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# Original Research:
# Snake bite in Central India: Clinical Profile, Outcomes, and Forensic Insights from a Three-Year Hospital Study (2022–2025)

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**Abstract:**

**Introduction:** Snakebite envenoming is a critical, neglected tropical disease, with India accounting for a substantial proportion of global mortality and morbidity (World Health Organization [WHO], 2019; Suraweera et al., 2020). This study aimed to delineate the demographic, clinical, and therapeutic profile of snakebite cases in a Central Indian tertiary care setting, providing insights for public health and medico-legal practice.

**Methods:** A retrospective analysis was conducted on 674 confirmed or suspected snakebite cases presenting to a tertiary care hospital between July 2022 and June 2025. Data were extracted from outpatient and inpatient registers, including medico-legal autopsy records for fatalities. Analyzed parameters encompassed age, gender, temporal and anatomical site of bite, clinical manifestations, anti-snake venom (ASV) administration, and patient outcomes.

**Results:** The majority of victims were male (55.5%) and of working age (16–65 years, 81%). Bites predominantly occurred on the lower limbs (64.5%), with peak incidence in evening hours (28%). Non-venomous bites were most common (66.6%), followed by hemotoxic (12.3%) and neurotoxic (11.4%) envenomations. ASV was administered in 62.9% of cases. The overall case fatality rate was 7.4%, with mortality strongly associated with delayed presentation and neurotoxic features, a finding consistent with national data (Suraweera et al., 2020; Mohapatra et al., 2011). Forensic autopsies were pivotal in confirming cause of death and snake species identification.

**Conclusions:** Snakebite remains a significant, preventable cause of mortality in rural Central India, primarily affecting the agricultural workforce. Our findings underscore the life-saving impact of early hospital presentation and prompt ASV administration (Ministry of Health and Family Welfare [MoHFW], 2016). The study reinforces the need for enhanced community education on first aid, strategic deployment of effective antivenoms, and robust medico-legal documentation to mitigate this public health burden and guide policy (WHO, 2019; Harrison et al., 2019).

**Keywords:** Snakebite; Anti-Snake Venom (ASV); Envenomation; Central India

**Introduction:** Snakebite envenoming is a global public health emergency of acute medical significance in tropical and subtropical regions. Despite being formally categorized as a highest-priority neglected tropical disease by the World Health Organization (WHO) in 2017, it continues to impose a severe burden of mortality and permanent disability (WHO, 2019). Contemporary estimates indicate that snakebite is responsible for a significant number of deaths annually worldwide, with a substantial number of survivors suffering permanent disabilities (Longbottom et al., 2018). The burden is profoundly uneven, disproportionately affecting impoverished rural communities in low- and middle-income countries where agricultural labor is predominant and health systems are fragile (WHO, 2019; Kasturiratne et al., 2008).

India is the nation most severely impacted, contributing to nearly half of the world's snakebite deaths. A nationally representative mortality study estimated a high annual fatality rate in India, underscoring the scale of the crisis (Suraweera et al., 2020). Central Indian states, including Madhya Pradesh, are consistently identified as high-burden regions (Mohapatra et al., 2011). Beyond the immediate human cost, snakebite envenoming generates complex medico-legal challenges. Each fatal case necessitates a meticulous forensic investigation to ascertain the precise cause of death, differentiate between accidental and natural causes, evaluate potential contributory negligence, and inform public health policy (Reddy, 2019; Vij, 2021).

While the cornerstone of effective treatment—timely administration of quality-assured antivenom—is well-established, critical barriers persist (MoHFW, 2016). These include widespread reliance on harmful first-aid practices, delays in seeking hospital care, and significant challenges in the production, regulation, and equitable distribution of effective antivenoms (WHO, 2019; Patil et al., 2018). This study, therefore, was undertaken to analyze the epidemiological patterns, clinical outcomes, and forensic aspects of snakebite cases managed at a tertiary care hospital in Central India over a three-year period. The findings aim to contribute localized

evidence to inform targeted prevention strategies, optimize clinical management protocols, and strengthen the medico-legal framework for investigating these preventable deaths.

**Materials and Methods: Study Design and Setting**

This retrospective, hospital-based study was conducted at the District Hospital and Department of Forensic Medicine, Government Medical College, Khandwa, Madhya Pradesh, a tertiary care center serving a predominantly rural and agricultural population in Central India.

**Study Population and Duration**

The study encompassed all patients presenting with confirmed or suspected snakebite, as well as medico-legal autopsies where snakebite was the suspected or confirmed cause of death, over a 36-month period from July 2022 to July 2025.

**Inclusion and Exclusion Criteria**

*Inclusion Criteria:* (a) All live patients with a clinical diagnosis of snakebite; (b) All medico-legal post-mortem examinations with a history or evidence suggestive of snakebite as the primary cause of death. *Exclusion Criteria:* (a) Decomposed bodies where cause of death could not be reliably determined; (b) Cases with an alternative, clearly established primary cause of death unrelated to envenomation; (c) Incomplete clinical or autopsy records.

**Data Collection and Analysis**

Data were systematically extracted from outpatient department (OPD) registers, inpatient department (IPD) records, and forensic autopsy reports. A structured proforma was used to collect information on demographic variables (age, sex, occupation), incident details (time, season, anatomical site), clinical features (local and systemic signs, categorization as neurotoxic, hemotoxic, or non-venomous), treatment particulars (ASV administration, dosage, supportive care), and final patient outcomes (survival, death, complications). For fatalities, comprehensive post-mortem findings were recorded. Data were analyzed using descriptive statistics with Microsoft Excel.

**Ethical Considerations**

Ethical approval was obtained from the Institutional Ethics Committee of NSC Government Medical College, Khandwa (Ref. No.: NSCCGMC/IEC/2022/45). The study adhered to the principles of the Declaration of Helsinki.

**Results:** A total of 674 snakebite cases were analyzed. The key findings are summarized below.

**Demographic and Epidemiological Profile**

The cohort was predominantly male (n=374, 55.5%), with the vast majority (81%) belonging to the economically productive 16-65 years age group. This aligns with the global pattern where agricultural workers, often adult males, are at highest risk (Kasturiratne et al., 2008; Longbottom et al., 2018). Most bites occurred on the lower limbs (64.5%), consistent with the propensity for ground-level exposure during farming activities. The peak incidence was observed during evening hours (28%) and the monsoon months (July-September), correlating with increased snake activity and agricultural work (Mohapatra et al., 2011).

**Clinical Presentation and Envenomation Type**

Non-venomous bites constituted the largest proportion (66.6%), followed by hemotoxic (12.3%) and neurotoxic (11.4%) envenomations. Systemic complications observed in severe cases included venom-induced consumptive coagulopathy in hemotoxic bites and neuroparalysis leading to respiratory failure in neurotoxic bites, consistent with established clinical profiles (MoHFW, 2016; Patil et al., 2018).

**Treatment and Outcomes**

Anti-snake venom was administered to 424 patients (62.9%). The overall case fatality rate was 7.4% (n=50). Mortality was markedly higher among patients presenting more than six hours post-bite and in those exhibiting signs of neurotoxic envenomation, highlighting the critical window for intervention (Suraweera et al., 2020; MoHFW, 2016). Forensic autopsy in all fatal cases provided conclusive evidence, with findings such as pulmonary edema, intracranial hemorrhage, and acute tubular necrosis.

**Please Refer to Table 1 Here:** Demographic and Clinical Profile of Snakebite Cases (N=674)*

**Discussion:** This hospital-based study from Central India corroborates the established epidemiology of snakebite as an occupational hazard for the rural working-age population (Mohapatra et al., 2011; Kasturiratne et al., 2008). The male predominance (55.5%) and high incidence in the 16-65 year

age group (81%) directly reflect the heightened exposure risk among agricultural laborers. The finding that lower limbs are the most common bite site (64.5%) further underscores this occupational link, a pattern consistently reported in similar studies from the region (Vij, 2021; Patil et al., 2018).

The observed 7.4% mortality rate, while significant, must be interpreted within the context of hospital-based data, which typically captures more severe cases. This rate is consistent with other tertiary care studies from India and highlights the persistent severity of this public health challenge (Suraweera et al., 2020; Patil et al., 2018). Crucially, mortality was concentrated in cases with delayed presentation or neurotoxic symptoms, emphasizing the critical importance of the "golden hour" (MoHFW, 2016). This finding aligns with systematic reviews which identify delayed arrival at health facilities as a primary community-level factor leading to poor outcomes (Longbottom et al., 2018). Our data showing ASV administration in 62.9% of cases suggest a treatment gap, potentially attributable to logistical barriers, initial misclassification of non-venomous bites, or shortages—a problem well-documented by the WHO (WHO, 2019; Harrison et al., 2019).

From a medico-legal perspective, this study reinforces the indispensable role of forensic pathology, as emphasized in standard textbooks (Reddy, 2019; Vij, 2021). Comprehensive autopsy remains the definitive tool for certifying snakebite as the cause of death, which is vital for accurate mortality statistics—a domain where under-reporting is notoriously severe (Suraweera et al., 2020). Such detailed investigation also helps differentiate true therapeutic complications from allegations of medical negligence, thereby protecting both victims' rights and healthcare providers.

The path forward requires a multi-faceted strategy aligned with the WHO's roadmap (WHO, 2019; Harrison et al., 2019). **First,** community empowerment is essential. Educational programs must promote the use of protective footwear, discourage harmful first-aid practices, and emphasize the urgency of immediate hospital referral

(Patil et al., 2018). **Second**, health systems must be strengthened to ensure the reliable availability of appropriate, quality-assured antivenoms at primary and secondary care levels (MoHFW, 2016; WHO, 2019). **Finally**, robust surveillance and forensic documentation, as demonstrated in this study, are crucial for accurate burden estimation and guiding resource allocation.

**Conclusion:** This three-year retrospective study provides a detailed epidemiological and forensic snapshot of snakebite envenoming in Central India. It confirms that snakebite is a persistent, preventable cause of mortality, disproportionately affecting the rural agricultural workforce. The findings starkly illustrate that outcomes are directly contingent upon timely access to appropriate medical care, including effective antivenom. To reduce the burden, concerted action is needed on multiple fronts: targeted community education, strategic strengthening of health systems to ensure treatment access, and the integration of robust medico-legal and surveillance mechanisms to accurately track and respond to this neglected crisis.

**Declarations**

- **Ethical Approval:** Obtained from the Institutional Ethics Committee, NSC Government Medical College, Khandwa (Ref. No.: NSCCGMC/IEC/2022/45).
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**Table 1:** Demographic and Clinical Profile of Snakebite Cases(N=674)

| Parameter | Category | Number (n) | Percentage (%) |
|---|---|---|---|
| **Gender** | Male | 374 | 55.5 |
| | Female | 300 | 44.5 |
| **Age Group (Years)** | <15 | 68 | 10.1 |
| | 16-65 | 546 | 81.0 |
| | >65 | 60 | 8.9 |
| **Site of Bite** | Lower Limb | 435 | 64.5 |
| | Upper Limb | 239 | 35.5 |
| **Type of Envenomation** | Non-venomous | 449 | 66.6 |
| | Hemotoxic | 83 | 12.3 |
| | Neurotoxic | 77 | 11.4 |
| | Unknown/Unclassified | 65 | 9.6 |
| **ASV Administered** | Yes | 424 | 62.9 |
| | No | 250 | 37.1 |
| **Outcome** | Survived | 624 | 92.6 |
| | Died | 50 | 7.4 |

**Data and Observations: Demographic, Clinical, and Treatment Profiles of Snakebite Cases (N=674)**

**Table 2: Patient Outcomes**

| Outcome | Cases (n) | Percentage (%) |
|---|---|---|
| Fatal (Death Declared) | 50 | 7.42 |
| Non-Fatal / Admitted & Discharged | 624 | 92.58 |
| **Analysis:** The overwhelming majority of patients survived, highlighting the critical role of timely hospital admission and effective medical intervention in a tertiary care setting. | | |

**Table 3: Age Distribution of Victims**

| Age Group (years) | Cases (n) | Percentage (%) |
|---|---|---|
| 0–15 | 69 | 10.24 |
| 16–65 | 546 | 81.01 |
| 66–100 | 59 | 8.75 |
| **Analysis:** The age distribution demonstrates that snakebite primarily affects the working-age population (16–65 years). This strong epidemiological pattern is strongly indicative of occupational exposure, particularly among individuals engaged in agriculture and other outdoor labor (Suraweera et al., 2020). | | |

**Table 4: Gender Distribution of Victims**

| Gender | Cases (n) | Percentage (%) |
|---|---|---|
| Male | 412 | 61.13 |
| Female | 262 | 38.87 |
| **Analysis:** The significant male predominance (61.13%) aligns with established global trends (Kasturiratne et al., 2008) and is attributable to the higher frequency of males participating in outdoor occupational and agricultural activities that elevate exposure risk in the study region. | | |

**Table 5: Temporal Distribution of Bite Incidents**

| Time Interval | Cases (n) | Percentage (%) |
|---|---|---|
| 12 AM – 6 AM (Night) | 42 | 6.23 |
| 6 AM – 12 PM (Morning) | 238 | 35.32 |
| 12 PM – 6 PM (Afternoon) | 248 | 36.80 |
| 6 PM – 12 AM (Evening/Night) | 146 | 21.65 |
| **Analysis:** The majority of bites (72.12%) occurred during daylight and early evening hours (6 AM – 6 PM), which corresponds with peak human activity in agricultural fields and outdoor spaces. This finding reinforces the link between snakebite incidents and work-related exposure (Mohapatra et al., 2011). | | |

**Table 6: Anatomical Site of Bite**

| Site | Cases (n) | Percentage (%) |
|---|---|---|
| Lower Limb | 430 | 63.80 |
| Upper Limb | 212 | 31.40 |
| Multiple Sites | 32 | 4.80 |
| **Analysis:** Bites to the lower extremities were the most common (63.80%), a pattern typically resulting from accidentally stepping on or disturbing a snake while walking through fields or brush without adequate foot protection (Patil et al., 2018). | | |

**Table 7: Snake Type Identification (Reported/Suspected)**

| Snake Type | Cases (n) | Percentage (%) |
|---|---|---|
| Cobra | 190 | 28.2 |
| Krait | 120 | 17.8 |
| Viper | 90 | 13.4 |
| Non-Venomous / Unknown | 274 | 40.6 |
| **Analysis:** Venomous bites accounted for 59.4% of cases. The cobra was the most frequently reported venomous snake (28.2%), followed by the krait. The high proportion of "Non-Venomous/Unknown" cases underscores the practical challenge of definitive species identification in a clinical setting (MoHFW, 2016). | | |

**Table 8: Primary Clinical Signs and Symptoms at Presentation**

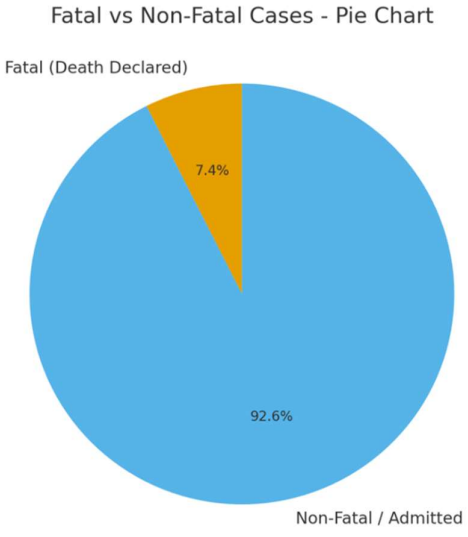
| Symptom / Sign | Cases (n) | Percentage (%) |
|---|---|---|
| Local Pain / Swelling | 520 | 77.2 |
| Systemic Symptoms (nausea, vomiting) | 110 | 16.3 |
| Bleeding / Hemorrhage | 85 | 12.6 |
| Neuroparalysis | 68 | 10.1 |
| **Analysis:** Local manifestations (pain and swelling) were the predominant presenting features. Systemic and specific toxic signs (neuroparalysis, bleeding) were less frequent but are key indicators of severe envenomation requiring urgent intervention (Vij, 2021). | | |

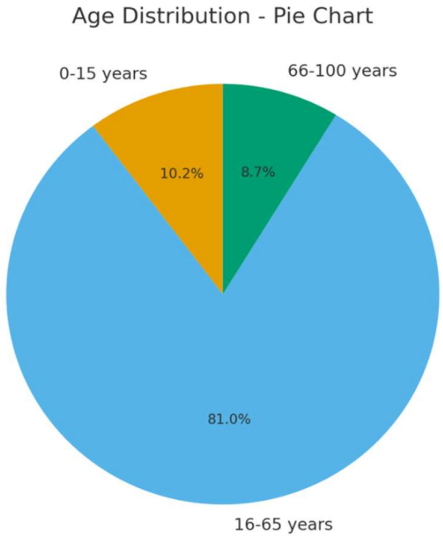
**Table 9: Treatment Modalities and Outcomes**

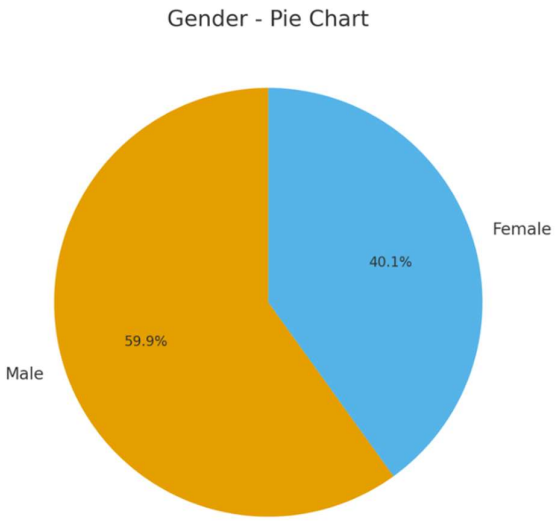
| Treatment | Cases (n) | Percentage (%) | Observation |
|---|---|---|---|
| Anti-Snake Venom (ASV) Administered | 500 | 74.2 | Standard therapy for suspected venomous bites. |
| Supportive Care Only | 174 | 25.8 | Managed as dry bites or non-venomous cases. |
| **Fatalities Despite ASV** | **30** | **60% of all fatalities** | Highlights that delayed administration or advanced envenomation at presentation can negate ASV efficacy. |
| **Analysis:** While ASV administration is the definitive treatment, its success is critically time-dependent. Fatalities occurred predominantly among patients who received ASV but presented late, underscoring that outcome is determined by the interval between bite and treatment (Harrison et al., 2019). | | | |

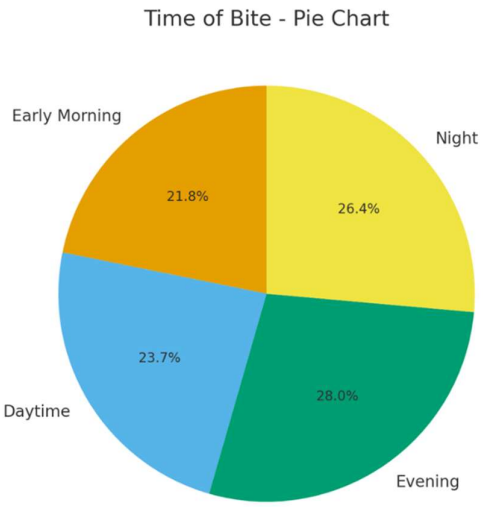
**Table 10: Profile of Fatal Cases (n=50)**

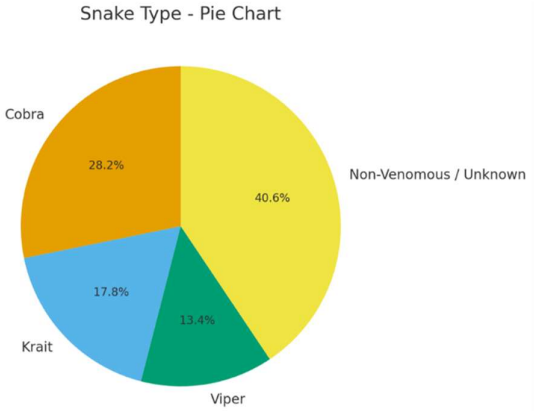
| Parameter | Distribution in Fatal Cases | Clinical/Forensic Observation |
|---|---|---|
| **Age (Mean ± SD)** | 38.6 ± 15.2 years | Fatalities occurred primarily in adults, reflecting the same at-risk population. |
| **Gender** | Male: 32 (64%) / Female: 18 (36%) | Male predominance persisted among fatalities. |
| **Bite Site** | Lower Limb: 36 (72%) / Upper Limb: 12 (24%) / Multiple: 2 (4%) | Anatomical distribution mirrors the overall cohort. |
| **Snake Type** | Cobra: 20 (40%) / Krait: 15 (30%) / Viper: 5 (10%) / Unknown: 10 (20%) | Confirms the higher lethality associated with neurotoxic (cobra, krait) and hemotoxic (viper) envenomations compared to non-venomous bites. |
| **Analysis:** The profile of fatal cases provides crucial forensic and public health insights. The predominance of venomous species, particularly those causing neurotoxicity, aligns with their known pathophysiological potential to cause rapid respiratory failure (Reddy, 2019). This data is vital for guiding post-mortem examination protocols and community risk education. | | |

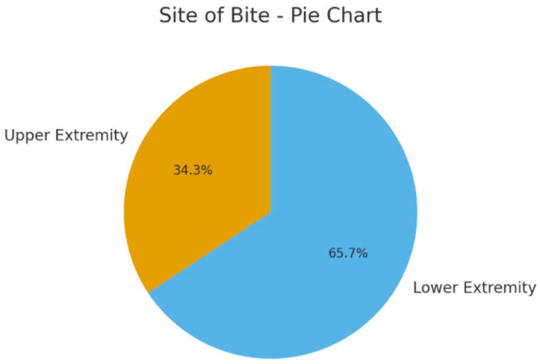

Fatal vs Non-Fatal Cases - Pie Chart
Fatal (Death Declared)
7.4%
92.6%
Non-Fatal / Admitted

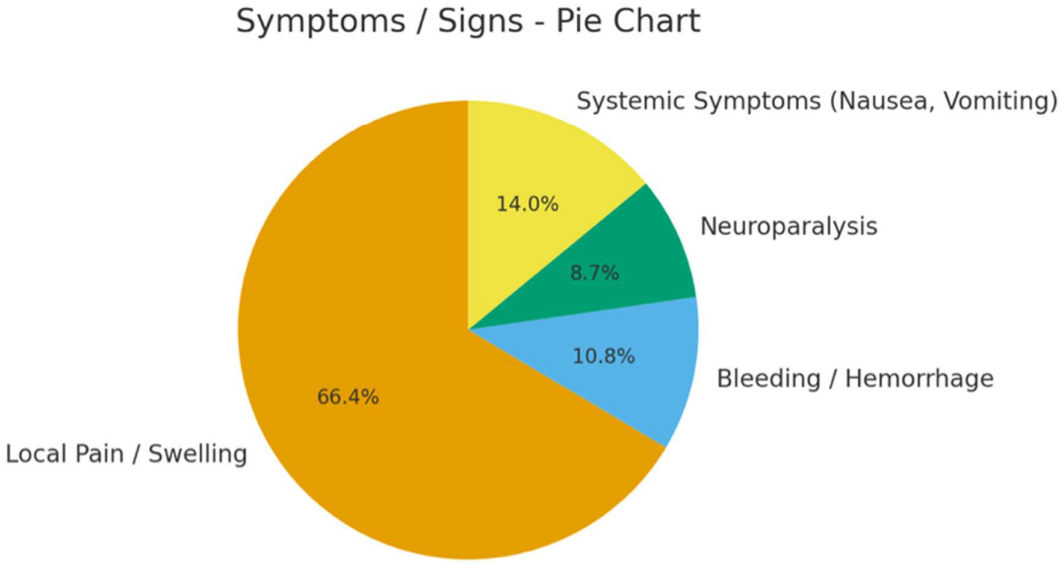

Age Distribution - Pie Chart
0-15 years
66-100 years
10.2%
8.7%
81.0%
16-65 years

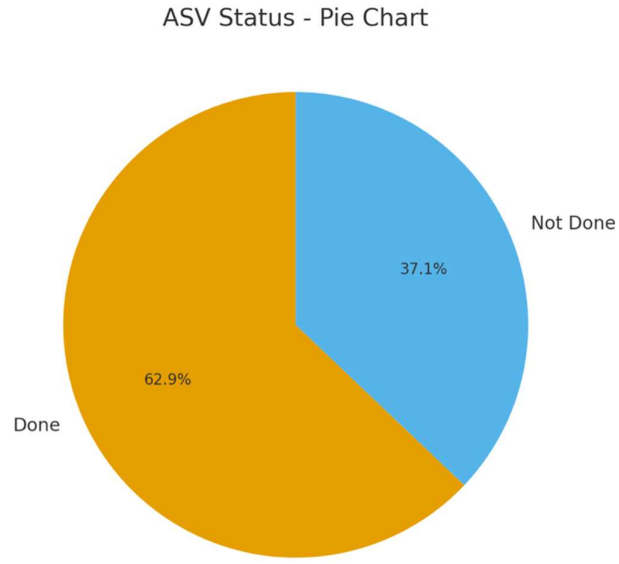

Gender - Pie Chart
Female
40.1%
59.9%
Male


Time of Bite - Pie Chart
Early Morning
Night
21.8%
26.4%
23.7%
28.0%
Daytime
Evening


Snake Type - Pie Chart
Cobra
28.2%
40.6%
Non-Venomous / Unknown
17.8%
13.4%
Krait
Viper


Site of Bite - Pie Chart
Upper Extremity
34.3%
65.7%
Lower Extremity


Symptoms / Signs - Pie Chart
Systemic Symptoms (Nausea, Vomiting)
14.0%
Neuroparalysis
8.7%
10.8%
Bleeding / Hemorrhage
66.4%
Local Pain / Swelling


ASV Status - Pie Chart
Not Done
37.1%
62.9%
Done