Snakebite knowledge assessment and training of healthcare professionals in Asia, Africa, and the Middle East: A review

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A B S T R A C T

Snakebite envenoming (SBE) is a common neglected tropical disease in rural communities of Asia, Africa and Latin America. Among the several challenges besetting the control of SBE is inadequate access to high-quality care by snakebite victims, partly contributed by inadequate knowledge of SBE among healthcare professionals (HCPs). This narrative review examined the existing literature on the knowledge of snakebites among HCPs, the factors associated with their knowledge of snakebites and their training needs. Data on the knowledge of healthcare professionals regarding snakebites appeared scanty and were predominantly from studies done in Asia, Africa, and the Middle East. We found that the proportion of health workers with adequate knowledge of local medically important snakes could be as low as 20.2% in some settings in India, while as much as three-quarters of health workers still recommend tourniquets and Blackstone as first aid in some settings in India and Rwanda, respectively. In addition, the mean knowledge score of local snake-induced clinical syndromes could be as low as 46.2% in some settings in Ghana, while 52.7% of tertiary hospital doctors in northern Nigeria recommend antivenom in all snakebite cases. Similarly, 23% of Bhutan health workers have adequate overall knowledge of snakebite management. Furthermore, several sociodemographic characteristics of the HCPs (such as increasing age, years of experience, work setting, medical specialty, health profession and previous involvement in snakebite management) are associated with adequate snakebite knowledge. Moreover, most studies have consistently reported a lack of training on snakebites as a challenge. Therefore, the knowledge gaps identified could be incorporated into training programs and regional policies on SBE treatment protocols.

1. Introduction

Snakebite envenoming (SBE) is a common medical emergency that disproportionately affects rural dwellers, farmers and children in many tropical communities of Asia, Africa and Latin America and parts of Oceania (Gutiérrez et al., 2006, 2017; Harrison et al., 2009; Warrell, 2010; Williams et al., 2010). In 2017 the World Health Organization (WHO) recognized SBE as a category A neglected tropical disease to streamline efforts and build a formidable global response toward its control (Williams et al., 2019). Although the exact incidence of snakebite remains unknown, the WHO estimates an incidence of 5.4 million snakebites, 2.7 million envenoming, and 81,000 to 138,000 deaths globally; however, around 400,000 survivors of SBE suffer amputations and permanent disabilities (Williams et al., 2019). With an ambitious target to half the number of deaths and disabilities from SBE by the year 2030, the WHO prioritized some specific objectives towards achieving this goal, which include (1) ensuring that safe and effective treatment is accessible and affordable for all (2) empowering regional, national, and local communities to take proactive action (3) strengthening health systems to deliver better outcomes; and (4) building a robust global coalition of partners to build advocacy, mobilize resources, coordinate action, and ensure that implementation of the roadmap is successful (Williams et al., 2019).

Furthermore, SBE predominantly affects the world’s poorest people...
Managing SBE. Examples of these guidelines are the validated WHO regional guidelines for preventing and managing SBE. Essential sources of snakebite information are the WHO regional guidelines for preventing and managing SBE. Examples of these guidelines include the WHO South East Asia Regional Office (SEARO) guidelines for the management of snakebites (2016) (Organization, 2016) and the WHO Africa Regional Office (AFRO) guidelines for the prevention and clinical management of snakebites in Africa” (2010) (Organization, 2010). These guidelines are used in the training and permanent educational programs of physicians and nurses. In addition, many countries have developed national guidelines, which are valuable items for training physicians and nurses.

Furthermore, the training of HCPs (e.g., medical doctors, nurses, pharmacists, etc.) has profusely been reported as suboptimal and will need to be addressed (Gutierrez, 2014). Moreover, a qualitative study in Kenya has indicated that HCPs welcomed their training in snakebite management, diagnosis and antivenom administration (Barnes et al., 2021). However, this will require identifying the training needs of these professionals.

Table 1
Summary of snakebite knowledge studies and their key findings.

| First authors name and year | Country | Design | Population | Key findings on knowledge |
|-----------------------------|---------|--------|------------|----------------------------|
| Knowledge of local medically important snakes |
| Fung et al. (2009) | Hong Kong | Cross-sectional | Doctors | 57% incorrectly identified Naja atra as neurotoxic |
| Inthanomchanh et al. (2017) | Lao PDR | Cross-sectional | Doctors, nurses | 27.7% had adequate knowledge of identifying snakes |
| Michael et al. (2018) | Nigeria | Cross-sectional | Doctors | - 50.8% had adequate knowledge of snake species that cause most injuries and deaths |
| Malik and Chatterjee (2020) | India | Cross-sectional | Doctors | - 85.3% Incorrectly identified Naja nigripalpis as neurotoxic |
| Sapkota et al. (2020) | Bhutan | Cross-sectional | Doctors, nurses, others | 6.8% knew of the number of local medically important snake species |
| Ameade, 2020 | Ghana | Cross-sectional | Doctors, pharmacists, nurses | 55% lacked confidence to identify local venomous snakes |
| Khurshua et al. (2020); Sulaiman et al. (2020) | Palestine | Cross-sectional | Nursing students | Mean snake knowledge score was 46.2% |
| Knowledge of snakebite first aid measures |
| Fung et al. (2009) | Hong Kong | Cross-sectional | Doctors | 52% would recommend applying a tourniquet after snakebite |
| Michael et al. (2018) | Nigeria | Cross-sectional | Doctors | Only 48% recommended pressure immobilization and transport to hospital |
| Subedi et al. (2018) | Nepal | Cross-sectional | Medical students | 75.7% had adequate knowledge of first aid |
| Malik and Chatterjee (2018) | Bangladesh | Cross-sectional | Doctors, nurses and others | 77.8% erroneously believed applying tourniquet was an appropriate first aid measure |
| Khurshua et al. (2020); Sulaiman et al. (2020) | Palestine | Cross-sectional | Nursing students | 72% correctly recommended non-use of tourniquet |
| Knowledge of the clinical presentation of snakebites |
| Fung et al. (2009) | Hong Kong | Cross-sectional | Doctors | 50% believed that inability to identify the biting snake hindered effective treatment |
| Inthanomchanh et al. (2017) | Lao People’s DR | Cross-sectional | Doctors and nurses | 59% could identify symptoms of SBE |
| Malik and Chatterjee (2020) | India | Cross-sectional | Doctors | 52% and 20% knew the clinical presentation of the local Krait and other elapid snakes |
| Michael et al. (2018) | Nigeria | Cross-sectional | Tertiary hospital doctors | 62% had adequate knowledge of the clinical features of SBE |
| Khurshua et al. (2020); Sulaiman et al. (2020) | Palestine | Cross-sectional | Nursing students | Mean knowledge score for signs and symptoms was 60% |
| Ahmad (2009) | United Kingdom | Cross-sectional | Emergency physicians and plastic surgeons | Poor knowledge of the clinical consequences of SBE and administering antivenom |
| Fung et al. (2009) | Hong Kong | Cross-sectional | Physicians | 92% had confidence in treating SBE |
| Inthanomchanh et al. (2017) | Lao DR | Cross-sectional | Physicians & Nurses | 45.4% had adequate knowledge of managing SBE |
| Michael et al. (2018) | Nigeria | Cross-sectional | Tertiary hospital doctors | 50% believed that inability to identify the biting snake hindered effective treatment |
| Sapkota et al. (2020) | Bhutan | Cross-sectional | doctors, nurses, and others | - Mean overall knowledge score of 70.2% |
| Ameade et al. (2021) | Ghana | Cross-sectional | Pharmacist, Doctors, nurses | - 25% had adequate knowledge of snakebite treatment |
| Schurer et al. (2022) | Rwanda | Cross-sectional | Physicians and medical interns | 50.3% had confidence in managing SBE |
| Knowledge involvement in the treatment of snakebite |
| Fung et al. (2009) | Hong Kong | Cross-sectional | Doctors | 52% had treated snakebite before |
| Ahsan et al. (2017) | Bangladesh | Cross-sectional | Doctors, nurses and others | 30% had managed snakebite before |
| Inthanomchanh et al. (2017) | Lao PDR | Cross-sectional | Doctors and nurses | 47.9% had treated snakebite before |
| Michael et al. (2018) | Nigeria | Cross-sectional | Doctors, nurses and others | 78.3% had been involved in managing SBE |
| Taieb et al. (2018) | Cameroon | Quasi-experimental | Doctors, nurses and others | 33.7% had managed snakebite the previous year |
| Malik and Chatterjee (2020) | India | Cross-sectional | Doctors | 76.1% had managed a case of snakebite with or without assistance |
| Sapkota et al. (2020) | Bhutan | Cross-sectional | Doctors, nurses and others | 81% had treated snakebite before |
| Bala et al. (2021) | Nigeria | Cross-sectional | Doctors, pharmacists, nurses | Only 19% had ever administered or dispensed antivenom before |
| Ameade et al. (2021) | Ghana | Cross-sectional | Pharmacist, Doctors, nurses | 82.8% had managed snakebite before |

PDR: Peoples Democratic Republic.
The objective of this narrative review was, therefore, to explore literature from Asia, Africa, the Middle East and Latin America on HCPs’ (1) knowledge of snakebite care, (2) factors associated with knowledge of snakebite management and (3) to identify their training needs. We hope that the findings will be helpful in the strategic planning of training programs to improve snakebite management since a study has demonstrated the positive impact of training on snakebite knowledge (Taieb et al., 2018); this, in turn, could improve practice.

2. Review

Current literature on the knowledge of healthcare professionals regarding snakebites appeared scanty and was predominantly from studies carried out in Asia, Africa, and the Middle East, as shown in Table 1.

2.1. Knowledge gaps in snakebite care

2.1.1. Knowledge of local medically important snakes

Snake species identification is sometimes essential in caring for snake-envenomed patients that require antivenom (e.g., in Australia, where venom detection kits and monospecific antivenom are readily available), given the differences in the venom composition of different snake species. However, in many cases, especially in Africa and Asia, identifying the offending snake is not strictly required for treatment, as the snake-induced clinical syndrome is used in addition to the knowledge of the main venomous snakes in that setting (Blaylock, 2005; Ariaratnam et al., 2009). Remarkably, a knowledge deficit exists regarding local venomous snakes of medical importance. For instance, in Asia, only about a quarter (27.7%) of HCPs (physicians and nurses) in the Lao People’s Democratic Republic (PDR) could confidently identify local snakes of medical importance (Inthanomchanh et al., 2017). Similarly, only 6.8% of the medical practitioners (doctors) knew the number of snake species of medical importance in India, while only 50.2% and 20.2% of the practitioners knew the local Kraits and vipers, respectively; however, 91.7% of them knew of other elapids (like the Indian cobra) (Malik and Chatterjee, 2020).

Furthermore, in Bhutan, 55% of health workers (doctors, nurses and others) lacked sufficient confidence to identify venomous snakes (Sapkota et al., 2020), while about half (57%) of selected doctors ((working in accident and emergency, internal medicine, ICU, family medicine, orthopaedic, anaesthesiology departments) in Hong Kong, China reported Naja atra as neurotoxic when, in fact, they are mainly cytotoxic (Fung et al., 2009). This finding appears to be a common finding even in Africa, as 85.3% of northern Nigerian tertiary hospital doctors also incorrectly reported that Naja nigricollis causes neurotoxic symptoms when, in fact, they are cytotoxic (Michael et al., 2018).

Similarly, among students in Palestine (Middle East), the mean knowledge score for the most common medically important snakes (e.g., Vipera palestinae) was 5.1/13 (i.e., 39.2%) among nursing students and 3.8/13 (29.2%) among medical students (Kharusha et al., 2020; Sulaiman et al., 2020). These findings suggest that the knowledge deficit among practising health workers may be due to a deficient or ineffective undergraduate curriculum/program.

2.1.2. Knowledge of snakebite first aid measures

HCPs are respected leaders in communities where they work, especially in rural areas; they are also effective health promotion agents, as seen in the impact of simple office counseling and education on chronic disease prevention (Sharaf, 2010). Therefore, knowledge of evidence-based first aid practices for snakebites is crucial. Counseling and education of snakebite survivors or their caregivers could be offered in the health facility setting or when there are opportunities to talk to community groups on snakebite prevention. However, as reported in many studies, there appears to be a significant knowledge gap in this area. For instance, in Asia, about half (52%) of Indian and Pakistani doctors in a study recommended at least a tourniquet application after snakebite, with only a quarter (25.8%) suggesting pressure immobilization and transport to the hospital as first aid (Simpson, 2008). Three quarters (74.5%) of doctors in Kerala, India, recommended tourniquet application as a first aid management strategy (Pillay et al., 2021). Similarly, in Hong Kong, only about half (48%) of the doctors recommended immobilization of the victim and transport to the hospital (Fung et al., 2009). However, about three-quarters (72%) of respondents in a Bhutan study correctly recommended the non-use of a tourniquet when snakebite occurs (Sapkota et al., 2020). Unsurprisingly, over three-quarters (77.8%) of Nepal preclinical and clinical medical students believed that applying a tourniquet on the limb proximal to the bite site is an appropriate first-aid practice (Subedi et al., 2018). Moreover, in the middle east, low mean first-aid knowledge scores of 44% and 55.3% were reported among Palestinian nursing and medical students, respectively (Kharusha et al., 2020; Sulaiman et al., 2020).

In Africa, a similar proportion of Nigerian doctors (75.7%) had sufficient knowledge of snakebite first aid (Michael et al., 2018). However, a recent study in Rwanda among hospital physicians and interns not only showed that a third (34.8%) of respondents believed that traditional healers could manage snake-envenomed patients successfully but that two-thirds of those also believed that Blackstone application at the bite site was an appropriate first aid for snakebite (Schurer et al., 2022).

2.1.3. Knowledge of the clinical presentation of snakebites

SBE is a medical emergency requiring a high index of suspicion from the HCP. The HCPs will have to rely on their knowledge of snakebites to make a prompt diagnosis and commence appropriate management. Unfortunately, many HCPs and medical and nursing students have insufficient knowledge of the clinical features of SBE. For instance, in Asia, a study in Hong Kong reported that 50% of physicians reported that the inability to identify the clinical presentation of Krait bites was hindering the effective treatment of SBE (Fung et al., 2009); similarly, only about 59% of health care providers in Lao DR could correctly identify symptoms of envenoming (Inthanomchanh et al., 2017). Likewise, only about 52.2% and 20.2% of Indian medical practitioners are aware of the common presentations of Common Krait and Viper envenoming, respectively (Malik and Chatterjee, 2020).

In Africa, a study reported that only 62.3% of tertiary hospital doctors in Northern Nigeria had sufficient knowledge of the clinical features of SBE in the region (Michael et al., 2018), while 46.2% was the mean medically important snake knowledge score in a study among Ghanaian health workers (doctors, pharmacists, nurses) (Ameade, 2020).

Interestingly, there is a similar knowledge gap among nursing and medical students regarding snakebite presentation. For instance, mean knowledge scores of 9.6/16 (60%) and 8.2/16 (51.3%) for signs and symptoms of SBE had been reported among Palestinian nursing and medical students, respectively (Kharusha et al., 2020; Sulaiman et al., 2020).

2.1.4. Prior involvement in the treatment of snakebite

Exposure of HCPs to snakebite care varies with the context; for instance, 29.6% and 17.3% of HCPs in Bangladesh had been involved in snakebite treatment before and in the preceding twelve months, respectively (Ahsan et al., 2017); only about a third (33.7%) of health workers in Cameroon had been involved in snakebite care in the preceding year (Taieb et al., 2018); 52% of doctors have treated snakebite in Hong Kong (Fung et al., 2009); 47% of health care workers (doctors and nurses) had been involved in the treatment of snakebite in Lao PDR (Inthanomchanh et al., 2017), while in a Nigerian study that examined knowledge of antivenom, only 19% of the HCPs (doctors, pharmacists, nurses and pharmacy technicians) had ever administered or dispensed antivenom (Bala et al., 2020, 2021). However, three-quarters (75.1%) of Indian and Pakistani doctors reported having treated snakebite victims (Simpson, 2008); a similar proportion of Indian doctors (76.1%) had managed a case of snakebite with or without assistance (Malik and

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that the topic of snakebite needs more emphasis at the undergraduate curriculum was inadequate to deal with snakebite, while 91.4% thought medical practitioners felt that their undergraduate medical education training on snakebite at the undergraduate level is inadequate and that snakebite consequences and antivenom administration (Ahmad, 2009).

had sufficient knowledge of antivenom treatment for snakebites; how technicians) have adequate knowledge of antivenom, an essential training in snakebite management remains low. For instance, only 12% (32.6%) of Indian medical practitioners had correct knowledge about managing adverse reactions to anti-snake venom (Malik and Chatterjee, 2020). However, in Kerala, India, a high mean overall knowledge of the doctors was reported (10.65/14 (76.1%)) (Pillay et al., 2021). The situation is similar in African studies; for instance, only 12.7% of Nigerian HCPs (doctors, pharmacists, nurses, and pharmacy technicians) have adequate knowledge of antivenom, an essential therapy in managing SBE (Bala et al., 2021). Moreover, another study among northern Nigerian doctors showed that half of the respondents had sufficient knowledge of antivenom treatment for snakebites; however, about half (52.7%) of them incorrectly reported that antivenom is given in all cases of snakebite (Michael et al., 2018). Furthermore, a low overall mean knowledge score of 49.4% (range: 31.3–70.8%) was reported among hospital physicians and medical interns in Rwanda (Schur et al., 2022). However, the inadequate knowledge of SBE management is not limited to the poor regions of Africa, Asia and the Middle East. For example, a study carried out among emergency physicians and plastic surgeons in the UK reported low knowledge of snakebite consequences and antivenom administration (Ahmad, 2009).

2.1.5. Adequacy of health care professional’s overall knowledge of snakebite

The knowledge of HCPs has remained worryingly low over time in Asia and Africa. For instance, in Asia, only 29% of doctors in Hong Kong were confident in treating snakebites (Fung et al., 2009), while Inthamomchanh et al. reported that 45.5% of health workers in Lao DR had sufficient knowledge of snakebite management (Inthamomchanh et al., 2017). Similarly, only 23% of Bhutanese health workers (nurses and doctors) have adequate knowledge of snakebite management (Sapkota et al., 2020). Furthermore, an online survey in 2020 showed that only a third (32.6%) of Indian medical practitioners had correct knowledge about managing adverse reactions to anti-snake venom (Malik and Chatterjee, 2020). However, in Kerala, India, a high mean overall knowledge of the doctors was reported (10.65/14 (76.1%)) (Pillay et al., 2021). The situation is similar in African studies; for instance, only 12.7% of Nigerian HCPs (doctors, pharmacists, nurses, and pharmacy technicians) have adequate knowledge of antivenom, an essential therapy in managing SBE (Bala et al., 2021). Moreover, another study among northern Nigerian doctors showed that half of the respondents had sufficient knowledge of antivenom treatment for snakebites; however, about half (52.7%) of them incorrectly reported that antivenom is given in all cases of snakebite (Michael et al., 2018). Furthermore, a low overall mean knowledge score of 49.4% (range: 31.3–70.8%) was reported among hospital physicians and medical interns in Rwanda (Schur et al., 2022). However, the inadequate knowledge of SBE management is not limited to the poor regions of Africa, Asia and the Middle East. For example, a study carried out among emergency physicians and plastic surgeons in the UK reported low knowledge of snakebite consequences and antivenom administration (Ahmad, 2009).

2.1.6. Previous training on snakebite

There appears to be a consensus among HCPs that the current level of training on snakebite at the undergraduate level is inadequate and that regular training is required after graduation. For instance (Malik and Chatterjee, 2020), reported that nearly three-quarters (72.3%) of Indian medical practitioners felt that their undergraduate medical education curriculum was inadequate to deal with snakebite, while 91.4% thought that the topic of snakebite needs more emphasis at the undergraduate level. In Bhutan, all the health workers stressed the need for snake identification and snakebite management training (Sapkota et al., 2020), while the study by (Fung et al., 2009) suggested the need for locally relevant training and protocols. Unfortunately, some HCPs in a Ghanaian study over-rated their knowledge about snakebite envenoming (Ameade, 2020). Similarly, 98.7% of doctors in northern Nigeria believed they had knowledge of SBE in a study (Michael et al., 2018).

Furthermore, the proportion of healthcare workers receiving training in snakebite management remains low. For instance, only 12% of health workers in a multi-country study (Kenya, Uganda and Zambia) reported having had formal training in snakebite management (Ooms et al., 2020), while 33.7% and 30.6% of health workers had received any form of post-graduation training on snakebite management in Cameroon and Ghana, respectively (Taeib et al., 2018; Ameade et al., 2021). However, those who have had the privilege of attending training programs have recommended regular training (Taeib et al., 2018). This clearly makes training of health workers an area for investment.

2.2. Factors associated with healthcare professionals’ knowledge of snakebite

Interestingly, some characteristics of HCPs have been associated with higher knowledge of snakebites. These include the male gender (Ameade, 2020; Pillay et al., 2021; Sapkota et al., 2020), increasing age (>35years) (Sapkota et al., 2020), higher years of experience (Michael et al., 2018; Pillay et al., 2021; Sapkota et al., 2020), prior training on snakebite (Ameade, 2020), and previous participation in managing snakebite (Michael et al., 2018; Sapkota et al., 2020) were more likely to have sufficient knowledge of snakebite.

2.3. Training needs of healthcare professionals that manage snakebites

The HCPs’ preparedness in managing snakebite envenoming begins with sufficient knowledge and skills in managing the condition. While the WHO regional and National guidelines are becoming readily available, disseminating these essential materials and their utilization by health professionals remain challenging. Ingenious ways of surmounting these challenges could involve using information and communication platforms and technologies to educate health professionals on snakebite; these include webinars, podcasts, online courses, etc. Regional and national toxology societies could take up this challenge with support from other partners.

Furthermore, The HCP should have adequate knowledge of the local venomous snakes and their clinical presentation after a bite, the recommended snakebite first aid/prehospital care, as well as the complications of using inappropriate prehospital care, the nearest health care facility with the capacity to treat snakebites, the local treatment protocol for snakebite, rational use of antivenom, and the identification and treatment of its adverse effects. Moreover, the managing team should be able to detect and treat mental disorders (e.g., depression and post-traumatic stress disorders) in survivors of snakebite, especially those with sequelae such as permanent and severe scars and amputations (Bhaumik et al., 2020; Islam et al., 2018; Muhammed et al., 2017) and refer them for rehabilitation as appropriate. Health care workers also require knowledge of these long-term effects of snake envenoming such as chronic kidney diseases, disfigurations, long term pain, muscle contractures and deformities.

Ideally, all HCPs likely to be confronted with snakebite treatment should receive training and retraining to offer the best care possible to snakebite victims. However, where resources are constrained, younger healthcare workers with few years of experience, especially those who are likely to see the victim first in the health facility, those in the emergency departments and surgeons likely to be involved in complicated snakebite (e.g., in cases of compartment syndromes, amputations, etc.), pharmacy technicians/pharmacists, and those without previous training should be considered for training.

2.4. Limitations of the study

Being a narrative review, the literature search may not have been exhaustive, especially non-English language studies. Second, there is a lack of snakebite knowledge studies in Latin America and Oceania; hence, data from these regions were poorly represented. Third, only a few knowledge studies were carried out among pharmacists/pharmacy technicians who also handle the storage and dispensing of anti-snake venom. Fourth, most studies designed their questions with different assessment domains; this suggests the need for a standardized questionnaire that may require only slight modifications to accommodate local peculiarities in the holistic assessment of snakebite knowledge.
2.5. Conclusion

A preponderance of studies in this review identified knowledge gaps among HCPs regarding snakebites; this suggests that current efforts to curtail the injuries and deaths from SBE should include training and retraining of HCPs, as some of the recorded deaths may have been due to wrong decisions by these important stakeholders.

Credit author statement

Godpower C. Michael conceived the idea, reviewed the reports and co-wrote the manuscript. Anwul A. Bala and Mustapha Mohammed reviewed the reports and co-wrote the manuscript.

Ethical statement

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

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