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The Epidemiology of Snakebite Injury in the Amazonian Regions of Ecuador

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ABSTRACT

Introduction:
Morbidity and mortality from snakebite envenomations is a major public health issue in remote areas of under-developed countries. Several attempts have been made to approximate the impact of snakebites worldwide, however these are assumed to be underestimations due to the lack of documentation on the local level. Ecuador's Amazonian region lacks a comprehensive community-based surveillance system, however it is unique in that an aero-medical transport system is in place to transfer the patients requiring hospitalization to one of the five urban medical centers. Beginning in 1998, Servicio Aéreo Misional (SAM), one of the two transport companies serving three of the rural provinces, began documenting flight data including the demographics of patients and their diagnoses.

Methods:
The SAM database was used to conduct a retrospective study to describe the incidence, patient demographics and geographic location of snakebite injuries in three rural provinces of Ecuador. SPSS was used for frequencies and Chi squares analyses.

Results:
In the years 2003 to 2005 there were a total of 1,340 aero-medical transports in this region. Of those, snakebite injuries constituted 4.2% of all medical diagnoses. The majority of snakebites occurred in males ($p=0.027$) aged 10-29 ($p<0.001$) and were concentrated in the low-lying areas of the province of Morona-Santiago.

Discussion:
These results describe the distribution of snakebites; efforts are now underway to identify the risk factors involved in this patient population. This information would then be used to optimize prevention and treatment.

INTRODUCTION

Morbidity and mortality from snakebite envenomations is a major public health issue in remote areas of under-developed countries (1,2). This is primarily due to lack of access to healthcare, the use of inappropriate and low efficacy anti-venom, as well as the increased number of individuals within the agricultural sector. (3,4) The World Health Organization (WHO) has recently added snakebites to its list of Neglected Tropical Diseases. WHO is striving to address the issue through such actions as making anti-venom more available and effective, educating local healthcare workers and implementing prevention programs.(5) The challenge of this effort is finding comprehensive data to accurately estimate the incidence and geographic locations of envenomations and deaths due to snakebites in order to appropriately allocate resources.(6)

Several attempts have been made to approximate the impact of snakebites worldwide. As early as 1954, Swaroop and Grab estimated the total number of snakebites to be about 500,000 annually with about 30,000-40,000 deaths per year. (1) These numbers, however, were a gross underestimation since their study was based solely on hospital statistics and poorly documented national statistics. In addition, they failed to get data from several highly populated countries like the USSR and China. More recently in 2008, Kasturiratne et al. extrapolated figures from published data along with information from Ministries of Health, Poison Control Centers, hospitals and community clinics to estimate the global occurrence of snakebites to range from 1.2 to 5.5 million per year, with a mortality figure of 20,000 to 94,000 deaths per year.(7)

The accuracy of these numbers, however, is still uncertain since many snakebites occur in rural areas where there is a lack of data.

There are two families of venomous snakes known to inhabit the eastern lowlands of Ecuador, Viperidae and Elapidae. Three of the four venomous snakes are classified as Viperidae, including *Bothrops,* more commonly known as lanceheads*; Bothriopsis,* pit vipers; and *Lachesis*, also known as the bushmaster. (8-11) The Elapidae family includes the genus *Micrurus*, which encompasses all species of coral snakes found in this area. [See Appendix A](12) The World Health Organization/South East Asian Region Organisation (13) states that treatment for snakebites includes First Aid, immobilization of the affected limb, administration of anti-snake venom (ASV) and supportive therapy. (13-15)   These guidelines are specific for the South East Asian region but have been adopted by many countries as standard for the clinical management of snakebites. (14)

Anti-snake venom (ASV) consists of antibodies taken from an animal following its exposure to the venom. It is the only treatment proven to slow, if not cease, the progression of the local and systemic effects of envenomation. (16) The limiting factors associated with ASV are the inadequate supplies, due to both an underestimation of need and inadequate distribution; poor assessment of the situation leading to erroneous ASV administration (both from the patient's inability to recognize snake and the provider's physical exam); and finally from problems with the anti-snake venom itself. (14,15) ASV can vary in efficacy due to its preparation, immunology of the antivenom, its specificity to the snake's venom

and the amount of time that has lapsed since envenomation occurred.(3,17)

Complications such as anaphylaxis and reactions to the animal serum used in

the production of ASV can also influence the patient's outcome. (3,18)

In order to ensure the administration of an ASV with sufficient specificity,

accurate identification of the snake is necessary. This can be accomplished by

patient identification or evaluation of signs and symptoms by the provider. It is

therefore necessary for health workers to be educated on the genera with the

greatest prevalence in addition to the presenting symptoms.(14,18) In this region

of Ecuador, the majority of documented bites are from the *Bothrops* genus

followed by *Lachesis.* (18-20) Although the Elapidae family is in abundance

throughout the Amazonian region of South America, including these provinces in

Ecuador, there have only been two documented cases of its envenomation

throughout this area. (18,21) This is most likely due to the coral snake's short,

fixed fangs that have difficulty penetrating clothing and skin. (14) Bothrops,

however, have short hollow fangs that are positioned against the upper jaw but

swing down when the snake opens its mouth to inject its venom, contributing to it

being the cause of the majority of bites and fatalities in South America. (22,23)

The two different families of snakes have unique venomous effects.

Elapids have neurotoxic venom, leading to descending paralysis and eventually

respiratory distress, however there is little to no damage at the bite site. Vipers

have primarily hemotoxic and myotoxic venom, which produces severe damage

surrounding the bite site, including complete necrosis of the local tissue.

Eventually systemic manifestations occur, mainly coagulopathy, acute renal

failure and acute respiratory distress. (6,24) A test with a high specificity is the 20-min whole blood clotting test, which consists of placing a thin layer of blood on the side of a clean test tube and if it has not coagulated after 20 minutes, the bite was most likely caused by a member of the Viperidae family. When the snake family is recognized, antivenom can be administered according to protocol. (6,12,25)

There have been several studies done at hospitals within the Amazon region that have focused on the treatment and outcome of snakebite injuries.(4,13,18,21) Praba-Egge's "Snakebites in the Rainforests of Ecuador" described age, gender, occupation, anatomic location of injury and the time of year for all patients seen at Hospital Pio XII in Sucua but failed to describe the epidemiology of each individual province. They found the overall incidence to be 150/100,000 and of the 142 patients assessed for snakebites, the mean age was 27±18 years old and more than 40% were agricultural workers.   Most of the bites occurred in the months of March through May. (19) Kevin Kerrigan of Hospital Vozandes Oriente, which is also in Shell, Pastaza, published his findings of all patients admitted to that hospital for snakebites between 1980-1989. All of the 93 cases in which the snake was identified were due to the Viperidae family, 57 of the *Bothrops* genus and 36 of the *Lachesis* genus. Of all 294 patients, there were no cases of progressive paralysis and none of the serological studies indicated that any of the bites were from the genus *Micrurus*. There was a 5.4% mortality rate (16/294) all due to coagulopathy and 12 of the 16 deaths were from intracranial hemorrhage. (18)

Three of the provinces in eastern Ecuador; Morona Santiago, Pastaza and Azuay have an aero-medical transport system that transfers all medical emergencies to the urban hospitals in Sucua and Macas, Morona Santiago; Taisha, a city in Pastaza, and Cuenca, the city in Azuay with the biggest of the four hospitals, where the majority of the transfers go. Patients initially are seen by the local physician who determines which patients are in need of transport for better medical care. The company Servicio Aéreo Misional (SAM) is one of two companies responsible for the medical transfers. All transports have been documented and entered into an aerial data registry that will serve as a community-based surveillance system for emergency medical needs. For 2003-2005, there were a total of 1,340 medical transports, of which 59 were due to snakebites.

OBJECTIVE

The purpose of this project is to conduct a retrospective study to describe the

incidence and geographic location of snakebite injuries in the Amazonian

provinces of Ecuador to assess the magnitude and distribution of the problem in

order to optimize prevention and treatment.

METHODS

The medical transport records of Servicio Aéreo Misional (SAM) for
January 2003-December 2005 were reviewed with all transported patients
considered for the study. Patients are diagnosed by history and physical
examination by the physicians serving the provincial clinics who make the
decision regarding transport for further treatment. Patients or their relatives gave
informed consent for transportation, admission and investigation.

Snakebite cases were defined as any patient given a diagnosis of ICD 10
code T63.0, "Toxic effect of contact with snake venom." (28) Variables
abstracted from the flight records included age, gender, flight date, the airport of
origin and the city to which the patient was being transferred.

Mapping was done using Quantum GIS to examine the distribution of
snakebite transports by airport of origin.(29)

Frequencies and Chi square analyses were conducted using SPSS
Complex Samples.(30)

RESULTS

During the three-year period, 1,340 patients were transported by SAM. There were 56 persons with a snakebite diagnosis or 4.2% of the total and they accounted for 107 transports for treatment. Of those 1,340 patients, 87.1% originated in Morona-Santiago, 10.0% in Pastaza and 2.9% in Azuay.

For Morona-Santiago, there were a total of 1,167 patients over the three years with 46 or 3.9% due to snake envenomation. The number of flights per year was similar for 2003 and 2005 but increased in 2004 with snakebites accounting for 3.4% to 4.3% of the transports for their respective years (Table 1). A similar trend occurred in Pastaza for overall transports with 2004 showing a 39% increase over 2003 with a decrease again in 2005 with a total number of snakebites of 6 or 4.5%, ranging from 1.8% to 7.3%, annually. In Azuay, the total number of transports was much lower than the other Provinces but snakebites (numbering 4) accounted for over 10% of the total. Figure 1 shows a 26% decline in snakebite transfers from 2003 to 2005, with 5.0% in 2003 to 3.9% in 2004 to 3.7% in 2005. (p=0.63)

As seen in Table 2, the 56 patients diagnosed with snakebite envenomation consisted of 22 women (39%) and 34 men (61%), a significantly different distribution from all other transports where women accounted for 54% and men only 46% (p-value <0.01). The age distribution was also significantly different with fewer young children or older persons among those with snakebites. Persons between the ages of 10 and 29 made up 57% of all snakebite transports compared to only 34% of non-snakebite flights. The mean

age for snakebites was 24.7 ± 16.2 years (range <1-68 years), whereas the mean age for non-snakebite victims was 22.0 ± 15.8 years (range <1-92 years).

As shown on the map (Figure 2), the greatest number of flights due to snakebites that originated from a single airstrip was 3. Those airstrips include Inayua Norte, Santiago and Wasakentsa, all three of which are located in Morona-Santiago; Patukmai of Azuay and Yutsunts of Pastaza. There were 12 airstrips that each transferred 2 snakebites. The distribution of flights due to snakebite envenomations is concentrated in the northeastern region of Morona-Santiago, the most rural area with lower elevations.

The monthly distribution (Figure 3) of total snakebites for the years 2003-2005 showed a peak in January at 10 and then gradually dropped each month until no snakebites were reported in July and then there was a steady increase to 4 snakebites in December. Seventy-one percent of the bites occurred between January and May. For 2003, January and February each had 5 snakebites per month but then decreased 60% in March and remained low for the duration of that year. The year 2004 had its peak in March with 5 bites. January, February and April each had 3 snakebites per month. The greatest number of snakebites in a single month for the year 2005 was 2 (December, January, April and May) and the least was 0 in July and August.

DISCUSSION

Snake envenomation morbidity and mortality plagues tropical areas worldwide. To successfully contend with this burden requires a proper assessment of the incidence, which is often challenging in rural areas. (7,19, 23) The purpose of this paper was to provide a better estimate as to the number of snakebites occurring in the rural areas of Eastern Ecuador in order to improve prevention and treatment.

An overwhelming majority of transports originated in the province of Morona Santiago, concentrated in the areas of lower elevations. This is probably a result of the high rural nature of this province where 67% of the population (115,000) is considered rural compared to Pastaza with 46% of a population of 62,000 living in rural areas. According to Kasturiante, snakebites occur more often in rural areas and in regions with elevations less than 7700 ft. (7) In addition, the ALAS transport system rather than the SAM system flies mostly within the province of Pastaza. Azuay is predominantly urban where 67% of the population lives within or in the surrounding area of the city Cuenca, home to one of the largest medical centers in Ecuador, and would therefore not require transportation by plane. In addition, Azuay has a better-developed road system [see Appendix B], thus eliminating the need for air transportation. The province of Azuay is also situated in the Sierra region of Ecuador with elevations above 7,700 ft, conditions that are not desirable for snakes belonging to venomous genera. (26) It is of interest to note that a higher proportion of all transports from

Azuay were due to snakebites, indicating occurrence in areas of the Province with poor healthcare coverage.

Environmental and geographical variables such as temperature, season, and altitude are known determinants of snake distributions including density and more importantly, the type of snake. (9-12, 25) For example *Bothrops* is found more commonly in lower elevations, usually meaning higher temperature and increased rainfall. (10) This snake is estimated to account for most snakebite envenomations in these regions. Knowing this type information can be useful at allocating resources and directing further studies to areas where snakebites are more likely, and more importantly where they may lead to greater morbidity and mortality. The same is true for seasonal variations in snakebite incidence. This study concluded that the majority of envenomations, 71%, occurred during the months of January to May. While snakebites are a year round concern, understanding seasonal variations in incidence may also better direct resources for those times that envenomations are more likely. These types of environmental variables, while not usually controllable, can be better quantified and qualified in order to predict both areas and times of increased relative risk.

As for specific demographics of patients suffering from snakebite envenomations, our data clearly showed that males suffered a statistically significant higher rate of snakebites as compared to women. Like many previous studies conducted on snakebites worldwide, this finding is consistent with the supporting hypothesis that males are more likely to be exposed in higher numbers to higher risk environments, mainly due to their increased involvement

in agriculture and other outdoor activities. (18-20,24) Similar high-risk exposure environments likely contributed to an increase in snakebite envenomations amongst individuals less than 30 years of age. Like gender however, there are likely other confounding or intervening variables that were not measured that may have contributed to the increased incidence amongst these groups. Including more variables and performing multivariate analysis would assist in determining strengths of associations of these unknown variables and should be the focus of future studies aimed at determining what risk factors are most likely determinants for snake bite injury. (2,4,5)

Although our data provided additional information to the hospitals' documentation such as approximate distribution of the snakebite locations, there are still several components lacking in the data that would help better quantify and qualify the incidence in order to provide a more comprehensive surveillance system. The first is that we did not have access to the ALAS records, an additional aero-medical transportation system serving both Morona-Santiago and Pastaza. In addition, our data only included those patients with severe enough conditions to require hospitalization. Our data therefore fails to account for those patients who were treated at the local clinics but required only minimal treatment, those who were never evaluated by the clinic, either because they sustained no serious injuries, they sought treatment from a traditional healer, or they died before reaching the clinic. (2,4-7)

Establishing a more comprehensive surveillance system in a region with very limited monetary and logistical infrastructure requires a clear identification of

the problem, allocation of resources to appropriate locations considering cost vs. benefit, and constant data gathering with appropriate restructuring of both hypotheses and implementation programs. Data is very limited in this region, and while there is not currently a very comprehensive surveillance and treatment program at the local level, there is potential to establish an efficient and statistically supported initiative that differs from the current inadequate system.

TABLES

Table 1: Snakebite Percentages per Year

	All Medical Transfers (n)	Snakebite (n)	Snake bite (% of Transfers)
Morona-Santiago			
2003	325	14	4.3
2004	518	21	4.1
2005	324	11	3.4
	1167 (87.1%)	**46**	**3.9**
Pastaza			
2003	41	3	7.3
2004	57	1	1.8
2005	36	2	5.6
	134 (10.0%)	**6**	**4.5**
Azuay			
2003	13	2	15.4
2004	11	1	9.1
2005	15	1	6.7
	39 (2.9%)	**4**	**10.3**
Total			
2003	379	19	5.0
2004	586	23	3.9
2005	375	14	3.7
	1340 (100%)	**56**	**4.2**

Table 2: Demographics of Non-Snakebite Transfers Compared to Snakebite Transfers

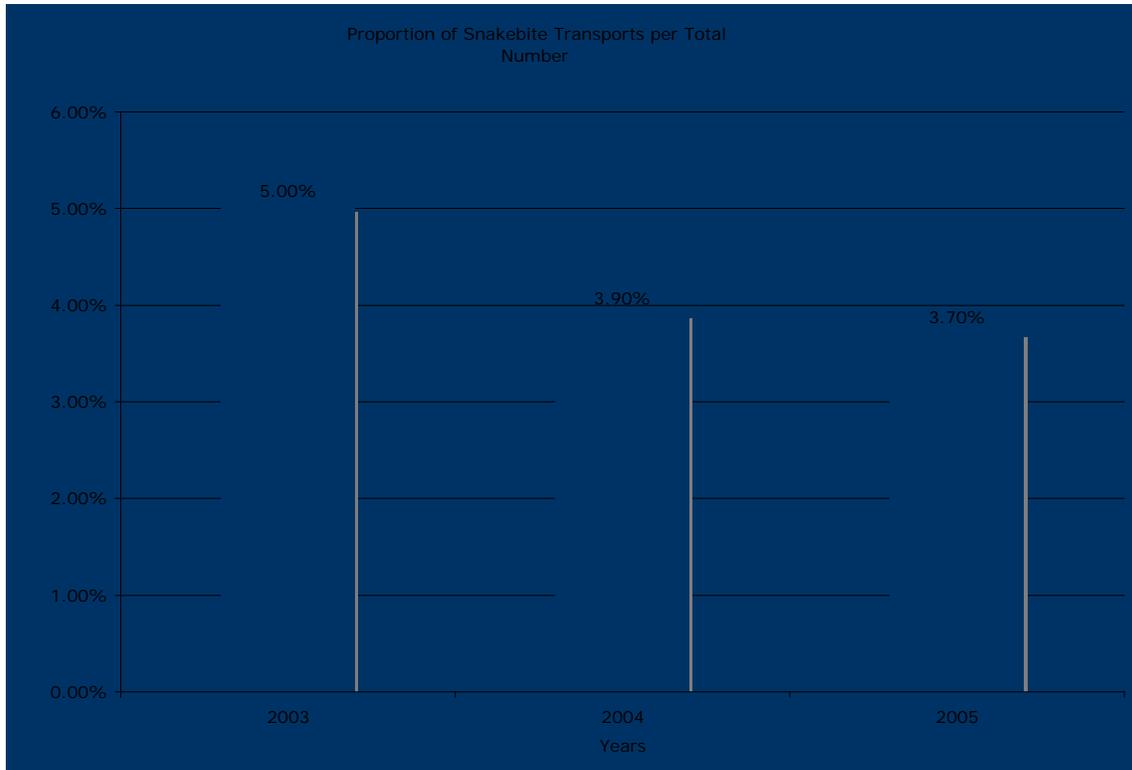|	NON-SNAKEBITES (N)	NON-SNAKEBITES (%)	SNAKEBITES (N)	SNAKEBITES (%)	P-VALUE
Age					
0-9	433	34.4	8	14.3	p<0.001
10-19	190	15.1	17	30.4	
20-29	244	19.4	15	26.8	
>30	392	31.1	16	28.6	
Total	**1259**	**100**	**56**	**100**	
Gender					
Male	580	46.1	34	60.7	p=0.027
Female	679	53.9	22	39.3	
Total	**1259**	**100**	**56**	**100**	

Figure 1: Proportion of Snakebites to Total Transports

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Figure 2: Map of Snakebite Transports per Airport

Monthly Distribution of Snakebites per Year

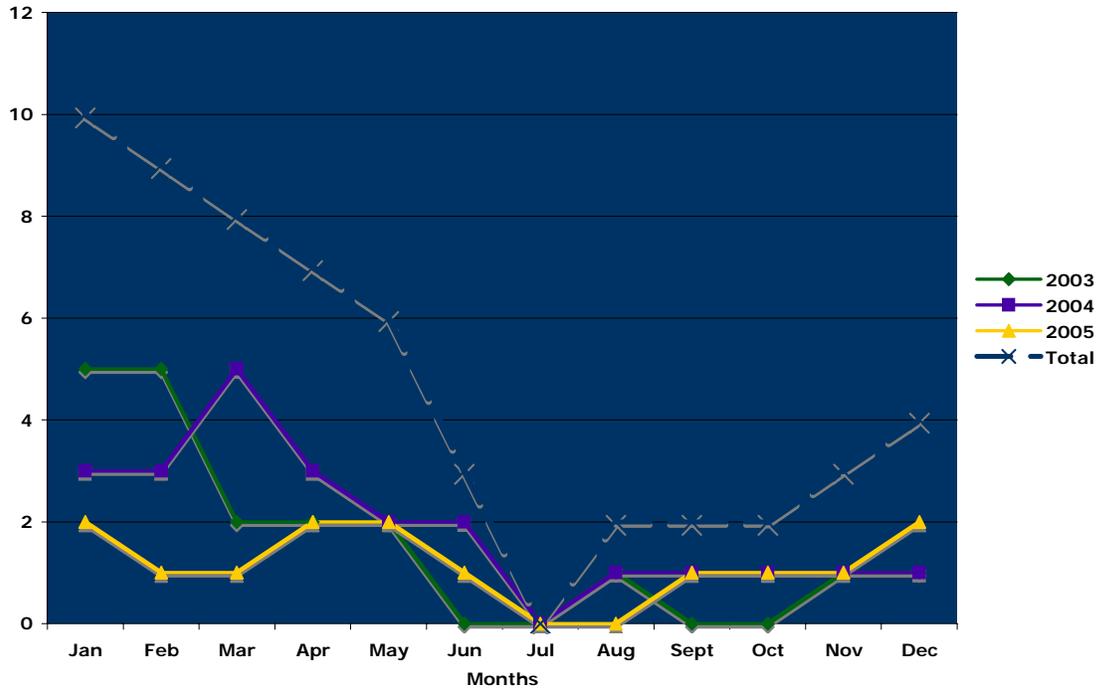Figure 3: Seasonal Variations of Snakebites for 2003-2005

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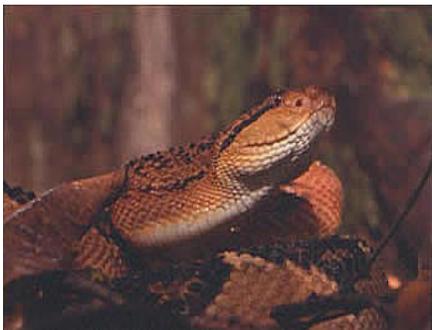31. SPSS, Inc. SPSS complex samples 13.0. Chicago, IL: SPSS, Inc, 2004.

Appendix A: The Four Genera of Venemous Snakes Inhabit Eastern Ecuador (26)

Bothrops – Lanceheads

Bothriopsis - Pit Vipers

Lachesis – Bushmaster

Micrurus - Coral Snakes

Appendix B: Major Roadways of Ecuador (27)

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