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Life after Surviving a Snakebite in Rural Sri Lanka: Lessons Learnt and the Way Forward

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ABSTRACT

Snakebite is a neglected tropical disease affecting underprivileged farming communities in rural tropics and subtropics, causing significant morbidity and mortality. While acute effects of envenoming are well-known, information on long-term consequences remains scarce, despite the public health importance of the issue. Therefore, we explored the existing knowledge about the long-term effects of snake envenoming in the global literature by conducting a scoping review, which revealed that existing literature on snakebite predominantly relies on retrospective associations between envenoming and clinical outcomes, often without precise offending snake species authentication, comprehensive documentation of acute management, or baseline clinical data. Consequently, they could not provide a detailed picture of the long-term clinical epidemiology of envenoming. To overcome these gaps, we prospectively followed up snakebite patients to determine the true prevalence, severity, clinical progression, and risk factors of long-term effects of snakebites using a cohort of snakebite patients admitted to the Teaching Hospital, Anuradhapura, Sri Lanka. Based on a prospective study conducted at one and four-years post-envenoming, long-term musculoskeletal impairments appear to be infrequent and less severe among snakebite survivors in rural Sri Lanka. In contrast, a substantial proportion of individuals report persistent, non-specific systemic and oral symptoms, with the prevalence increasing over time after the bite. In the same two groups of patients, renal functions showed no significant association between snakebite or snakebite-associated AKI, with the development of CKD, or CINAC on review, though microalbuminuria was common. Serum sickness was reported in only 4% of the patients after discharge, despite high rates of acute adverse reactions to antivenom. Meanwhile, a significant number of viper bite patients leave the hospital with mild persistent local effects, which commonly leads them to seek further treatment, emphasizing the need for post-discharge follow-up of snakebite survivors.

Keywords: Snakebite, Long-term effects, Disabilities, Health-seeking behaviours

INTRODUCTION

Snakebite – Global context

Snakebite is a significant public health concern in South Asia, Southeast Asia, Sub-Saharan Africa, and Latin America. The literature-based global estimate of snakebite burden showed that these regions account for more than 90% of the global snakebites, which is approximately 0.5-1.8 million cases per year [1]. Snakebite mainly affects the socio-economically deprived rural farming

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communities, with the most affected being men, children, and farmers in the above regions. Snakebite is, therefore, considered a disease of poverty and an occupational health hazard associated with farming [2]. The highest burden occurs in countries where health systems are weakest and medical resources are sparse. Poor reporting of snakebites in most affected regions resulted in a poor understanding of the true disease burden, which led to the declaration of snakebite as a neglected tropical disease by the World Health Organisation in both 2009 and 2017 [3].

Snakebite – Local context

Sri Lanka is a tropical island in the Indian Ocean, and the climatic heterogeneity and environmental complexity of natural and anthropogenic habitats have led to Sri Lanka's rich reptile fauna. Currently, Sri Lanka's snake fauna includes 108 species, with 60 (55.5%) species endemic to the country. This includes 93 land snake species and 15 sea snake species. Forty-six species of colubrids (Family: Colubridae), 20 species of elapids (Family: Elapidae), including the sea snakes, and seven species of viperids (Family: Viperidae) [4].

Sri Lanka reports one of the highest snakebite incident rates in the world. The community-based, estimated annual incidence of snakebites and envenomings is 398 and 151 per 100,000 people in the country, respectively [5]. The majority of the snakebite victims are farmers; hence, snakebites are considered an occupational health hazard in Sri Lanka [6]. It imposes a tremendous socioeconomic burden, with the annual estimated total number of Disability Adjusted Life Years (DALYs) ranging from 11,101 to 15,076 per year for envenoming [7].

Among the medically important venomous snake species reported from Sri Lanka, the Indian cobra (*Naja naja*), Russell's viper (*Daboia russelii*), Common krait (*Bungarus caeruleus*), saw-scaled viper (*Echis carinatus*), and Merrem's hump-nosed viper (*Hypnale hypnale*) are medically most important, with the former three species accounting for almost all the snakebite-related deaths [8,9]. Venom-induced consumption coagulopathy (*D. russelii*, *E. carinatus, H. hypnale*), neuromuscular paralysis (*B. caeruleus, N. naja, D. russelli, B. ceylonicus*), acute kidney injury (*D. russelii, H. hypnale*), and severe local necrosis (*N. naja, H. hypnale*) are the commonest acute effects of snake envenoming in Sri Lanka [10–15].

North-Central province records the highest snakebite incidence rate in the country (623 snakebites per 100,000 population/year), which accounts for double the national figures, and the highest envenoming incidence rate in Sri Lanka (440 envenomings per 100,000 population/year), which is three times the national figure. According to the government census done in 2013, the majority of the farmers in Anuradhapura are engaged in paddy cultivation during the two main seasons, named "Yala" and "Maha". In addition to paddy, most of the people are involved in chena and home garden cultivation. All these farming activities increase the risk of exposure to snakebites. This is evident by the identification of snakebite hotspots in the North-central province in the spatiotemporal dynamics of snakebite in Sri Lanka [16].

Snakebite – Acute envenoming

Local effects of acute snake envenoming

The term 'local effects' has been widely used in snakebite literature to describe a range of clinical effects of the tissues at the site of snakebite and the response of the host tissue to the toxin effects [17]. Pain at the bite site, swelling, local dermo-necrosis, and blistering are known common local effects of snakebite, which can progress into myonecrosis and eventually amputation of the affected digit, finger, or limb at times. Moreover, tissue necrosis can also occur from tissue ischemia secondary to increased intra-compartmental pressure [18]. Secondary infections at the bite site, such as gangrene, necrotising fasciitis, and abscesses, could further complicate the local effects, and the oral bacteria of snakes may also play a role [19]. Mild to severe local effects are common in snake envenomings from many Asian and African cobras (Gen. *Naja*), South and Central American pit vipers (genus *Bothrops*, *Crotalus*), and some Asian pit vipers (*Callocellasma* and *Hypnale*) [17].

Venom-induced consumption coagulopathy (VICC)

Venom-induced consumption coagulopathy (VICC) due to snake venom procoagulant toxins is the

most common systemic effect of envenoming. The procoagulant toxins in snake venoms specifically activate the inactivated forms of clotting factors in the circulation of a bite victim, thereby activating the clotting cascade downstream. This leads to the progressive consumption of circulating clotting factors, leading to a dangerous drop in clotting factors, including fibrinogen, and, at times, to complete afibrinogenaemia. VICC alone or together with the action of the toxins that damage the vascular integrity, such as the haemorrhagic metalloproteinases, leads to spontaneous haemorrhages in many internal organs, including the brain. Almost all the vipers and Australian elapids have potent pro-coagulant toxins in their venoms [20].

Neurotoxicity

Neuromuscular paralysis due to snake venom neurotoxins is common among elapids (e.g., Genus *Bungarus*, *Naja,* and *Oxyuranus*) and some viperid envenoming. Blockade of neurotransmission at the neuromuscular junction classically leads to flaccid paralysis that descends from extraocular and facial muscles to bulbar, respiratory, and limb muscles [21]. Snake venom neurotoxins that act on the neuromuscular junction are broadly categorised as presynaptic and postsynaptic toxins based on their sites of action, motor nerve terminal, and the nicotinic acetylcholine receptors (nAChR) at the motor end plate, respectively [22].

Myotoxicity

Some snake venoms are known to have local and systemic degenerative myotoxins. Local tissue necrosis and local muscle degeneration at the bite site can occur in envenomings by cobra and some vipers like *Daboia russelii, Bothrops asper,* and sea snakes [23]. Myotoxicity can lead to muscle damage throughout the body, resulting in muscle pain, muscle tenderness, rhabdomyolysis, and myoglobinuria, evident by dark red or black-colored urine.

Nephrotoxicity

Acute kidney injury is a well-known life-threatening clinical manifestation of snake envenoming by viperids and some Australasian elapids [24,25] The pathophysiology of snake-venom-induced acute kidney injury has never been elucidated. However, haemodynamic instability following envenoming leads to hypoperfusion of the kidney, snake venom metalloproteinases (SVMP) mediated destruction of glomerular membranes, and deposition of myoglobin in the glomerular membrane following rhabdomyolysis secondary to myotoxicity of the snake venoms and direct cytotoxic effects of nephrotoxins, thought to be the causes for the acute kidney injury. In addition, acute injury is associated with thrombotic microangiopathy (TMA), caused by thrombosis of small blood vessels and endothelial damage of the renal vasculature, and thrombocytopenia, with or without microangiopathic haemolytic anaemia (MAHA). Depending on the severity of the renal impairment, patients have to undergo renal replacement therapy, though it is not very common [25].

In addition to coagulopathy, neuromuscular paralysis, myotoxicity, and AKI, cardiovascular collapse, non-specific features such as nausea, vomiting, abdominal pain, and headache are a few other important acute systemic effects of snake envenoming [26]

Antivenom has been the mainstay of treatment following snakebite during the acute stage and is known to cause severe adverse reactions during the acute stage, as well as delayed serum sickness [27].

Life after surviving the snakebite: Long-term effects of snake envenoming

The vast majority of the literature related to snake envenoming describes the acute effects of snakebite. In contrast, the data on the long-term effects of snake envenoming are scarce and often questionable in scientific accuracy. Lost follow-up after discharge from the acute hospital admission, lack of compliance with follow-up plans, and seeking traditional treatment after discharge are some of the causes leading to under-reporting of long-term complications of snake envenoming. Therefore, the understanding and awareness of the long-term effects of envenoming is poor. Hence, a scoping review on the long-term effects of snake envenoming was conducted in order to understand the gravity of this unspoken, neglected burden.

What is known and unknown about the long-term effects of snake envenoming?

The scoping review of the long-term effects of snake envenoming [28] was based on a literature survey carried out on MEDLINE (from 1946) and EMBASE (from 1947) until October 2018. Clinical conditions lasting or appearing for more than six weeks following snakebite are considered long-term or delayed effects of envenoming.

The scoping review has compiled the long-term sequelae of local effects, chronic kidney disease, neurological effects, endocrine effects, and psychological effects of snakebites reported around the world.

The key findings of the scoping review were,

Long-term local effects at the bite site.

The local effects of Indian cobra (*Naja naja*) and Hump-nosed vipers (*Hypnale* spp.) in Sri Lanka are less frequent and severe than those of some South American vipers and some Asiatic and African cobras. Disability from amputations, deformities, contractures, and chronic ulcers mainly results from local necrosis caused by bites, especially from cobras and pit vipers. Literature also reports chronic pain, numbness, paresthesia, and discoloration at the bite site. Persistent swelling after viper bites is common, and rare malignant changes have been noted. Additionally, muscle wasting, joint stiffness, and reduced mobility are seen in patients who missed necessary physiotherapy.

Long-term renal effects.

Some true vipers, such as Russell's vipers (*Daboia russelii* and *D. siamensis*) and Carpet vipers (*Echis carinatus*), pit vipers such as hump-nosed vipers (*Hypnale spp*.), Lance-headed pit-vipers (*Bothrops spp.*), and rattlesnakes (*Crotalus spp*.), and some Australasian elapids such as Brown snake (*Pseudonaja textillis*), Taipan (*Oxyuranus spp.*), and Tiger snake (*Notechis scutatus*) are known to cause acute kidney injury (AKI) during the acute phase of snake envenoming. Even though patients with acute kidney injury are managed with or without renal replacement therapy during the initial stage, the persistence of abnormal renal functions and progression into chronic kidney disease (CKD) has been reported in a few studies locally as well as globally [29–31].

Long-term neuromuscular effects.

Neurotoxicity is one of the most important systemic effects of snake venom, which can threaten the life of the patient during the acute stage. Neuromuscular paralysis is the main clinical manifestation of neurotoxicity. Elapids such as kraits (Genus: *Bungarus*), cobras (Genus: *Naja*, taipans (Genus: *Oxyuranus)*, tiger snakes (Genus: *Notechis*), and some viperids such as Russell's viper (*Daboia russelii*) envenomings result in acute neurotoxicity [21]. Snake venom neurotoxins primarily affect the neuromuscular junction and disrupt the neurotransmission across the neuromuscular junction. Clinically, this appears as a rapidly progressing, descending, flaccid paralysis starting from the extraocular and facial muscles, then affecting the bulbar muscles, neck muscles, respiratory muscles, and, last, limb muscles. Many observational studies have shown that the neuromuscular paralysis in snake envenoming completely resolves within several days [13,32]. However, there are rare records that describe long-term neurological sequelae such as unilateral ptosis and cerebral ataxia.

Respiratory paralysis and cardiac arrest caused by acute envenomation by snakes such as kraits and cobras can result in hypoxic brain damage, leading to hypoxic ischaemic encephalopathy, which in turn results in long-term neurological manifestations. Snake venom procoagulants and heamatotoxines found in snakes such as vipers can result in haemorrhagic cerebral damage, which in turn causes long-term neurological sequelae in snakebite survivors [33].

Endocrine anomalies

Procoagulant toxins and haemorrhagic toxins present in viper venom are known to cause venom-induced consumption Coagulopathy and vascular endothelial damage, leading to spontaneous haemorrhages. This results in haemorrhagic infarctions of the pituitary gland, leading to hypopituitarism. Such incidents have been reported in Burmese Russell's viper (*D. siamensis*) bite, and Russell's viper bite in Sri Lanka (*Daboia*

russelii). Additionally, Addisonian crisis in Russell's viper bite in India (*Daboia russelii*) has also been reported [34,35].

Delayed psychological effects

Psychological sequelae are important yet greatly underreported effects of snake envenoming. These effects are unlikely to be direct venom effects, but rather the effects triggered by the traumatic experience of snake bite and the severe socioeconomic consequences associated with snakebite. There are reports of depressive symptoms, post-traumatic stress disorder, and somatisation following snakebite. A randomised controlled trial of brief psychological intervention, which included psychological first aid, psychoeducation, and cognitive behavioural therapy, reduced psychiatric symptoms and disability in snakebite victims in Sri Lanka compared to the controls. However, the intervention was not effective in preventing depression or post-traumatic stress disorder [36,37].

This study revealed that previous studies linked clinical effects to snakebite retrospectively, lacking accurate snake identification, details of acute management, and baseline clinical data. They could not provide a detailed picture of the long-term clinical epidemiology of envenoming. Therefore, we noted the need to follow snakebite patients over a longer period to better understand the true prevalence, severity, clinical progression, and risk factors of long-term effects.

long-term effects of snakebite perceived by snakebite survivors in rural Sri Lanka.

Sri Lanka has a high snakebite incidence, especially in Anuradhapura, the capital of the North Central Province, which has the highest regional rate. This predominantly rural area relies on paddy, chena cultivation, and livestock farming, where snakebite is common. The long-term impact on survivors in this region remains unknown.

Anuradhapura Teaching Hospital, Sri Lanka's third largest and main tertiary center in the region, established a Snakebite Cohort that prospectively records authenticated snakebite admissions, providing an ideal platform to study long-term effects prospectively to address the previous study limitations. Ethical approval allows the collection of comprehensive data on demographics, prehospital information, acute envenoming details, investigations, management, complications, medical history, and discharge plans.

Using this resource, a prospective study was conducted on long-term effects perceived by survivors. A review clinic was organized at the hospital, contacting participants via phone, letters, or home visits, and inviting them to attend [38].

A total of 367 snakebite survivors: 199 after four years (Group I) and 168 after one year (Group II) were reviewed at the clinic. Health effects were categorized into musculoskeletal symptoms, medically unexplained symptoms, and daily life impact. At four years, 54% of Group I and 33% of Group II reported health issues, indicating perceived problems increase over time. Sixteen (all viper bites) had permanent musculoskeletal issues like contractures, scars, pain, swelling, and numbness; four had amputations but no significant disability.

Long-term renal effects of snake envenoming in rural Sri Lanka.

According to the published literature, the presence of AKI during the acute stage of envenoming can lead to CKD later in life, especially among viper-bitten patients from India and Sri Lanka. Most snakebites in Anuradhapura are caused by Russell's viper (*Daboia russelii*) and Hump-nosed viper (*Hypnale hypnale*), and both are known to cause renal injury during the acute stage. Moreover, Anuradhapura is also endemic for Chronic Interstitial Nephritis in Agricultural Communities (CINAC), or formerly known as CKDu. CINAC/CKDu is a condition where there is no detectable etiology causing the kidney injury, such as diabetes mellitus, chronic or severe hypertension, or any other glomerulopathies. However, past studies have described the association with snakebites, agrochemical exposure, hot climates, poor socio-economic conditions, heavy metals, pesticides, and hard water with fluoride with the development of CKDu. Importantly, in both CKDu/CINAC and snakebites, the majority of the affected people are farmers. Therefore, the association between snakebite-induced CKD and CINAC is unclear; whether shared risk factors or causality are

involved remains unknown. To explore this, renal functions of the snakebite survivors were prospectively evaluated to determine the development of CKD or CINAC later in their lives [39].

Figure 1: A: A sixty-three-year-old female presented with a hump-nosed viper bite to the right small finger and developed severe local necrosis of the distal phalanx and compartment syndrome involving the forearm. She was managed by decompression fasciotomy, followed by amputation of the two distal phalanxes of the right small finger. B: The same patient after four years with lost phalanxes and the fasciotomy scar.(Adopted from: Waiddyanatha S, Silva A, Weerakoon K, Siribaddana S, Isbister GK (2022) Long-term health effects perceived by snakebite patients in rural Sri Lanka: A cohort study. PLoS Negl Trop Dis 16(9): e0010723. https://doi.org/10.1371/journal.pntd.0010723)

We followed 367 snakebite survivors from the cohort, assessing serum creatinine (to calculate estimated glomerular filtration rate; eGFR) and urinary albumin to creatinine ratio (ACR) after one and four years. Twelve of 199 (6%) in Group I and nine of 168 (5%) in Group II had AKI, and three and two of these, respectively, underwent haemodialysis during the acute stage. Of them, after one and four years, none developed CKD, as all had eGFR over 60 mL/min/1.73m^2. At discharge, 234 patients had documented creatinine levels in the Anuradhapura snakebite cohort. Of them, 17/140 in Group I and 11/94 in Group II had low eGFR (<60mL/min/1.73m^2) at discharge. In Group I, 14/17 recovered to normal eGFR after four years, including 11/12 who had AKI, while three had pre-existing CKD or related comorbidities. In Group II, 10/11 recovered after one year, including all who had AKI during the acute stage; one with low eGFR had pre-existing CKD. Nine patients had low eGFR (CKD stages 3–5) on review, but had pre-existing CKD or comorbidities for CKD beforehand. Fifty in Group I and 43 in Group II had high urinary ACR, mostly microalbuminuria. Multivariate analysis

showed that having comorbidities leading to CKD was linked to high ACR in both groups, with additional factors like AKI during acute envenoming and offending snake type in Group II.

In Anuradhapura, CINAC is prevalent, especially in Vilachchiya and Nachchaduwa, where microalbuminuria reached 69.4% among farmers without comorbidities and 85.4% with CKD or diabetes. Over 70% of participants were farmers, so the background renal injury likely stems from CINAC and associated conditions.

Accordingly, there is no significant association between snakebite or snakebite-associated AKI and development of CKD in two patient groups followed up at one- and four-years post-bite. Microalbuminuria was common, likely due to other conditions such as hypertension, diabetes mellitus, and CINAC in this rural farming population. There was no evidence supporting a correlation between snakebite-associated AKI and CINAC in an area where CINAC is endemic and previously linked to snakebite.

Serum sickness due to antivenom therapy

Timely administration of antivenom is crucial for the treatment of snake envenoming. Antivenoms are animal-derived polyclonal antibodies developed against snake venoms. They are lifesaving but can cause immediate and delayed adverse reactions. Acute reactions may be pyrogenic or anaphylactic and require prompt intervention such as premedication, adrenaline, steroids, and even advanced life support. [40] Hence, patients should be closely monitored during the antivenom infusion and managed according to the severity of the adverse reactions.

In Sri Lanka, Indian polyvalent antivenom treats envenomation by *Daboia russelii*, *Bangarus caeruleus*, *Naja naja*, and *Echis carinatus*. This antivenom is associated with frequent acute adverse reactions and delayed reactions like serum sickness, which is a type III hypersensitivity reaction that develops 5-20 days post-administration. However, due to non-specific symptoms and lack of routine follow-up, reporting of serum sickness is limited in the literature.

Aiming to fill this knowledge gap, the prevalence of serum sickness among the snakebite survivors in the Anuradhapura snakebite cohort was studied [41]. Two groups were recruited: those treated with antivenom within a year and those not. Participants were contacted over the phone 3-4 weeks after envenomation and asked about symptoms like rash, fever, joint or muscle pain, malaise, headache, and gastrointestinal issues occurring 5-20 days post-treatment. Symptoms of serum sickness include fever with chills, skin rash or urticaria, arthralgia, myalgia, abdominal pain, headache, nausea or vomiting, and lymphadenopathy, and the presence of three or more symptoms indicates serum sickness [42]. Out of 122 antivenom-treated patients, 98 (80%) were contacted; out of 588 patients who did not receive antivenom, 423 (72%) were contacted. The treated group received a median of 20 vials of Indian polyvalent antivenom; 92% received premedication to prevent adverse reactions. Despite that, 68% developed acute adverse reactions, including 19% with anaphylaxis. Only 4% of antivenom-treated patients met the criteria for serum sickness, while none in the untreated group. All with serum sickness were viper envenomed, premedicated, and received VINS Bioproducts antivenom. Three were treated with hydrocortisone during acute reactions. Despite seeking medical advice for the symptoms, only one was treated as serum sickness at the Teaching Hospital, Anuradhapura, while others were treated as viral infections at other health care settings.

The study revealed that the Indian polyvalent antivenom used in Sri Lanka is associated with high rates of acute adverse reactions, but serum sickness occurs only in 4% of the patients.

Health-seeking behaviours of patients for health effects post-discharge

This study examined the long-term health effects reported by snakebite survivors, noting ongoing health issues even after one and four-years post-bite. These included persistent musculoskeletal problems and unexplained health issues that could affect daily life. The patient's health-seeking journey continues long after hospital discharge. Survivors are typically not routinely monitored for post-discharge effects due to limited health infrastructure and public awareness, leading many to seek alternative treatment options.

A group of patients from the Anuradhapura snakebite cohort was followed up at three weeks and three months to record unresolved effects of snakebite and their treatment-seeking behaviours after discharge from the hospital [43]. All the snakebite patients over 18 years, recruited between July 2021 and June 2022, were included for a telephone survey. From 384 patients reviewed at both three weeks and three months, data were collected using a guided questionnaire regarding unresolved health problems, adherence to follow-up plans, new health issues, and their impact on daily routines.

At discharge, 65% (248/384) had unresolved effects, mainly local symptoms such as pain, swelling, and unhealed wounds, particularly in bites from *H. hypnale* (54%), *D. russelii* (23%), and unidentified snakes (19%). By three weeks and three months, unresolved local effects persisted in 26% (98/384) and 14% (52/384), respectively (Figure 2). One patient with a *H. hypnale* bite underwent amputation after three weeks. Six patients at three weeks and three at three months complained of visual impairments, mainly following *D. russelii* and *B. caeruleus* bites. At three months, 9% (33/384) reported new health issues post-discharge, not typical of snake envenoming, such as fatigue, body aches, and aura-like symptoms during outdoor activities. A small number also experienced fear, reluctance to engage in routine outdoor activities, or panic upon seeing snake-like objects, with flashbacks linked to farm-related bites.

In the first three months following snakebite, 112 of 384 patients (29%) independently sought additional healthcare. Two-thirds of these visits were due to persistent local effects at the bite site. Among those seeking further care, 76% (86/112) were victims of viper envenomation. Although 64 of the 112 patients (57%) had been advised at discharge to attend a follow-up review at Teaching

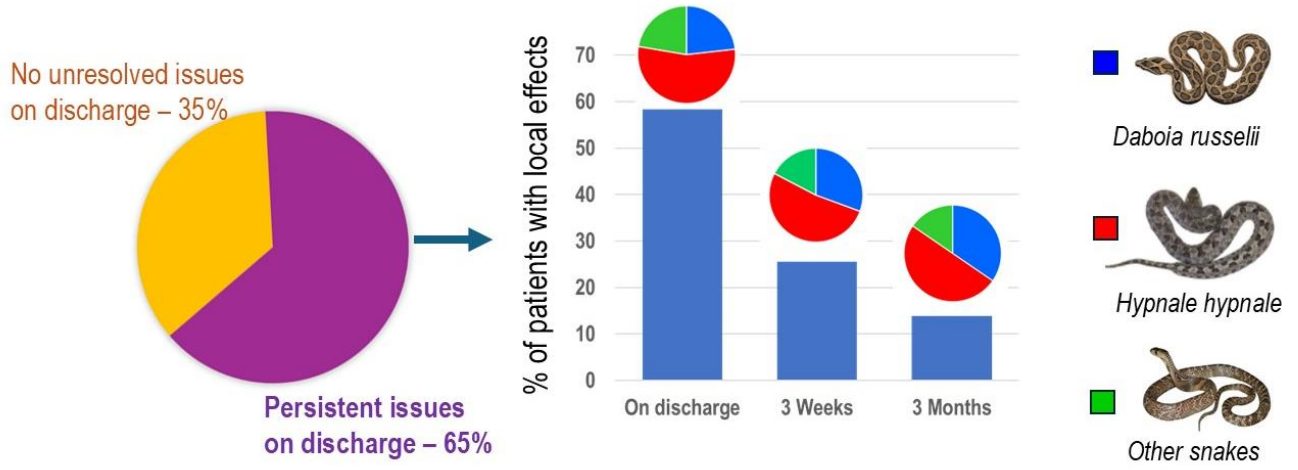

Figure 2: Persistent health effects following snakebite during the post-discharge period in a cohort of 384 snakebite patients from Anuradhapura, Sri Lanka.

Hospital Anuradhapura, only 47 adhered to this recommendation. A substantial majority (87/112; 78%) sought care from indigenous medical practitioners after the hospital discharge. Of these, 32 patients did so specifically to "remove residual venom from their bodies."

Among the 240 patients not scheduled for post-discharge review, 50 (21%) independently sought further treatment. Of them, 84% (42/50) consulted indigenous medical practitioners, primarily due to persistent local symptoms (67%) or concerns about residual venom (36%) despite the treatment received from the hospital. Despite that, almost all snakebite survivors had returned to work at three months post-bite.

In conclusion, a significant number of viper bite patients leave the hospital with mild persistent local effects, which commonly leads them to seek further treatment after discharge.

Changing snakebite pattern.

For a long time, Hump-nosed vipers have been responsible for most snakebites in the wet zone,

while Russell's viper bites have been more common in the dry zone.

However, Hump-nosed vipers are the snakes that cause the most problems with unresolved health issues in the Anuradhapura snakebite cohort. Interestingly, there is an increasing trend of Hump-nosed viper bites in Anuradhapura, surpassing

Russell's viper bites. This was more prominently noted during and after the COVID-19 pandemic than before the pandemic. The rising number of Hump-nosed viper bites corresponded to the rising number of snakebites in home gardens, likely due to increased home gardening during and after the pandemic. Russell's viper bites mostly occur in paddy fields, and the decreasing number of Russell's viper bites may be due to decreasing paddy farming due to multiple factors during the pandemic and post-pandemic period, and due to increasing mechanization of paddy farming in the region [44].

The way forward

Our studies discovered that long-term musculoskeletal disabilities are rare and mostly not severe in snakebite survivors in rural Sri Lanka. However, many patients continue to perceive various non-specific symptoms that cannot be explained by envenoming pathophysiology. There was no evidence to support the scenario of developing CKD or CINAC following snake envenoming in this area, where CINAC is endemic and previously linked to snakebite. We also found that serum sickness occurs in 4% of patients receiving antivenom. The one-year and four-year follow-up showed that preventable permanent musculoskeletal issues like contractures, scars, and recurrent swelling continue to affect a smaller number of patients. However, a significant number of viper bite patients leave the hospital with mild persistent local effects, which commonly leads them to seek further treatment, mostly from the indigenous practitioners.

Snakebite is a major public health issue in rural Sri Lanka, yet there is no established mechanism to address the long-term health problems that the snakebite survivors would encounter. Our observations suggested the necessity of establishing a dedicated, permanent post-snakebite care clinic in areas where snakebite is a major problem, so that snakebite patients could seek solutions for their unresolved issues of snakebite.

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