households (60,759 inhabitants) surveyed. One case-control pair was excluded from analysis because of a matching error. The 56 remaining pairs came from Chulachuli (32%), Itahara (29%), Rajghat (29%) and Kerabari (11%). The male:female ratio was 0.6 (21/35) in both cases and controls, and the median (range) age of cases (33.5 years, range = 5–70 years) and controls (30 years, range = 4–82 years) were similar ($P = 0.5$). For cases, bites had occurred at a median interval of 3 years (range = 0.1–22.3 years) before the survey.

Sleeping conditions of both cases and controls are shown in Table 1. The place of sleep within the household was not associated with the risk of being bitten ($P = 0.75$). Sleeping

* Address correspondence to François Chappuis, Travel and Migration Medicine Unit, Geneva University Hospitals, 1211 Geneva 14, Switzerland. E-mail: francois.chappuis@hcuge.ch

TABLE 1

Sleeping conditions at the time of snake bite in 56 cases or at corresponding time in 56 controls from four villages in southeastern Nepal

Sleeping conditions	Cases no. (%)	Controls no. (%)	<i>P</i> *
Place of sleeping in the house			0.75
Bedroom	46 (82)	47 (84)	
Terrace (roof)	2 (4)	3 (5)	
Backyard	3 (5)	3 (5)	
Veranda	5 (9)	3 (5)	
Mode of sleep			0.2
On the floor	18 (32)	12 (21)	
On a cot	38 (68)	55 (79)	
Floor of the house			1
Ground	16 (29)	16 (29)	
Upper	40 (71)	40 (71)	
Use of bed nets			< 0.001
Yes	10 (18)	51 (91)	
No	46 (82)	5 (9)	
Condition of the bed net			< 0.001
Good	3 (30)	45 (88)	
Not good	7 (70)	6 (12)	
Bed net treated with insecticide†			0.02
Yes	2 (22)	0	
No	7 (78)	50 (100)	
Explanation for lack of bed net use			0.59
No bed net	17 (37)	1 (20)	
Not habituated	10 (22)	1 (20)	
Too poor	5 (11)	2 (40)	
No mosquito nuisance	9 (20)	1 (20)	
Too hot	3 (7)	0	
Bed net owned but not used	2 (4)	0	

* *P* measured by Pearson chi-square or Fisher's exact test.

† Data missing in one case and one control with bed net use.

on a cot, a locally made wooden bed of various heights, or on an upstairs floor was not identified as a protective factor (Table 2). However, use of a bed net was a strong protective factor with an OR of 0.02 (95% CI = 0.007–0.07, $P < 0.0001$). Furthermore, the use of bed nets in good condition provided significantly better protection than bed nets in bad condition ($P < 0.001$). The results of the matched-pair analysis were comparable. The protective effect of bed nets was slightly reinforced in a multivariate analysis that included the mode of sleep as a potential confounder. Not using a bed net at the time of being bitten was explained by not owning a bed net (e.g., too poor) or reluctance to use (e.g., not habituated, too hot, or no mosquito nuisance).

DISCUSSION

In this study, sleeping under a bed net was an extremely efficient protection against snake bites occurring indoors

TABLE 2

Risk of snake bite in relation to sleeping conditions in four villages in southeastern Nepal*

Sleeping conditions	OR	95% CI
Under a bed net	0.02	0.007–0.07
Under a bed net in good condition (vs. no bed net)	0.007	0.002–0.03
Under a bed net in bad condition (vs. no bed net)	0.13	0.03–0.53
Under a bed net in good condition (vs. bed net in bad condition)	0.06	0.01–0.28
On a cot (vs. on the floor)	0.58	0.25–1.35
On ground floor (vs. on upper floor)	1.0	0.44–2.27

* OR = odds ratio; CI = confidence interval.

while asleep. The mode of protection is likely due to a mechanical barrier effect because only 3.3% of the bed nets were declared to have been insecticide-treated. Consistent with this explanation, bed nets in good condition offered even stronger protection than bed nets in bad condition, which highlights the importance of proper maintenance and exchange of damaged nets. We did not find any association between the risk of bites and the location of sleeping in the household. Moreover, sleeping on a cot (versus on the floor) or on an upstairs floor (versus on the ground floor) was not protective. The latter findings were unexpected because kraits have limited climbing abilities.

In a recent study conducted in the same area, snake bites occurring indoors while victims were resting represented only a minor fraction (9%) of the global incidence of snake bites, but were associated with a high (23%) case-fatality rate,⁴ which was confirmed in the present study (23%). This may be related to an increased difficulty in finding a vehicle at night for transporting victims to a specialized treatment center and/or an increased likelihood of bites from common kraits, which have been associated with high case-fatality rates. The paucity or absence of local pain and swelling after krait bites may falsely reassure the victim and thus delay or prevent transport to a treatment center. Moreover, victims of envenomed krait bites often show severe signs of neurotoxicity and a less reliable clinical response to anti-snake venom serum and anticholinesterase drugs than after cobra bites.^{6,11} Preventing snake bites from occurring indoors while asleep is therefore crucial to decreasing the number of deaths caused by krait bites in this region. This should be complemented by the promotion of rapid transport of victims to medical facilities able to manage patients with severe signs of neurotoxicity because 80% of deaths caused by snake bites in this region occur in the village or during transport to the treatment center.⁴

The case-control design of our study has some limitations. Because most bites occurred several years prior to the study, a certain degree of recall bias cannot be excluded. Controls may have been more likely to misreport sleeping behaviors, such as bed net use, at the time of a non-event (absence of bite), especially if they were sleeping under the net intermittently.

Our findings provide an additional argument to promote the distribution and proper use of bed nets in the Terai plain of Nepal. Bed nets need to be treated with insecticide to provide optimal protection against the main vector-borne diseases endemic in this region: malaria, kala-azar, and Japanese encephalitis.

Received December 14, 2006. Accepted for publication April 4, 2007.

Acknowledgments: We thank Chandra Shah, health assistant in charge of the Damak Red Cross Snake Bite Treatment Centre, for his precious contribution to the fieldwork. We are also grateful to Gabrielle Landry for kindly editing the manuscript.

Financial support: The study was funded through grants allocated by the Geneva University Hospitals and by the Sonisca Foundation.

Authors' addresses: François Chappuis and Louis Loutan, Travel and Migration Medicine Unit, Geneva University Hospitals, 24 Rue Micheli-du-Crest, 1211 Geneva 14, Switzerland, Telephone: 41-22-372-9620, Fax: 41-22-372-9626, E-mails: francois.chappuis@hcuge.ch and louis.loutan@hcuge.ch. Sanjib K. Sharma, Department of Medicine, B. P. Koirala Institute of Medical Sciences, Dharan, Nepal, Telephone: 977-25-525335, Fax: 977-25-520251, E-mail: drsanjib@

yahoo.com. Nilhambar Jha, Department of Community Medicine, B. P. Koirala Institute of Medical Sciences, Dharan, Nepal, Telephone: 977-25-525335, Fax: 977-25-520251, E-mail: niljha@yahoo.com. Patrick A. Bovier, Department of Community Medicine, Geneva University Hospitals, 24 rue Micheli-du-Crest, 1211 Geneva 14, Switzerland, Telephone: 41-22-372-9636, Fax: 41-22-372-9600, E-mail: patrick.bovier@hcuge.ch.

REFERENCES

1. Chippaux J-P, 1998. Snake-bites: appraisal of the global situation. *Bull World Health Organ* 76: 515-524.
2. World Health Organization, 1987. Zoonotic disease control: baseline epidemiological study on snake-bite treatment and management. *Wkly Epidemiol Rec* 42: 319-320.
3. Bhetwal BB, O'Shea M, Warrell DA, 1998. Snakes and snake bites in Nepal. *Trop Doct* 28: 193-195.
4. Sharma SK, Chappuis F, Jha N, Bovier PA, Loutan L, Koirala S, 2004. Impact of snake bites and determinants of fatal outcomes in southeastern Nepal. *Am J Trop Med Hyg* 71: 234-238.
5. Desilva A, 1981. Snakebites in Anuradhapura District. *Snake* 13: 117-130.
6. Bawaskar HS, Bawaskar PH, 2002. Profile of snakebite envenoming in western Maharashtra, India. *Trans R Soc Trop Med Hyg* 96: 79-84.
7. Theakston RD, Phillips RE, Warrell DA, Galagedera Y, Abeysekara DT, Dissanayaka P, de Silva A, Aloysius DJ, 1990. Envenoming by the common krait (*Bungarus caeruleus*) and Sri Lankan cobra (*Naja naja naja*): efficacy and complications of therapy with Haffkine antivenom. *Trans R Soc Trop Med Hyg* 84: 301-308.
8. Saini RK, Singh S, Sharma S, Rampal V, Manhas AS, Gupta VK, 1986. Snake bite poisoning presenting as early morning neuroparalytic syndrome in Jhuggi dwellers. *J Assoc Phys India* 34: 415-417.
9. Bawaskar HS, Bawaskar PH, 2004. Envenoming by the common krait (*Bungarus caeruleus*) and Asian cobra (*Naja naja*): clinical manifestations and their management in a rural setting. *Wild Environm Med* 15: 257-266.
10. Hennekens CH, Buring JE, 1987. Evaluating the role of confounding. Mayrent SL, ed. *Epidemiology in Medicine*. Boston: Little, Brown and Company, 287-323.
11. Warrell DA, 1999. WHO/SEARO guidelines for the clinical management of snake bites in the southeast Asian region. *Southeast Asian J Trop Med Hyg* 30 (Suppl 1): 1-85.