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SnakeMap: 4 years of experience with a national small animal snake envenomation registry

Short title: SnakeMap registry

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Abstract

SnakeMap is a national cloud-based, veterinary snakebite registry. It was designed to prospectively collect data of the clinical circumstances and temporospatial information on cases of snake envenomation in dogs and cats. We herein introduce the project and summarise the data from the first 4 years of SnakeMap.

The registry is a veterinary community-based online database allowing case entry from veterinary hospitals across Australia. Registry data comprise hospital characteristics, patient characteristics, envenoming snake type, treatment and outcome variables, including time and geolocation of the snake bite. We present summative information on select key variables from the SnakeMap registry (1 July 2015 to 30 June 2019). Twenty-eight hospitals from 6 states/territories entered 624 cases into the registry, including 419 dogs (67%) and 205 cats (33%). Bite time was available in 216 animals of which 90 (42%) were reported to be bitten in the three hours between 3:00 pm and 5:59 pm; median bite to presentation interval was 60 (IQR 30, 211) minutes in dogs and 95 (IQR 41, 238) minutes in cats. Bites occurred in the owner's yard in 356 dogs (85%) and 53 cats (26%). A snake venom detection kit was reported used in 172 cases (28%) and antivenom was administered in 523 cases (85%). Most animals (*n* = 534, 88%) survived to discharge (median hospitalisation of 25 [IQR 16, 62] hours). SnakeMap effectively collects relevant clinical data from dogs and cats with presumed snake bite and provides locally-specific information on the epidemiology of snake envenomation in small animals.

Keywords

Snake bites, envenomation, antivenoms, dogs, cats, epidemiology

Abbreviations

ACT, activated clotting time

ANZCVS, Australian and New Zealand College of Veterinary Scientists

aPTT, activated partial thromboplastin time

PT, prothrombin time

REDCap, research electronic data capture software

SVDK, snake venom detection kit

Introduction

Snake envenomation in humans and domestic animals is of particular significance in Australia due to the large number of highly venomous species in this country.[1, 2] Despite estimated snake envenomations in approximately 500-1,000 people annually, only 2-4 people die each year due to a well-developed medical system and routine use of antivenom.[3, 4] Due to limited avoidance behaviour, snake bites in dogs and cats are more common than in people and are a frequent cause for emergency consultations in veterinary hospitals across Australia. Despite this, epidemiological data on snake envenomation in dogs and cats are scarce. Published information is predominantly region-specific, obtained from observational or interventional studies at single veterinary hospitals, or from questionnaires.[5-9] The largest national study on snake envenomated small animals surveyed 106 veterinarians across Australia and estimated that in the mid-to-late 1990s, veterinarians treated approximately 6,000 snake envenomed dogs or cats annually.[8]

A more comprehensive, quantitative understanding of the epidemiology of canine and feline snake envenomation across Australia is needed. Prospective documentation of snake envenomation cases permits collection of information on the exact location and time of the snake bite event alongside patient, treatment and outcome data. With this possibility in mind, the SnakeMap Project was established in 2014 in the form of an online registry with the goal of prospectively collecting population characteristics, clinical circumstances, and importantly, temporospatial information. The project was initiated by a core group of the Australian and New Zealand College of Veterinary Scientists (ANZCVS) Emergency and Critical Care (ECC) chapter and has since received case entries from across Australia. In this paper we describe the SnakeMap Project and present a summary of the registry data for animals treated between 1 July 2015 and 30 June 2019.

Material and methods

SnakeMap Program organisation

SnakeMap is a volunteer-based initiative executed by two co-chairs and overseen by a scientific advisory board, which is composed of the members of the ANZCVS ECC chapter scientific committee, external veterinary and human medical snake envenomation experts and epidemiologists. Contributing veterinary hospitals are regionally organised according to the state or territory of their location, whereby each area is supported by a local chairperson (i.e., regional lead). The responsibilities of the scientific advisory committee and executive board are to: develop registry data elements and structure, regulate registry access and privacy, conduct data quality control, assure data security and backup, implement and maintain the actual database, review and approve appropriate requests for registry data use and disseminate annual SnakeMap reports. Regional leads build a local network of SnakeMap hospital contributors by identifying, instructing and supporting data entry personnel from partnering veterinary practices. Hospital contributors ensure timely data entry into the registry and are responsible for obtaining verbal consent from pet owners in accordance with human ethics requirements (Human Ethics Committee University of Melbourne, Application ID Ethics ID: 1443565). Hospital contributors may access their own records in the electronic database, while they cannot view data entered by other hospitals. However, hospital contributors seeking to address a specific research question can submit a request to the advisory committee to receive the entire, de-identified, SnakeMap dataset.

Registry infrastructure

The SnakeMap registry uses Research Electronic Data Capture software (REDCap) to collect and store data from snake envenomed dogs and cats.[10] REDCap is a secure, robust clinical research data management tool developed by Vanderbilt University (USA) and is used for approximately 804,000 research projects worldwide at the time of writing.[11] Data are entered into the SnakeMap registry via the REDCap online data submission platform using any desktop or mobile computing device, which allows contributors in different settings to enter case information in an expedient and secure way. Electronic data entry templates force entered data into a standardised format and data can be automatically validated for format and limits (e.g., maximum age accepted). Data can be directly exported to all major statistical packages, reducing time and error associated with transcribing data. The registry also allows upload of image files to case records, including pictures of snakes or snake bite sites. The data are backed up twice daily on the University of Melbourne servers and the REDCap software and infrastructure is safe guarded and updated by the university's information technology specialists.

Registry data structure

Data collection in the registry occurs electronically via REDCap, however, intermediary data entry on a paper case report form is encouraged (**Appendix 1**). One case report form is completed for each envenomed dog or cat. The data structure of the SnakeMap registry was established by the SnakeMap advisory committee based on a catalogue of variables, operational definitions and the designations of ‘core’ or ‘supplemental’ to each variable, similar as reported for other veterinary registries.[12] Core data must be entered as it is essential for the understanding of the reported snake envenomation case (e.g., species of animal bitten by snake), while supplemental data is desirable or may be hypothesis generating, but is not crucial information and is not always available (e.g., snake species). Each case report form contains 122 data fields that capture characteristics of the hospital reporting the snake envenomation (i.e., hospital variables), the animal affected (i.e., animal variables), snake bite information (snake bite variables) and the final outcome (i.e., outcome variables). Branching logic, radio buttons (e.g., Yes – No), and pull-down menus (e.g., breeds) facilitate and accelerate data entry and reduce data entry errors.

As the name suggests, SnakeMap gathers information on the exact geographical location of the interaction between dog or cat and snake. If the location is known to the pet owner (e.g., a snake bite was witnessed or occurred in an enclosed yard), the owner is asked to identify the location on a Google map (Google Map data© 2015-2019) that can be accessed via a link on the SnakeMap case report form. Decimal degrees of latitudinal and longitudinal coordinates are then retrieved from the Google map and entered into the database. These spatial data are linked with date and estimated time of the snake bite and an application programming interface (API) is used to access and extract these data from the registry to populate an online map twice a day (**Figure 1**). As a result, an increasingly dense pattern of geographic distribution of canine and feline snake encounters results as the number of reported cases grows. Additional information collected includes the use of a snake venom detection kit (SVDK), antivenom type and units administered, treatment with mechanical ventilation, duration of hospitalisation, survival to hospital discharge and to 30 days after envenomation.

Inclusion criteria

All dogs or cats with a clinical diagnosis of snake envenomation based on the assessment of the contributing veterinarian are eligible for inclusion. Specifically, the criteria applied by the hospital contributor for inclusion of patients are the presence of an appropriate history, characteristic clinical signs and at least one of the following: (1) a positive urine or blood test on SVDK either on initial presentation or following initial antivenom therapy; (2) a creatine kinase > 1000 U/L; (3) laboratory evidence of a snake venom induced consumptive coagulopathy as demonstrated by a markedly prolonged prothrombin time (PT), activated partial thromboplastin time (aPTT) or activated clotting time (ACT); or, (4) seen to be bitten by a snake. Verbal informed owner consent is required, although only de-identified data are used for SnakeMap data analysis.

Data analysis

We extracted case information from cases entered into the database over the course of the first four snake seasons of SnakeMap (1 July 2015 to 30 June 2019) from the registry and uploaded it to a commercial statistical program (JMP 12, SAS Institute Inc., Lane Cove, NSW, Australia). The authors then selected variables to be included in this report.

Continuous variables were tested for normality using the Shapiro-Wilks test and were summarised as either means and standard deviations, or medians and interquartile range. Differences between groups (e.g., dogs and cats) were assessed using either the Student's *t*-test, ANOVA, Mann-Whitney or Kruskal-Wallis tests, as appropriate. Categorical variables were expressed as proportions and 95% confidence intervals. The level of significance for all statistical tests was set at 5%.

Results

Hospital contributors

During the four snake seasons reported herein, 28 veterinary hospitals contributed 624 cases to the registry, whereby the case numbers per hospital varied from a single snake bite event to 185 events. Four university hospitals and 24 private practices entered 273 and 351 cases, respectively. Cases were contributed by six hospitals located in Victoria (n = 274, 44%), eight in Western Australia (n = 210, 34%), five each in New South Wales (n = 68, 11%) and Queensland (n = 37, 6%), two in South Australia (n = 19, 3%), and one each in Tasmania (n = 13, 2%) and the Northern Territory (n = 3, 0.5%).

Animal data

Two thirds of the animals in the registry were dogs (n = 419, 67%) and one third were cats (n = 205, 33%). With a median age of 2 years (IQR 1.4, 5), cats were younger than dogs (5 years; IQR 3, 8; P <0.001), while animals of all ages were affected. Two thirds of dogs were pure-bred (**Table 1**) and the most common breed affected was Staffordshire bull terrier (16%

of all pure-bred dogs) followed by the Jack Russell terrier (9% of all pure-bred dogs, **Table 2**). In contrast, only 21% of cats were purebred. Cats were more commonly male (65%) than female (P<0.01) while male (50%) and female dogs were equally affected. Most cases in the database presented between 12 pm and midnight (n = 502, 80%) and approximately half of all cases in the 6-hour interval from 4 pm to 10 pm (n = 341, 55%).

Snake envenomation data and diagnostic tests

As expected, most consults for snake bite occurred during the warmer months of the year with 559 cases (90%) presenting during the 6-month period from 1 October and 31 March. However, the date of snake bite was only known to pet owners in 79% of cases (91% of dogs and 55% of cats, **Table 3**). Compared to the date of the presumed bite, the owners of the animals were less commonly aware of the specific time of the snake bite in both species (45% of dogs and 15% of cats). Of the 216 animals with known time of snake bite, 90 animals (42%) were bitten in the three hours between 3:00 pm and 5:59 pm, independent on whether these animals were seen at general practitioners (39%) or referral/emergency practices (43%). The median time from bite to presentation was 60 (IQR 30, 211) minutes in dogs and 95 (IQR 41, 238) minutes in cats. The geographic location of the bite was the owner's yard in 356 dogs (85%) and 53 cats (26%). Public property was identified as bite location for only 19 dogs (4%) and 7 cats (3%), while in the remaining 44 dogs (10%) and 145 cats (71%) the location was reported as unknown. Likewise, coordinates for geocoding were not available for all animals, but were entered for 361 dogs (86%) and 78 cats (38%). These data allowed mapping of snake bites (**Figure 1**).

Most animals displayed clinical signs either prior to presentation, or at presentation to the attending veterinarian (**Table 3**). In 63 animals (10%) a bite site was identifiable, with 49% of bite sites found on the lips or cheek and 10% on a forelimb below the elbow. A SVDK was used in 172 animals (28%), with a positive result returned in 132 (77%) tested animals; the majority were of the brown (*n* = 73, 55%) and tiger snake immunotype (*n* = 47, 36%), and only 9 (7%) of the black immunotype. Urine was used in 75% of cases for SVDK testing, followed by whole blood (13%) and serum or plasma (9%), with bite site swab only reported in a single case (0.1%). Coagulation testing results were reported in 337 cases (54%) with aPTT most frequently used (*n* = 290, 86%), followed by PT (*n* = 205, 61%) and ACT (*n* = 38, 11%). The median first creatine kinase value obtained was 1302 (IQR 283, 5514) U/L in dogs (*n* = 207) and 1952 (IQR 471, 14256) U/L in cats (*n* = 111).

Treatment data

Antivenom was administered to 358 dogs (86%) and 165 cats (82%), the most common being bivalent tiger-brown antivenom (87%), followed by monovalent brown antivenom (9%) (**Table 4**). Amongst those animals receiving tiger-brown antivenom, the majority of animals (*n* = 279, 63%) received a single vial (i.e., 3000 units anti-tiger, 4000 units anti-brown), 119 animals (27%) were given two vials, and 48 animals (11%) were administered at least three vials. Premedication for preventing the occurrence of a hypersensitivity response to antivenom was administered to 40% (*n* = 211) of the animals receiving antivenom and consisted of antihistamines (*n* = 182, 29%) and less frequently corticosteroids (*n* = 55, 9%) or adrenaline (*n* = 43, 7%). These premedication drugs were predominantly administered subcutaneously (*n* = 77, 48%), followed by the intravenous (*n* = 44, 27%) and intramuscular (*n* = 40, 25%) route, with data not reported for 50 animals. Acute hypersensitivity after antivenom administration was uncommonly observed (*n* = 15, 3%), with all affected animals surviving to hospital discharge. It was reported in 2% (*n* = 3) of animals that received premedication (n = 195), and in 4% (*n* = 12) of animals that did not (*n* = 299). Positive pressure ventilation was part of the treatment in 82 animals (13%) and was applied for a median duration of 8.3 (IQR 1.5, 18.0) hours in dogs and 4.0 (IQR 1.0, 22.0) hours in cats. Five of the 46 animals (11%, 95% CI = 5%, 23%) with tiger, 14 of the 59 animals with brown (19%, 95% CI = 12%, 30%) and 1 of the 9 animals with black immunotype (11%, 95% CI = 2%, 44%) received mechanical ventilation.

Outcome data

Most animals (*n* = 534, 88%) survived to hospital discharge which occurred after a median duration of 24 (IQR 15, 61) hours in dogs and 27 (IQR 16, 64) hours in cats (**Table 5**). Animals with brown immunotype were discharged after 26 (IQR 15, 62) hours and those of the tiger immunotype after 35 (IQR 21, 80) hours. Rarely, survivors were hospitalised for extended periods of time, with one cat hospitalized for more than 2 weeks and four dogs for longer than 4 weeks. Approximately one third of the non-survivors died due to cardiopulmonary arrest (*n* = 23, 30%) with the remainder euthanized (*n* = 53, 70%). Veterinarians indicated that financial constraint (*n* = 27, 51%) and severity of illness (*n* = 26, 49%) were the primary reason for euthanasia. Of animals requiring mechanical ventilation, 76% (*n* = 62) survived to hospital discharge, with a mean hospitalisation duration of 63 (IQR

24.5, 96.5) hours. Of the animals for which 30-day follow up information was available (dogs: *n* = 203, 57%, cats: *n* = 96, 54%), three dogs (1.5%) and one cat (1.0%) were not alive at the time of inquiry. Three of these deaths were directly related to the snake envenomation. However, pet owners reported at the time of the 30-day follow-up, that 17 dogs (8%) and 6 cats (6%), had not yet returned to their pre-envenomation level of wellbeing.

Discussion

The SnakeMap project, a veterinary community-based project endorsed by the ANZCVS ECC chapter and executed by volunteers, offers a mechanism to collate prospectively important information on snake bites in dogs and cats. This report provides a description of data collected during the first 4 seasons of operation of the project and provides insight into the breadth of data in the SnakeMap registry. Important observations already emerge, such as: (1) most animals are bitten in the surrounds of their normal living space, rather than in public spaces, and (2) many bites occur in the outer boundaries of residential developments. Additionally, where tiger snakes are active, visual inspection of the SnakeMap as shown in Figure 1 revealed that bites are preferential to locations close to waterways. The prospective collection of data for the SnakeMap registry not only allows determination of the exact location of the snake bite event, but also when it occurred. The resulting data show that the highest frequency of snakebite occurred in mid to late afternoon, which could be the combined effect of snake activity and pet exposure, but also influenced by selection bias (i.e., hospital opening hours).

The combined consideration of time and location of snake bites in pets may, over time, inform snake envenomation risk exposure in people. As in our study, most snake bites in people occur around the house, a space cohabitated with family pets.[13] This One Health relevance of the temporospatial mapping in SnakeMap may emerge as very important, not only in Australia, but also with implementation in other countries. More than 100,000 deaths occur annually in people worldwide with many more disabled because of a snake bite.[14-16] In Australia, snake bites are much more common in dogs and cats than in humans. In people, a nationwide annual hospitalisation rate of approximately 500 cases of snake bite was reported, although not all of these cases are true envenomations.[13, 17] The number of dogs and cats presented to veterinarians for snake bite are believed to be at least an order higher.[8] This opens the opportunity to not only generate heat maps for snake bite risk in pets, but also develop predictive models for possible snake envenomation in people.

SnakeMap is not only focusing on temporospatial characteristics of snake bite in dogs and cats, but registry data also include information on the clinical practice of veterinary care provided to snake envenomed animals. We showed that SVDKs are not commonly used, perhaps because veterinarians are confident in their clinical diagnosis of snake envenomation without this test, may prefer screening diagnostics such as coagulation times, and because there is no direct impact on treatment, as some antivenoms can be used against multiple snake species. Drugs to prevent hypersensitivity reactions or anaphylaxis were commonly administered to animals reported in SnakeMap, especially antihistamines. In humans, antivenom administration is associated with a high incidence of anaphylaxis (10%) and premedication with low-dose adrenaline (0.01 mg/kg SQ) has been recommended, while antihistamines or steroids were found to be ineffective.[18, 19] In dogs and cats acute hypersensitivity reactions to Australian elapid antivenom are, while reported, uncommon and the topic is generally under-studied.[5, 6] Irrespective of receiving premedication or not, only a very small percentage of animals in SnakeMap displayed obvious clinical signs of hypersensitivity, and those that did all survived to hospital discharge. Nevertheless, premedication was a common clinical practice.

We purposefully did not present any inferential analyses results in this manuscript, as the primary objective was to introduce SnakeMap to the broader veterinary community in Australia and provide an overview on the breadth of data collected. Nevertheless, the data lends itself to such studies. For instance, the data allows one to investigate various associations of animal and snake bite variables with outcomes, such as how the time interval between bite and presentation influences survival to discharge, or how the distance from waterways or development fringes affects the likelihood of bite. While most animals survive, the SnakeMap database currently contains data on more than 70 non-survivors and a detailed analysis of these cases may provide important insight into causes of death and how these might be prevented. Approximately one third of non-survivors were euthanized primarily for financial reasons, which has previously been reported to be a significant issue in veterinary emergency medicine.[6, 20] The circumstances that lead to the death of the remaining cases, however, is of particular interest and should be further examined.

Such inferential studies are envisaged to be presented in subsequent SnakeMap studies. SnakeMap encourages its hospital contributors to apply for registry data to address specific hypotheses and has a peer review mechanism in place to facilitate the application process. It is our vision that such a process will allow broad and inclusive research activity across all contributing hospitals and will lead to scientific output that is most relevant to the veterinary community. The Veterinary Committee on Trauma (VetCOT) registry, has set a precedence for this approach with several publications authored by registry contributors.[21, 22]

While we herein present the largest dataset on snake envenomation in pets thus far in Australia, the quality of these data does not go unchallenged and represents a concern raised for medical registries in general.[23] Firstly, the registry asks for data to be entered for animals with a clinical diagnosis of snake envenomation and there is no laboratory proof required. This will naturally lead to the inclusion of dogs and cats that are not in fact envenomed and thus to misclassification. Hospital contributors agreed to enter all subsequent, eligible cases into the registry to minimise selection bias. However, as this is a volunteer-based initiative, there is no mechanism in place to enforce compliance and case entry may therefore be performed selectively. Likewise, SnakeMap currently does not have the resources to ascertain data entered are consistent with information in medical records, although the data validation functionality of REDCap constrains input errors to some extent. An additional data validation process would constitute an important quality assurance step in the future to quantify the effect of data entry error on registry validity.[24] Even if all the internal validity of the data could be ascertained, it is important that this information can be generalised to the entire population of snake envenomed dogs and cats (i.e., external validity). Because the SnakeMap registry includes cases from dozens of hospitals it does provide generalisable, clinically relevant information that reaches beyond a single veterinary facility and considers differences emerging from the regional diversity in snake envenomation.[25] Currently, the sample is relatively small, given that the number of approximately 120-150 reported SnakeMap cases per year embodies only 1-2% of all cases seen by veterinarians. Moreover, important data analyses into effects of region and snake species on outcomes such as mechanical ventilation, duration of hospitalization or survival to discharge require a larger dataset than what is currently contained in SnakeMap. Increasing and consistent participation by veterinarians is therefore essential for the SnakeMap registry to succeed.

In summary, the SnakeMap registry is a feasible, volunteer-based and veterinary community supported tool to collect a large data set of relevant clinical information from dogs and cats with snake bite. The prospective mechanism of case entry permits inclusion of locally-specific information on the epidemiology and outcome of snake envenomation in small animals. With continued contributions by veterinary hospitals from throughout Australia, SnakeMap may serve as a robust data repository to answer some of the most pertinent clinical questions surrounding snake envenomation in dogs and cats.

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Conflicts of interest

The authors declare no conflicts of interest.

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Tables

Table 1: Counts and percentages (95% confidence interval) of individual animal demographic details, stratified by species, entered into the SnakeMap registry

Variable	Dogs		Cats		*P* value [a]
	n	**% (95% CI)**	***n***	**% (95% CI)**	
Total records	419	67 (63, 71)	205	33 (29, 37)	<0.01
Pure-bred	267	66 (62, 71)	41	21 (16, 27)	<0.01
Age ≤ 2 years	115	27 (23, 31)	120	57 (51, 64)	<0.01
Male	211	50 (45, 55)	134	65 (58, 71)	<0.01

[a] Fisher's exact test, two-tail

Table 2: Counts and percentages (95% confidence interval) of breeds of dogs reported in the SnakeMap database.

Breed	*n*	% (95% CI)
Staffordshire Bull Terrier	43	16 (12, 21)
Jack Russell Terrier	25	9 (6, 14)
American Staffordshire Terrier	18	7 (4, 10)
Siberian Husky	14	5 (3, 9)
German Shepherd	14	5 (3, 9)
Labrador Retriever	13	5 (3, 8)
Border Collie	11	4 (2, 7)
Dachshund	11	4 (2, 7)
Golden Retriever	9	3 (2, 6)
German Shorthaired Pointer	7	3 (1, 5)

Table 3: Counts and percentages (95% confidence interval) of details of individual animal snake bite events, stratified by species, entered into the SnakeMap registry.

Variable	Dogs		Cats		*P* value [a]
	n	% (95% CI)	*n*	% (95% CI)	
Bite time:					
Date known	378	91 (88, 93)	112	55 (48, 62)	<0.01
Time known	186	45 (40, 50)	30	15 (11, 20)	<0.01
Bite location:					
Owners' yard	365	85 (83, 89)	53	26 (32, 46)	<0.01
Geocoded	361	86 (83, 89)	78	38 (32, 45)	<0.01
Clinical signs present:					
Before presentation	348	84 (80, 87)	183	91 (86, 94)	0.08
At presentation	351	85 (81, 88)	188	93 (89, 96)	<0.01
Bite site located	55	17 (13, 21)	8	4 (2, 9)	<0.01
SVDK used	101	24 (20, 29)	71	35 (29, 42)	<0.01
Coagulation tested	241	58 (53, 62)	96	47 (40, 54)	0.01

SVDK, snake venom detection kit. [a] Fisher's exact test, two-tail

Table 4: Counts and percentages 95% confidence interval) of individual animal treatment details, stratified by species, entered into the SnakeMap registry.

Variable	Dogs		Cats		*P* value [a]
	n	**% (95% CI)**	***n***	**% (95% CI)**	
Antivenom:					
Any	358	86 (83, 89)	165	82 (76, 87)	0.19
1 vial tiger-brown	175	56 (51, 61	104	78 (70, 84)	<0.01
2 vials tiger-brown	99	32 (27, 37)	20	15 (10, 22)	<0.01
3+ vials tiger-brown	38	12 (9, 16)	10	7 (4, 13)	0.18
Premedication:[b]					
Any [c]	143	41 (36, 46)	55	35 (28, 43)	0.39
Antihistamine	131	37 (32, 42)	51	32 (25, 40)	0.11
Adrenaline	31	9 (6, 12)	12	8 (4, 13)	0.61
Corticosteroids	46	13 (10, 17)	9	6 (3, 10)	<0.01
Hypersensitivity noted	14	4 (2, 7)	1	0.6 (0.1, 3)	0.03
Ventilation	71	17 (14, 21)	11	5 (3, 10)	<0.01

[a] Fisher's exact test, two-tail; [b] percentages refer to the proportion of animals treated with antivenom that received a drug for premedication; [c] number (proportion) of animals that received any combination of the three premedications listed

Table 5: Counts and percentages (and their 95% confidence intervals) of the outcome of snake bite events, stratified by species, entered into the SnakeMap registry

Variable	Dogs		Cats		*P* value [a]
	n	**% (95% CI)**	***n***	**% (95% CI)**	
Survived to discharge:	355	87 (83, 90)	179	90 (84,93)	0.36
Antivenom [b]	323	92 (88, 94)	156	95 (91, 98)	0.20
No antivenom [b]	31	54 (42, 67)	23	64 (48, 78)	0.40
Mode of death:					
CPA [c]	21	38 (27, 51)	2	10 (3, 29)	-
Euthanasia [c]	34	62 (49, 73)	19	90 (71, 97)	<0.01
Primary reason for euthanasia:					
Severity of illness	20	59 (42, 74)	6	32 (15, 54)	0.09
Cost of treatment	14	41 (26, 58)	13	68 (46, 85)	0.09

CPA, cardiopulmonary arrest. [a] Fisher's exact test, two-tail; [b] 358 dogs and 165 cats received antivenom, and 57 dogs and 36 cats did not; [c] count and percent amongst non-survivors

Legends

Figure 1: Google Earth image of the area administered by Wyndham Council, in the western suburbs of Melbourne. The locations of canine snake bite events for the period 1 January 2014 to 1 January 2018 are shown as banners. Note the apparent association with waterways on visual inspection, likely to be a consequence of the tiger snake being common in this area of Victoria. In addition, bites are preferentially located in the periphery of residential zones while the centre of settlement areas are mostly bite free.

Appendix 1: Case report form

SnakeMap Case Report Form

ANIMAL INFORMATION

Patient MRN ______ **Owner name** ______ (Last) **Pet name** ______

Species ☐ Dog ☐ Cat **Purebred?** ☐ No ☐ Yes → **Breed** ______

Sex ☐ M ☐ MC ☐ F ☐ FS **Date of birth** __ __ __ (Day Month Year) **Weight** ____ kg

Date/time of presentation __ __ __ (Day Month Year) ___:___ (Hour Min)

Was the animal referred? → ☐ No ☐ Yes **Date/time seen at ref vet** __ __ __ (Day Month Year) ___:___ (Hour Min)

ETHICS: VERBAL CONSENT REQUIRED

Inform the pet owner that...

☐ This is research

☐ Coordinates of the snake envenomation location will be recorded

☐ Should the animal survival to hospital discharge, a follow up phone call regarding the well-being of the animal will be made 30 days after discharge

☐ Participation/non-participation in the study will not affect the care of the animal

Verbal owner consent obtained? → ☐ Yes ☐ No

SNAKEBITE INFORMATION

Time and Location

Date of bite known? ☐ No ☐ Yes → __ __ __ (Day Month Year) **Time of bite known?** ☐ No ☐ Yes → ___:___ (Hour Min)

State, Postcode of bite location __________-_______ **Did bite occur in......** ☐ Owner's yard ☐ Public property

Exact location (google map) Latitude (decimal) ______ Longitude (decimal) ______

Was bite witnessed? ☐ No ☐ Yes → **Was snake witnessed?** ☐ No ☐ Yes → **Snake species identified by scale counting?** ☐ No ☐ Yes → Species ______

Clinical signs

When was the pet last seen normal? __ __ __ (Day Month Year) ___:___ (Hour Min)

Clinical signs present prior to arrival? ☐ No ☐ Yes → ☐ Vomiting ☐ Collapse followed by recovery ☐ Weakness or collapse without recovery ☐ Other:________________________________

Clinical signs present after arrival? ☐ No ☐ Yes → ☐ Vomiting ☐ Weakness or collapse ☐ Muscle tremors ☐ Dilated pupils ☐ Absent PLR ☐ Respiratory arrest or very weak respiratory effort ☐ Other:____

Was bite site located? ☐ No ☐ Yes → How many and where?____

Diagnostics

Was SVDK used? ☐ No ☐ Yes → **What sample?** ☐ Blood ☐ Urine

Result? ☐ Negative ☐ Positive → **Immunotype?** ______________

Other diagnostics @ time of presentation

PT _____secs **aPTT** _____secs **ACT** _____secs **PCV/TS** ____/_____

Lac ____mmol/L **SpO2** ____% **PaCO2** _____mmHg **PvCO2** _____mmHg

Blood pressure ____mm Hg ☐ Doppler ☐ Systolic Oscillometric

Highest CK value in first 24 hours: ________U/L

 Recorder:____________

SNAKEBITE INFORMATION, continued

Treatment

Was antivenom administered? ☐ No ☐ Yes **What type?** ____________ **How many vials?** ____________

Was SVDK used to guide repeat antivenom dose? ☐ No ☐ Yes **Acute hypersensitivity noted?** ☐ No ☐ Yes

Was premedication used prior to antivenom? ☐ No ☐ Yes → **What drug?** _________________ **Route?** ____________

Was PPV administered at any time? ☐ No ☐ Yes → **How long?** ___________hours

OUTCOME INFORMATION

Discharged alive? ☐ No ☐ Yes → **Date/time of discharge?** [Day] [Month] [Year] Time ___:___

Where was it discharged to? ☐ Home ☐ Other Veterinary Care Facility

→ **Date/time of death?** [Day] [Month] [Year] Time ___:___

Mode of death? ☐ Euthanasia ☐ Cardiopulmonary arrest

→ **MAIN reason for euthanasia?** ☐ Severity if illness ☐ Financial constraints

Total veterinary bill at your hospital? ____________AUD

Additional case information/notes

 Recorder:___________

Appendix 2: Hospital contributors, in alphabetical order

1	Adelaide Veterinary Specialists – AAERC, Adelaide, SA
2	AHVEC, Hobart, TAS
3	Animal Emergency Care, Osborne Park, WA
4	Animal Emergency Centre Gold Coast, Varsity Lakes, QLD
5	Animal Emergency Centre Hallam, Hallam, VIC
6	Animal Emergency Centre Mount Waverley, Mount Waverley, VIC
7	Animal Emergency Centre Noosa, Noosaville, QLD
8	Animal Emergency Service, Carrara, QLD
9	AREC, Newcastle, NSW
1-	ARH Canberra, Fyshwick, ACT
11	ARH Gosford, West Gosford, NSW
12	Baldivis Emergency Vets, Perth, WA
13	Brisbane Veterinary Emergency and Critical Care Services, Albany Creek, QLD
14	Bundoora Veterinary Clinic and Hospital, Bundoora, VIC
15	Green Cross Vets South Tamworth, South Tamworth, NSW
16	Howard Springs Veterinary Clinic, Howard Springs, NT
17	Karratha Veterinary Hospital, Karratha, WA
18	Lort Smith Animal Hospital, Melbourne, VIC
19	Murdoch University, The Animal Hospital, Murdoch, WA

20	Perth Vet Emergency, Yokine, WA
21	Southern Tablelands Vets, Goulburn, NSW
22	University of Adelaide – Veterinary Health Centre, Roseworthy, SA
23	University of Melbourne U-Vet, Werribee, VIC
24	University of Queensland Veterinary Hospital, Gatton, QLD
25	Vet24, Balcetta, WA
26	Waroona Veterinary Clinic, Waroona, WA
27	WAVES, Success, WA
28	Wyndham Veterinary Clinic, Werribee, VIC

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