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Evaluation of the Impacts of the COVID-19 Pandemic and Climate on Hospital Admissions for Animal-Related Injuries and Clinical Outcomes in Children and Adults

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Abstract

We aimed to examine influences COVID-19 pandemic and climate on hospital admissions for animal-related injuries and outcomes from 01/01/2018-31/12/2023, including the pandemic (01/03/2020-31//032021). Forty children and 306 adults of mean (±SD) age 6.9yr (±4.5) and 56.8yr (±18.0) respectively were studied. Animals included dogs, 'other mammals', and arthropods. Chi-squared tests were used to assess the association between categorical and ANOVA between continuous variables. Admissions for injuries from dogs, 'other mammals'', and arthropods were three, five and 32 children, and 52, 76 and 178 adults. Age between children admitted with injuries from these respective animals was similar (P=0.841): 5.3yr (±4.7), 7.0yr (±5.9), and 7.0yr (±4.4), whilst adults admitted for injuries from dogs and 'other mammals' were older than those from arthropods (P<0.001): 59.3yr (±19.5), 59.3yr (±18.6), and 51.2yr (±16.7), respectively. All admissions diminished during the pandemic, followed by a surge in the third-year after the beginning of the pandemic for dog-related injuries in adults. Admissions for arthropod-related injuries peaked in summer, and warmer, sunnier, drier, and calmer weather. The proportions (%) of admissions for arthropod-related injuries occurring indoor/outdoor were 40/60 in children and 20/80 adults, and dog-related or mammal-related injuries 35/65 in adults. Cellulitis was mostly resulted from arthropod-related injuries in all patients. Cellulitis in children, and injuries from dogs and 'other mammals', admissions to surgical units, and via emergency in adults were an independent risk of extended hospitalisation. In conclusion, injuries sustained from animals were influenced by the pandemic and climate. The surge in admissions for dog-related injuries emerged several years after the start of the pandemic.

Keywords: Public Health; Bites; Dogs; Arthropods; Hospitalisation; Infection

Introduction

The coronavirus disease (COVID-19) pandemic had a profound impact on the environment and behaviours of humans and animals [1,2], as well as human-animal interactions [3-5]. Repeated lockdown periods led to nationwide social isolation, resulting in a dramatic rise in physical and mental illnesses and exacerbation of pre-existing conditions [6,7]. The uncertainty of the seemingly never-ending waves of lockdowns precipitated fear, anxiety and depression in many individuals [8]. Healthcare workers had an additional concern due to their direct contact with patients with SARS-Cov-2, especially when facing shortages of personal protection equipment and lack of treatment options, as well as vaccination at the early stages of the pandemic [9,10]. These manifestations were heightened by job and financial insecurity [11,12] as well as by global socioeconomic downturns and soaring poverty [13]. Many people sought company through their pets, with dogs being the most popular choice [14,15]. The "pandemic puppies" became a new phenomenon of must-haves to first-time owners [16,17]. Furthermore, changes in human activities during the pandemic also affected the environment and wildlife [18]. A reduction in human activities during lockdowns minimised disturbances to wildlife habitats, thus allowed the opportunity for wild animals to thrive during the pandemic [19].

By the time lockdown restrictions were lifted, it became exceptionally challenging for domesticated animals to adapt to unfamiliar environments, such as interactions with other animals, human crowds, and surrounding noises [20]. On the other hand, the return of human outdoor activities increased exposure to arthropods that were thriving during the pandemic and became more populous afterwards. However, there is a paucity of empirical evidence on health consequences from these changes towards humans during and beyond the pandemic. This study aimed to evaluate the impacts of the COVID-19 pandemic and climate on paediatric and adult admissions for injuries from dogs, 'other mammals', and arthropods, and relate them to quality-care outcomes including the extent of hospitalisation and secondary complications.

Methods

Study Design, Participants and Setting

Prospective data of consecutive admissions to a UK hospital were collected from patients admitted before (1st January 2018 to 29th February 2020), during (1st March 2020 to 31st March 2021) and after the pandemic (1st April 2021 to 31st December 2023). The hospital is the largest provider of acute hospital services in Surrey, serving a population of 430,000.

Measurements

Clinical data were recorded including age, sex and causes of admissions, and information on the duration of stay in hospital was documented. Children and adults were defined according to the 18-year cut-off. Animals were categorised as: dogs, 'other mammals', and arthropods. The International Coding for Diseases (ICD-10) [21] was used to classify animal bites and stings (W53-W59) or animal contacts (X21-X26), and the types of animal-related injuries: cellulitis (L030-L039) and infection to the skin or subcutaneous tissue (L089). Patients who stayed longer than 24hr in hospital were considered to have an extended hospitalisation. Climate records were obtained from a local meteorological station (Wisley, Surrey) which provided monthly averages over the most recent three decades (1991-2020) [22].

Statistical Analysis

Chi-squared and Fisher's exact tests were used to examine changes in admissions for animal-related injuries before, during and after the pandemic, and their outcomes including extended hospitalisation. Analysis variance (ANOVA), with post hoc tests where applicable, was used to assess differences in continuous variables (age) between multiple groups. Multivariable logistic regression analysis was conducted to assess factors associated with extended hospitalisation. All analyses were performed using IBM SPSS Statistics, v28.0 (IBM Corp., Armonk, NY).

Results

Subject Characteristics

From a total of 52,781 children and 456,571 adults admitted to our hospital over a period of six years, 40 children (0.076% of all paediatric admissions) and 306 adults (0.067% of all adult admissions) were admitted with animal-related injuries. The mean (±SD) age of children was 6.9yr (±4.5) and adults was 56.8yr (±18.0). There were slightly more: male than female children but more female than male adults; admissions via emergency than via elective service; and admissions to medical wards than to surgical units. The numbers of children admitted for injuries from dogs, 'other mammals', and arthropods were three, five and 32 respectively, and the corresponding values for adults were 52, 76 and 178. The proportions of children and adults staying in hospital ≥24 hours were 67.5% and 35.0%, respectively. Cellulitis developed in 52.5% of children and 43.8% of adults, and infection of local skin and subcutaneous tissue in 10% of children and 3.3% of adults (Table 1).

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	Children (n=40)		Adults (n=306)	
	Mean	**SD**	**Mean**	**SD**
Age (years)	7.1	4.6	55.2	19
	n	%	n	%
Sex				
Male	22	55	122	40
Female	18	45	184	60
Admission method				
Elective	3	7.5	45	15
Emergency	37	93	261	85
Specialty				
Medical	40	100	248	81
Surgical	0	0	58*	19
Animals				
Dogs	3	7.5	52	17
Other mammals	5	13	76	25
Arthropods	32	80	178	58
Outcomes				
Extended hospitalisation (hospital stay ≥24 hours)	27	68	107	35
Cellulitis	21	53	134	44
Infection of local skin and subcutaneous tissue	4	10	10	3.3

*Including one to ITU and one to maternity unit; …Including one from a reptile in children and two from reptiles in adults.
Table 1: Characteristics of 346 individuals admitted to hospital between January 2018 and December 2023.

There were no age differences between children admitted with injuries from dogs, 'other mammals', and arthropods (P=0.841): mean age: 5.3yr (±4.7), 7.0yr (±5.9), and 7.0yr (±4.4), respectively. By contrast, adults admitted for injuries from dogs and 'other mammals' were older than for those from arthropods (P<0.001): mean age 59.3yr (±19.5), 59.3yr (±18.6), and 51.2yr (±16.7), respectively. Amongst children, the relative proportions of admissions for arthropod-related injuries occurring indoor/outdoor were 40%/60%. There were only a few admissions for dog-related injuries (two from three) and 'other mammal'-related injuries (one from five) that occurred at home. Amongst adults, the relative percentage proportions of injuries occurring indoor/outdoor for dogs and 'other mammals' were approximately 35/65%, and for arthropod-related injuries 20/80%. The relative proportions of male/female children admitted for injuries from dogs were 66.7/33.3%, 'other mammals' 40/60% and arthropods 56.3/43.8%. The corresponding figures for adults were 32.7/67.3% from dogs, 23.7/76.3% 'other mammals', and 48.9/51.1% arthropods.

Impact of COVID-19 Pandemic

Figure 1 shows that in children, admissions for arthropod-related injuries were eight and nine cases in each of the two years before the COVID-19 pandemic, which diminished to one admission during the pandemic (2020-2021), and then rose to the near pre-pandemic level of 14 admissions in the two years and eight months after the pandemic. There were little changes in the number of admissions for dogs and 'other mammals', but the numbers were too small to conduct a meaningful analysis. Amongst adults, admissions for arthropod-related injuries decreased drastically to 11 cases during the pandemic compared to 30 cases in the year immediately before the pandemic. After the pandemic, arthropod-related injuries rose progressively in each of the following three years to 24 cases in eight months, to 54 cases and 46 cases in each of the following two years, respectively. Admissions for injuries from dogs in each of the two years immediately before the pandemic were eight and six cases, but did not change during the pandemic (six cases), or the next eight months (seven cases) and the following

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year (five cases) after the pandemic. However, there was a considerable surge in admissions for dog-related injuries in adults (20 cases) in the third year after the pandemic. A similar trend was observed for adult admissions for injuries from 'other mammals' over time.

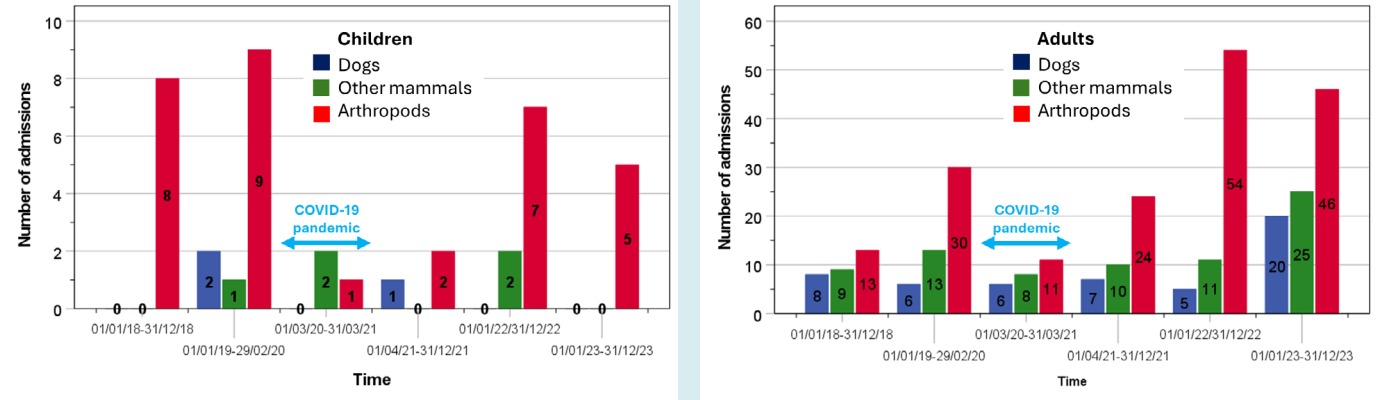


Figure 1: Admissions of animal-related injuries in children (A) and adults (B) over the period between 2018 and 2023, including the COVID-19 pandemic period (1st March 2020 to 31st March 2021).

Year	All	Dog-related		Other mammal-related		Arthropod-related		All animal-related	
	Admissions*	Admissions	Admissions per 100,000	Admissions	Admissions per 100,000	Admissions	Admissions per 100,000	Admissions	Admissions per 100,000
Children									
2018	10,281	0	0	0	0	8	77.8	8	77.8
2019	10,025	2	20	1	10	7	69.8	10	99.8
2020†	7,548	0	0	2	26.5	3	39.7	5	66.2
2021†	8,078	1	12.4	0	0	2	24.8	3	37.1
2022	7,974	0	0	2	25.1	7	87.8	9	112.9
2023	8,875	0	0	0	0	5	56.3	5	56.3
Total	52,781	3	5.7	5	9.5	32	60.6	40	75.8
Adults									
2018	70,850	8	11.3	9	12.7	13	18.3	30	42.3
2019	77,662	6	7.7	12	15.5	28	36.1	46	59.2
2020†	61,342	5	8.2	7	11.4	13	21.2	25	40.8
2021†	72,126	8	11.1	12	16.6	24	33.3	44	61
2022	79,014	5	6.3	11	13.9	54	68.3	70	88.6
2023	95,577	20	20.9	25	26.2	46	48.1	91	95.2
Total	4,56,571	52	11.4	76	16.6	178	39	306	67

*Admissions for all conditions; …Including the COVID-19 pandemic period (1st March 2020 to 31st March 2021).

Table 2: Hospital admissions for all conditions and for injuries from animals, expressed in absolute numbers of admissions and number per100,000 using formula: Admissions for animal-related injuries per 100,000 = (Number of admissions for animal-related injuries / Number of admission for all conditions) ×100,000.

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Table 2 shows absolute numbers of yearly hospital admissions for all conditions and for animal-related injuries, and the adjusted animal-related admissions per 100,000 hospital admissions for all conditions. The trends confirmed that after the pandemic, admissions for injuries caused by all animals rose to their highest levels in adults.

Impact of Climate

Admissions for arthropod-related injuries followed time (months) of the year, peaking in summer (August in children and July in adults). By contrast, admissions for injuries from dogs and 'other mammals' were relatively constant throughout the year, i.e. independent of time of the year (Figure 2). Similarly, admissions for arthropod-related injuries, both in children and adults, followed variation in climate, peaking during warmer and sunnier weather (except the hottest and sunniest weather in children), and during the period of less air frost, low rain fall, or low wind speed (Figure 3).

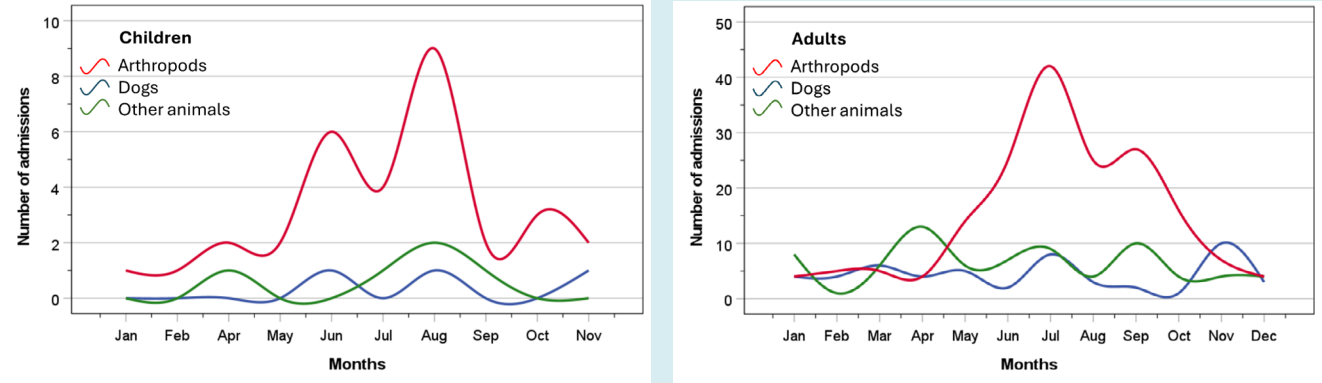
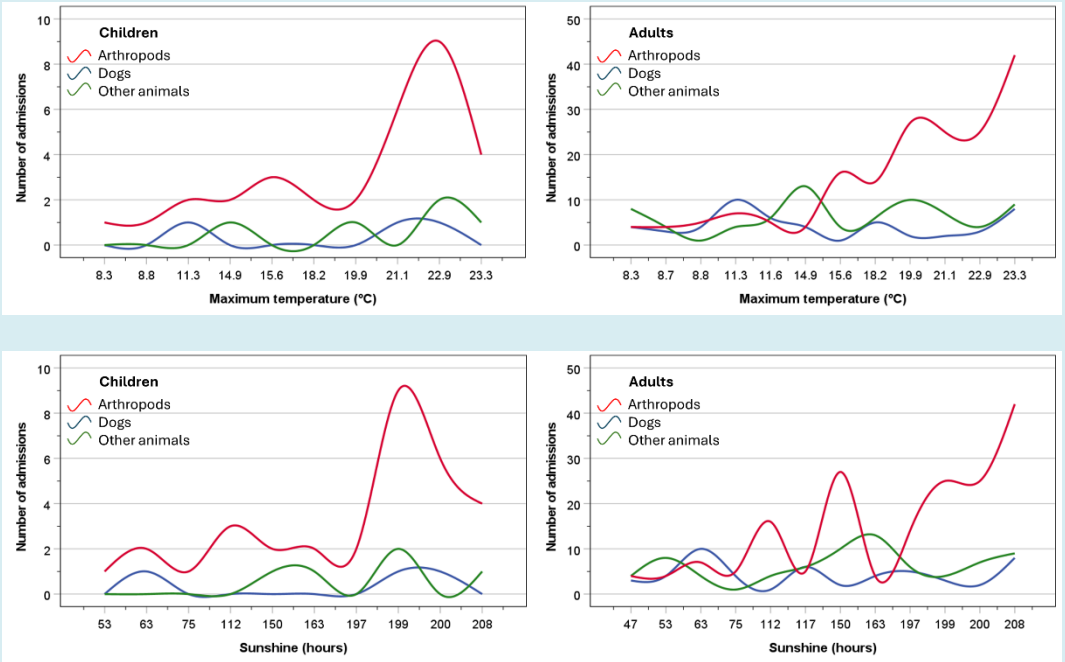


Figure 2: Number of admissions of animal-related injuries in relation to the time of year in children (A) and adults (B).



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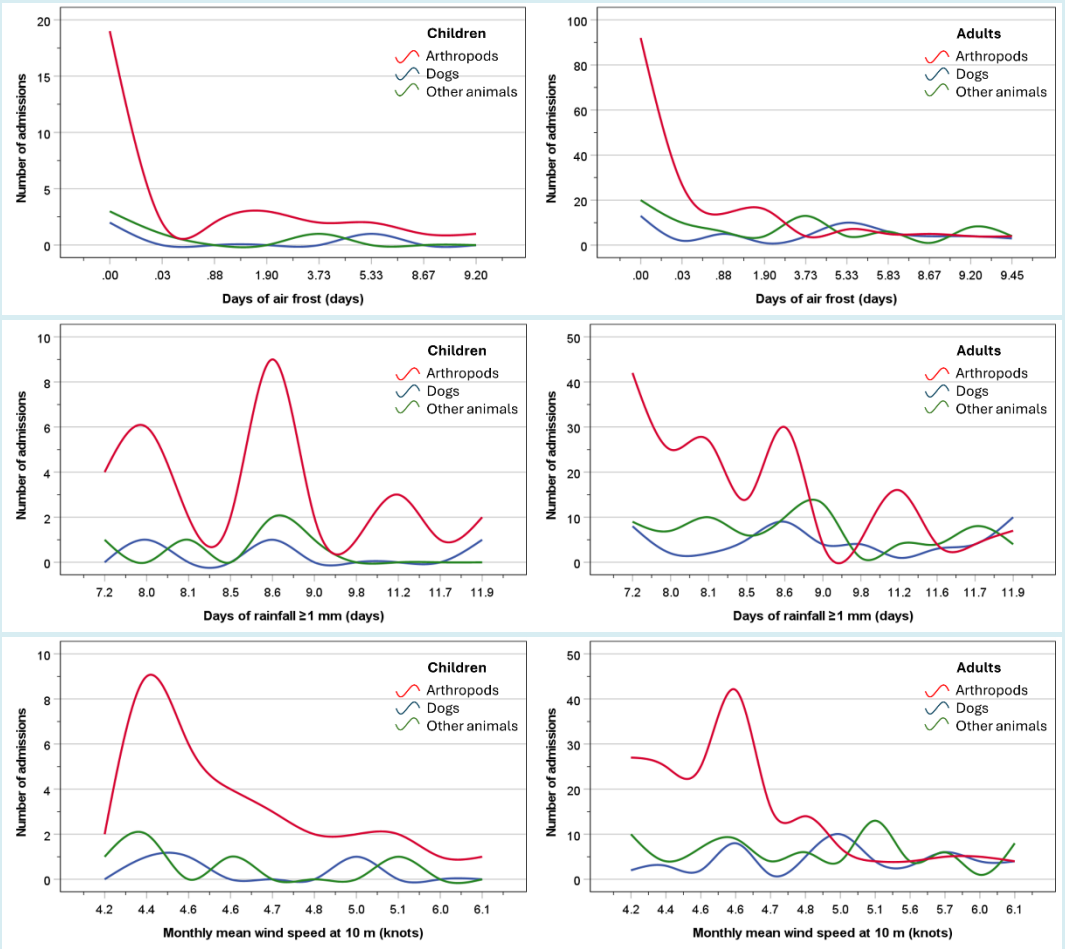


Figure 3: Admissions for animal-related injuries in relation to climate.

Outcomes

In children, cellulitis occurred most often from arthropod-related injuries (62.5%), followed by 'other animals' (20.0%), and no cellulitis occurred from dog-related injuries. The corresponding values in adults were 49.4%, 43.4% and 25.0%. All children were admitted to medical wards for treatment, i.e. no children were admitted to surgical units. Amongst adults, 248 (81%) were admitted to medical wards and 58 (19%) to surgical units. More adults were admitted to medical wards than surgical units for all types of animal-related injuries, but there were proportionally more patients who required admission to surgical units for injuries from dogs (20%) and 'other mammals' (32.1%) than for arthropods (10%) (Figure 4).

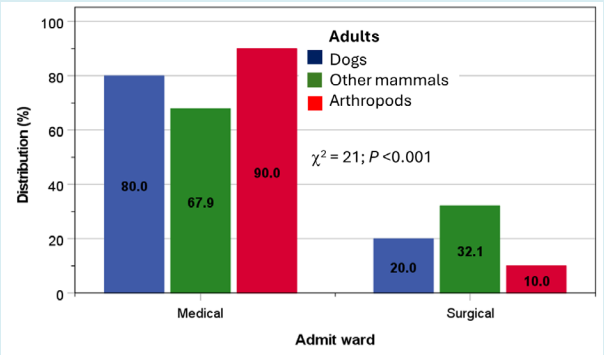


Figure 4: Distribution of admissions to medical surgical ward adults who sustained injuries from different types of animals.

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Hospitalisation						
	Children			Adults		
	<24 hours	≥24 hours	P	<24 hours	≥24 hours	P
Animals						
Dogs	2 (66.7)	1 (33.3)	0.015	26 (50.0)	26 (50.5)	<0.001
Other mammals	4 (80.0)	1 (20.0)		33 (43.4)	43 (56.6)	
Arthropods	7 (21.9)	25 (78.1)		140 (78.7)	38 (21.3)	
Admission methods						
Elective	3 (100)	0	0.029	41 (91.1)	4 (8.9)	<0.001
Emergency	10 (27.0)	27 (73.0)		158 (60.5)	103 (39.5)	
Admit wards						
Medical	13 (32.5)	27 (67.5)	--	169 (68.1)	79 (31.9)	0.015
Surgical	0	0		30 (51.7)	28 (48.3)	
Cellulitis						
No	11 (57.9)	8 (42.1)	0.001	115 (66.9)	57 (33.1)	0.261
Yes	2 (9.5)	19 (90.5)		84 (62.7)	50 (37.3)	
Local infection of skin or subcutaneous tissue						
No	13 (36.1)	23 (63.9)	0.192	192 (65.2)	103 (34.8)	0.486
Yes	0	4 (100)		6 (60.0)	4 (40.0)	
Sex						
Male	6 (27.3)	16 (32.7)	0.329	82 (67.2)	40 (32.8)	0.299
Female	7 (38.9)	11 (61.1)		117 (63.6)	67 (36.4)	
Age						
<7yrs in children, <55 yrs in adults	7 (35.0)	13 (65.0)	0.5	108 (69.7)	47 (37.3)	0.054
≥7yrs in children, ≥55 yrs in adults	6 (30.0)	14 (70.0)		91 (60.3)	60 (39.7)	

Table 3: Factors relating to extended hospital stay (≥24 hours).

Table 3 shows that injuries from arthropods, emergency admissions, and cellulitis in children, injuries from dogs or 'other mammals', emergency admissions and admissions to surgical units in adults were associated with higher rates of extended hospitalisation. Age, sex, or local infection to skin or subcutaneous tissue (and cellulitis in adults) did not relate to either children or adults. Multivariable logistic regression analysing all variables simultaneously, to adjust for each other's variable, showed that only cellulitis emerged as a significant factor associated with extended hospitalisation in children: OR = 12.42 (95% CI =1.60-96.65; P = 0.016). More factors were associated with extended hospitalisation in adults including injuries from dogs (reference group: arthropods): OR = 4.68 (2.25-9.77; P <0.001) and 'other mammals': OR = 5.10 (2.65-9.83; P <0.001), admission to surgical units (reference group: medical wards): OR = 2.04 (1.01-4.14; P = 0.047), and emergency admissions (reference group: elective admissions): OR = 9.15 (3.01-27.81; P <0.001).

Discussion

Key Findings

In this study, we observed that hospital admissions for animal-related injuries were influenced by the COVID-19 pandemic and by climate. The most striking feature to emerge was a two-year delay in the surge of adults admissions for injuries from mammals including dogs after the pandemic. To the best of our knowledge, this is first study to demonstrate that COVID-19 pandemic had a longer lasting impact on hospital admissions for animal-related injuries. Admissions for injuries from arthropods were dependent on sunnier, warmer, drier weather, and less windy weather. Cellulitis was mostly due to arthropod-related injuries in children and adults. Independent risk factors for extended hospitalisation included cellulitis in children, and included injuries from dogs and 'other mammals', emergency admissions and admissions to surgical units in adults.

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Impact of COVID-19 Pandemic

The diminished number of admissions from animal-related injuries during the COVID-19 pandemic is likely to be due to several factors leading to a reduction in exposure to animals. During lockdown periods, almost all children were kept at home [23-25]. On the other hand, adults were forced to change their working practice. Many adults started to work from home whilst others lost their jobs; only frontline workers continued to carry on working in high-risk occupations [26,27]. In adults and children, the increase in injuries from arthropods immediately after the pandemic may be due to greater exposure to arthropods that had thrived during the pandemic and subsequently became more populous. By contrast, the rise in dog-related injuries after the pandemic may partly be due to an increase in the number of dogs. It has been estimated that the recent increase of about one million dogs in the UK (from 10.1 to 11 million) was attributable to the pandemic [28], with 10% of those who did not consider to be an owner before the pandemic, and 40% of new owners reported be influenced by the pandemic [16].

Furthermore, the "pandemic puppies" had matured to adult animals to become more capable of inflicting more serious injuries. The most striking observation in the study was the emergence of a delayed onset in the surge of mammal-related injuries in the third year after the pandemic for dog-related in injuries. This observation was in line with a report suggested that dog behavioural problems often manifest between the age of 2.5 and 3.7 years [29]. Dogs raised as puppies during the pandemic began to face a new, unfamiliar environment after lockdowns were lifted. Studies have revealed that during the pandemic, many puppies did not attend training classes, exposure to visitors or had veterinary health checks [16,17]. Furthermore, many first-time pet owners were less experienced in controlling the behaviour of their dogs. Studies have shown that during the pandemic, although pets such as dogs had positive effects on mental health, they also became a burden to many owners as their health and economic situations deteriorated. This led to poor care for their dogs, leading to behavioural problems [14,30]. After the pandemic, owners began to face other issues such as new working hours which shifted away from care for their pets. Furthermore, the veterinary fees for treatment and insurance had risen to an unprecedented level after the pandemic. These factors led to rehoming of high number of pets [28]. Increased risk of injuries from mammals other than dogs may also be associated with those in close contact with humans such as horses and cows, either through leisure, sports, or occupations [31-33].

Impact of Seasonality

The observation of higher rates of arthropod-related injuries in children and adults during warmer, sunnier, and drier weather, and gentle breeze is consistent with previous studies [34]. Warmer weather is the season for breeding, maturation and migration of arthropods including insects [35]. Sunnier and drier weather, more common in summer months, encourages people to carry out more outdoor activities and for longer periods, thus increasing exposure to arthropods. The lack of correlation between mammal-related injuries and seasonality observed in this study is consistent with that from previous studies [34].

Geographical Variation in Aanimal-Related Injuries

Findings from our study are consistent with observations reported in other UK studies, i.e. the most common cause is from arthropods; followed by mammals including dogs; whilst admissions from reptile-related injuries were rare [36,37] but could be dangerous [38]. Dogs are the most common mammals to cause bite-related injuries in most western countries including the US [39], Europe [40,41] and Australia [42]. On the other hand, the types of animals causing injuries vary widely in different parts of the World. A study in Taiwan reported that admissions for mammal-related injuries were highest (65.2%), followed by insect stings (24.9%), and reptile bites (7.2%) - with dogs (54.3%), bees (12.9%), and snakes (7.0%) being the most common species [34]. Whereas in Iran, injuries were most commonly caused by dogs (69%), followed by scorpions (12.5%), mice (8.8%), and snakes (4.4%) [43], which are similar to those in Turkey, with dogs being the commonest species (67%), followed by scorpions (32%) and snakes (18%) [44]. On average, the yearly admissions for dog-related injuries of 11.4 adult cases per 100,000 of admissions for all conditions observed in this hospital is in line with national data in England [45]. However, there were very few admissions for dog-related injuries in children for any meaningful comparison.

Consequences of Animal Attacks

Our study showed injuries from dogs were rare in children, with only three cases out of 52,781 paediatric admissions over 5-years (equivalent to six cases per 100,000). All injuries were not severe, which are consistent with previous reports [34]. Although none of these cases were life-threatening, there have been national reports of deaths or life-changing injuries from dog attacks in children. A ban was introduced in February 2024 in England and Wales of certain dog breeds such as American XL bullies [46].

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It is likely that there were more people with animal-related injuries than reported in this study, since previous studies found that only a third of individuals with injuries from dogs required hospital admission [47].

Our observation that adults admitted for injuries from dogs and other mammals occurred more frequently in females than in males were in contrast to a previous study which reported more males being bitten by dogs [47]. Our observation of a similar sex distribution for admissions from arthropod-related injuries also differed from another report which found two-thirds of females were bitten by insects [37]. These differences may be due to geographical differences in populations, occupations, and climate.

A detailed analysis on extended hospitalisation was also conducted in this study, which has rarely been reported previously. Although there were proportionally more children with cellulitis, arthropod-related injuries and emergency admissions associated with extended hospitalisation, multivariable logistic regression analysing all factors simultaneously, to adjust for each other, revealed cellulitis as the only independent risk factor of extended hospitalisation. This is likely to be due to the dependence between cellulitis, arthropod-related injuries and method of admissions in children. On the other hand, there were more independent risk factors contributing to risk of extended hospitalisation in adults including injuries from dogs and 'other mammals', admission to surgical units, and emergency admissions.

Prevention

This study highlights that prevention of animal-related injuries in the warmer months is important in both children and adults. This includes the use of insect repellent outdoors on sunny days, especially when visiting places where insects and arachnids are in abundance such as forests. Education is important, particularly in families with very young children since injuries can be serious or fatal [41,48]. Caution should also be taken for older adults, especially when approaching a dog that is not known to that person, as most dogs causing the injuries are not known to the victims [47].

Limitations

The present study is limited by the relatively small sample size, particularly in children who had very low rates of mammal-related injuries, therefore we could not analyse this topic in detail, and bias could have been introduced and limited the generalisability of the findings. However, the number of animal-related injuries admitted to hospital (346 cases) reflects the entirety of admissions over the six-year period, i.e. admissions for animal-related injuries are rare compared to admissions for all admissions for general medical conditions. Analysis of seasonally-used data obtained from a local meteorological station with monthly averages over a period of 30-year data precluded identification of specific weather conditions on the day of animal-related injuries. On the other hand, the strengths of this study lie in its detailed description of the data, covering the period that included the pandemic to allow as to examine the impact of the COVID-19 pandemic on the local population.

Conclusion

Injuries sustained from animals were influenced by the pandemic and climate, possibly due to changes in the environment as well as human and animal behaviours, and their interactions. These adverse effects emerged two years after the pandemic.

Declarations

Funding statement: This study did not receive funding.
Conflicts of interest/Competing interests: The authors declare that they have no conflict of interest and have nothing to disclose.
Ethics approval: This study does not require NHS Research Ethics Committee approval since it involves secondary analysis of anonymised data. This study was conducted in accordance with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.
Consent to participate: Not applicable.
Written Consent for publication: Not applicable.
Availability of data and material: Data not available.
Code availability (software application or custom code): Not applicable.
Author contributions: TSH reviewed the topic related literature and performed the study concept and analysis design. GIJ, YJ, and JSF performed the study coordination and performed data collection. TSH wrote the first draft, analysed, interpreted the data and revised the manuscript. CHF edited the manuscript. All authors checked, interpreted results and approved the final version.

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