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Paediatric Emergency Department dog bite attendance during the COVID-19 pandemic: an audit

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Title: Paediatric Emergency Department dog bite attendance during the COVID-19 pandemic: an audit

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Abstract

Background

Responses to the COVID-19 pandemic include strict public health measures, such as national lockdowns. During these measures paediatric emergency department attendance rates have declined and the prevalence of presenting complaints has changed. This study sought to identify whether dog bite attendance rates and victim demographics changed during COVID-19 public health measures.

Methods

An audit was conducted of emergency department attendance data from a United Kingdom tertiary paediatric hospital between January 2016 and September 2020. Attendance rates for dog bites and victim demographics were explored using Chi^2 tests and multivariable Poisson regression. Monthly attendance rates in 2020 were compared against predicted attendance rates based on previous years data

Results

Dog bite attendance rates rose in conjunction with the introduction of COVID-19 public health measures and reached a peak in July 2020 (12.8 dog bites per 1000 attendances); more than four times higher than expected. By September 2020 attendance rates had returned to normal. The demographic profile of child dog bite victims remained the same. There was no overall difference in attendance rates between boys and girls. Boys had the highest attendance rates in 7-12 year olds, girls in 4-6 year olds. Girls showed higher attendance rates in the summer, whilst boys attendance rates were constant throughout the year. COVID-19 public health measures were associated with a 78% increase in attendance for boys, and an 66% increase in girls.

Conclusions

COVID-19 national public health measures were associated with an increase in paediatric emergency department dog bite attendance, and may be due to increased child exposure to dogs via 'stay at home' orders and school closures. National lockdowns are likely to continue globally throughout the COVID-19 pandemic; this is likely to result in more dog bites. Urgent public health communication and injury prevention strategies are needed to help prevent these avoidable injuries.

What is known about the subject:

- Children are frequent dog bite victims.
- Most children are bitten in the home, by a dog that they know.
- In adults, men are more likely to be bitten than women.

What this study adds:

- Emergency attendance for dog bites to children were four times higher during COVID-19 public health measures, than expected.
- The victim profile, regarding the age and sex of the child, did not change
- COVID-19 public health measures, such as lockdowns and school closures, may result in increased dog bites.

Introduction:

The COVID-19 global pandemic, caused by SARS-CoV-2 (severe acute respiratory syndrome coronavirus 2), has affected medicine and public health in a multitude of unforeseen ways. One of these was the significant reduction in patient attendance at paediatric emergency departments during COVID-19 national lockdowns.[1,2] Absolute attendance reduced between 27-72%,[2,3] though this reduction was not seen across all presenting complaints. For example, attendance for trauma has increased and decreased, dependent upon the reporting hospital.[1–3] One trauma of increasing concern is dog bites.

Dog bite hospital admission rates across England have tripled in adults between 1998 and 2018, yet remained stable in children, with a mean child annual admission rate of 14.4 dog bite hospital admissions per 100,000 population per year.[4] Both sexes have their highest admission rates in childhood, peaking between 5-14 years old for boys and 5-9 years old for girls.

The majority of dog bite injuries to children occur to the head;[5–8] 73.3% in English hospital admissions. In Canadian paediatric emergency departments, 25% of bites were classified as severe, 15% of victims were admitted, 7% needed operations, and 0.3% resulted in fatalities.[9] Children are overrepresented in fatal dog attacks; in the USA 55.6% of victims were less than 10 years old,[10] in Canada 86% were under twelve years old,[11] whilst in Europe 16% were less than 10, with 3% less than a year old.[12] United Kingdom (UK) fatality numbers are unknown. Even with excellent management of wounds, the physical and psychological consequences may be long-lasting,[13,14] with 70% of parents of dog bite victims having reported behavioural concerns in their children as a sequalae of the bite.[14]

During the COVID-19 pandemic, many public health measures directly affected children, primarily the implementation of national lockdowns, 'stay at home' orders, the restriction of socialisation outside their household unit, and the closure of schools.[15,16] Such measures resulted in children spending more time than usual at home. Previous research has demonstrated that dogs provided people and families with many positive benefits in lockdown by reducing loneliness, and improving well-being.[17] However, it is known that the majority of child dog bite victims are bitten inside the home, ranging from 41-91%,[4,8,18,19] and most dogs involved are known to the victim.[9,18] We, and others, have theorised that the increased time at home, and resultant increased contact time with a pet dog, could lead to more dog bites and a subsequent increase in dog bite attendance rates at paediatric emergency departments.[20,21] The aim of this study was to understand the impact that English COVID-19 public health measures had on emergency department dog bite attendance rates in a paediatric hospital.

Methods

An audit of emergency department records was performed at Alder Hey Children's Hospital to identify trends in attendance rates for dog bites, to explore patient demographics between the 1st of January 2016 and the 30th September 2020, and identify any impact associated with the COVID-19 public health measures. Alder Hey Children's Hospital has one of the busiest paediatric emergency departments in the UK. It primarily serves the children of Liverpool and surrounding areas, but major traumas are received from North-West England, North Wales, and the Isle of Man.

Anonymised data were collected from hospital patient electronic health records. These contain standard information regarding clinical and safeguarding aspects of the child presenting to the emergency department. The following variables were captured for all attendees of the emergency department; date of attendance, age, sex, and whether a dog bite was their reason for attendance (as a binary term). Annual and monthly attendance rates (dog bites per 1000 attendances) were calculated, for the whole audit period, with associated confidence intervals calculated using Byar's method. Monthly attendance rates were smoothed using LOESS (locally estimated scatterplot smoothing) methods.[22] Monthly attendance rates for 2020 were predicted based on monthly attendance rates of 2016-2019, using the ETS (Error, trend and seasonality) method.[23–25]

For this analysis, a binary variable ('COVID-19 Public Health Measures') was assigned to each patient to indicate whether any national COVID-19 public health measures were in place at the time of attendance; this variable was assigned the value 1 for attendances within the months March-September 2020,[15,16] and the value 0 otherwise. To compare the demographics (sex and age) of dog bite victims during and outside of COVID-19 public health measures a Chi-squared test was

performed. Age groups were defined as infants (<12 months old), toddlers (1-3 years old), early childhood (4-6 years old), middle childhood (7-12 years old), and adolescents (13-17 years old).[26]

Interrupted Poisson regression time series were performed to assess the following variables association with monthly attendances for dog bites; time (a linear term, with each unit equating to an individual month), month of the year, sex, age group, and COVID-19 public health measures. The number of dog bite victims per month was used as the numerator, whilst the dominator was the emergency department attending population. Sex specific multivariable models were created. Interaction between age and sex often occurs when analysing health care data. Thus, presenting sex stratified models provided clarity to our results, in addition to delivering clear sex dis-aggregated data as recommended by the World Health Organization.[27] Each model used attendance data for each specified sex as their dominator. A backwards stepwise process was performed to select the models with the best fit (only these will be presented). All models were checked for the presence of any interaction terms. Goodness-of-fit Chi-squared tests for Poisson models were used to assess model performance.

All statistical analyses were carried out using R language (version 3.5.3). Results were deemed statistically significant where $p<0.05$. Patients or the public were not involved in this research.

Results

Between the 1st January 2016 and the 30th September 2020, 919 individuals attended Alder Hey Children's Hospital's emergency department for a dog bite, representing an overall attendance rate of 3.33 dog bites per 1000 attendances (95% CI 3.13-3.56). There was a slight increase in annual attendance rate from 2.65 (95% CI 2.26-3.09) in 2016 to 3.19 (2.77-3.66) in 2019, followed by a sharp increase in 2020 to 5.82 (95% CI 5.04-6.69) (Fig 1).

Prior to March 2020 the mean monthly total attendance was 5035 (95% CI 4899-5171), and the mean monthly dog bite attendance was 15 cases (95% CI 14-16). The lowest monthly total number of attendances for dog bites was recorded in April 2020 (n=2056), this represents a 2.45 times reduction (Fig 2). The highest monthly dog bite attendance was in July 2020 (n=44), an almost three-fold increase (ratio: 2.93) compared to mean monthly dog bite attendance.

Monthly attendance rates prior to 2020 revealed a consistent yet fluctuating pattern of attendance rates, ranging from 1.34 dog bites per 1000 attendances to 5.65 dog bites per 1000 attendances, with a mean monthly attendance rate of 3.05 (95% CI 2.76-3.35) (Fig 3).

Attendance rate data for 2020 deviated from the projected data from May through to August, peaking in July with 12.78 dog bites per 1000 attendances (95% CI 9.41-16.99). This peak reflected a quadrupling (ratio: 4.19) of the average monthly attendance rate for dog bites.

There was no significant difference in the proportion of males and females attending based on whether they attended during COVID-19 public health measures or not (χ^2=0.17, p=0.68) (Table 1), nor was there a difference in the proportion of ages attending ((χ^2=3.92, p=0.42).

	COVID-19 Public Health Measures Absent (Jan 2019-Feb 2020)	COVID-19 Public Health Measures Present (March 2020-Sept 2020)	p value
Sex			
Male	51.9% (n=393)	53.7% (n=87)	
Female	48.1% (n=364)	46.3% (n=75)	p=0.68
Age			
Infant (<12 months)	3.6% (n=27)	1.9% (n=3)	
Toddler (1-3 years)	26.6% (n=201)	26.5% (n=43)	
Early Child (4-6 years)	21.9% (n=166)	27.2% (n=44)	
Middle Child (7-12 years)	33.4% (n=253)	33.3% (n=54)	
Adolescent (13-17 years)	14.5% (n=110)	11.1% (n=18)	p=0.42
Total	757	162	

Table 1 Demographics of paediatric dog bite victims stratified by the presence of national COVID-19 public health measures.

COVID-19 public health measures were independently associated with a 66% increase in dog bite attendance rates in females, and a 78% increase in males (Table 2).

	Univariable Analysis		Female Multivariable Model		Male Multivariable Model	
Variable	**ARR (95% CI)**	**p-value**	**ARR (95% CI)**	**p-value**	**ARR (95% CI)**	**p-value**
COVID-19 Public Health Measures (Ref=Absent)						
Present	2.29 (1.93-2.71)	<0.001	1.66 (1.18-2.32)	<0.001	1.78 (1.29-2.44)	<0.001
Time (Linear)	1.01 (1.01-1.02)	<0.001	1.00 (1.00-1.01)	0.38	1.01 (1.00-1.01)	0.03
Year (Ref=2016)						
2017	1.06 (0.85-1.32)	0.59	N/A		N/A	
2018	1.26 (1.02-1.55)	0.03	N/A		N/A	
2019	1.20 (0.98-1.48)	0.08	N/A		N/A	
2020	2.20 (1.78-2.71)	<0.001	N/A		N/A	
Month (Ref = January)						
February	1.23 (0.88-1.72)	0.23	1.69 (1.02-2.88)	0.05	0.95 (0.60-1.48)	0.81
March	0.97 (0.69-1.37)	0.87	1.27 (0.75-2.19)	0.38	0.60 (0.37-0.96)	0.04
April	1.41 (1.02-1.97)	0.04	1.66 (0.99-2.84)	0.06	1.08 (0.70-1.67)	0.73
May	1.76 (1.29-2.40)	<0.001	2.26 (1.41-3.76)	<0.01	1.10 (0.73-1.67)	0.65
June	1.57 (1.14-2.17)	<0.01	1.68 (1.01-2.86)	0.05	1.12 (0.74-1.70)	0.60
July	1.73 (1.27-2.37)	<0.001	2.05 (1.26-3.42)	<0.01	1.11 (0.74-1.69)	0.61
August	1.98 (1.45-2.72)	<0.001	2.28 (1.39-3.83)	<0.01	1.26 (0.83-1.93)	0.28
September	1.36 (0.99-1.90)	0.06	1.75 (1.06-2.96)	0.03	0.75 (0.48-1.17)	0.20
October	0.99 (0.69-1.41)	0.94	1.28 (0.73-2.27)	0.39	0.84 (0.52-1.34)	0.47
November	0.68 (0.45-1.00)	0.05	1.08 (0.60-1.93)	0.81	0.48 (0.27-0.82)	0.01
December	1.03 (0.72-1.48)	0.86	1.05 (0.57-1.91)	0.87	1.06 (0.67-1.66)	0.81
Sex (Ref=Female)						
Male	0.91 (0.80-1.03)	0.14	N/A		N/A	
Age (Ref = Toddler, 1-3 years old)						
Infant (<12 months)	0.19 (0.13-0.28)	<0.001	0.17 (0.09-0.29)	<0.001	0.21 (0.12-0.35)	<0.001
Early Childhood (4-6 years old)	1.75 (1.45-2.10)	<0.001	1.89 (1.46-2.45)	<0.001	1.53 (1.17-2.00)	<0.01
Middle Childhood (7-12 years old)	1.70 (1.44-2.01)	<0.001	1.44 (1.13-1.85)	<0.01	1.83 (1.46-2.31)	<0.001
Adolescent (13-17 years old)	1.30 (1.05-1.61)	0.01	0.94 (0.68-1.30)	0.72	1.65 (1.23-2.19)	<0.001

Table 2 – Univariable and multivariable Poisson analysis of monthly paediatric dog bite attendance rates in an emergency department (COVID-19 Public Health Measure were present March 2020 to September 2020. ARR=Attendance Rate Ratio. CI = Confidence interval)

Females had the highest dog bite attendance rates from May through to September. In contrast, male attendance rates were similar throughout the year except in March and November which displayed significantly lower rates. Female attendance rates showed similar attendance rates between toddlers and adolescents, with early and middle childhood showing the highest rates (peaking in early childhood), and infants the lowest. Male age attendance rates peaked in middle childhood. All male age groups had significantly higher rates than toddlers except infants who were significantly lower. To achieve final model fit the 'year' variable was excluded from both models. Both male and female models had good model fits with small residual differences (male model p=0.66, female model p=0.94). No interaction terms were identified.

Discussion

This study highlights that COVID-19 public health measures were associated with an increase in paediatric dog bite emergency department attendance rates, potentially due to children spending more time at home, with greater exposure to dogs. Additionally, the demographics of children at risk of dog bites have remained the same during this period. These results can be used to underpin the need for an evidence-based approach to dog bite injury prevention strategies targeted at children and their guardians during this pandemic, and future ones.

Following four years of stable monthly patterns of rates of emergency department attendance for dog bites, there was a sharp increase in monthly attendance rates between April and August 2020, an effective quadrupling. This is confirmed by a clear statistical association between the period of COVID-19 public health measures and a rise in dog bite attendances.

The national lockdown (March-May 2020),[15,16] saw a rapid reduction in overall emergency attendance levels, which reached their lowest in April. It was expected that overall attendance levels would decline as patients and parents were fearful of hospital acquired COVID-19 and were told not to seek medical aid unless absolutely necessary.[1–3] However, children continued to attend Alder Hey for dog bites, despite other reasons for attendance decreasing.

Our dog bites did not dramatically increase until May, over a month into the lockdown period. The initial stable level of dog bites during lockdown was unexpected given another study reported a rapid increase in dog bite attendance as soon as their lockdown began.[20] During the initial period, life satisfaction and happiness in adults declined, with anxiety levels raised.[28] Rates of self-harm and domestic violence also rose.[29,30] These studies highlight that in some households the normal emotional palette had been disrupted, and this could feasibly include dogs, who are viewed as family members. Dogs' routines also changed drastically during the first lockdown with 80% spending more time with children, and having less socialisation with other dogs and less exercise.[31] Dog owners reported behavioural changes in their dogs and many reported a hesitancy to walk their dog due to COVID-19 infection risks.[32] The observed time lag in attendances for bites may be due to a lag in household risk or a lag in attending hospitals.

Bite risk may not have increased immediately due to a range of reasons. It may have taken some time for dogs to exceed their tolerance threshold for behaviours directed towards them, and/or due to the accumulative effect of separate triggering experiences,[33] particularly where there was greater activity occurring within homes during lockdown. Parental supervision of their children with dogs within the home is often limited,[34] and this may have been further impacted during lockdown with parents having to juggle multiple conflicting demands on their time. In lockdown

there was also a fear of attending hospitals,[35] so it is possible that less severe dog bite injuries were managed at home.

From May through to July the number of dog bite attendances increased faster than overall attendance number, leading to a spike in dog bites per 1000 attendances. During this period, relaxation of public health restrictions and summer weather meant there was potentially more opportunity for children to be exposed to non-household dogs, providing another source of risk perhaps more absent previously. There may also have been increased exposure due to proliferation of dog adoptions and acquisition of 'pandemic puppies' as 2020 progressed.[36,37] Further, according to UK Kennel Club research, many new puppies were bought on impulse with little research.[38] Compounded by difficulty accessing professional advice due to 'emergency only' veterinary provision,[39] and closure of training classes, many dogs acquired during 2020 may have had inadequate training and socialisation, which may result in a greater likelihood to biting.

August and September saw declining attendance rates due to dog bites, returning to the normal range in September coincident with schools reopening,[15,16] and likely resulted in children spending less time at home with dogs. In a study in Colorado, dog bite attendance rates were not assessed beyond cessation of their lockdown,[20] and it is possible that, as public health measures eased attendance rates would have returned to normal as our data has.

This study found that the sex and age profile of dog bite victims remained the same during the COVID-19 public health measures, in line with available international trauma data.[1,3] Our data confirms dog bite seasonality,[4,8,19] but to the best of our knowledge, this work is the first to describe sex differences related to dog bite seasonality, with dog bites to girls increasing during the summer, but not to boys; research is needed to understand why.

Limitations

The main limitation of these data is how representative they are of the wider UK population. Alder Hey Children's Hospital is one of Europe's largest paediatric hospitals, and the community it serves has one of the largest hospital admission rates for dog bites in the country.[4] This research needs to be repeated at a national scale. For this audit, only case count and basic demographic information of the victims was captured. Further work exploring the association of COVID-19 public health measures with severity and anatomical location of the bites, and the context of the bite, is critically important if we are to understand why dog bites increased. The variable 'COVID-19 Public Health Measures' encompasses a complex range of measures varying in timing and likely impact. It is likely that multiple confounding and interacting factors led to the increase in dog bite attendance rates. It

was felt that the pragmatic decision to choose a broad definition was justified. All our hypotheses as to why dog bites rose are speculative, and more research is needed.

Conclusions

On the 5th January 2021 the UK was once again told to 'Stay at Home'; this third COVID-19 lockdown is expected to last at least two months. Lockdowns across the world will continue until public health measures are successful in bringing the COVID-19 pandemic to an end. Until that time, lockdowns and school closures are likely to be associated with a rise in paediatric dog bites. The victims who attend emergency departments probably have the most severe injuries and represent only a portion of the bitten population. There will be potentially thousands of children who receive preventable and life changing physical and psychological injuries. Urgent public health communication and education is needed to raise awareness of increased dog bite risk and promote safe interactions with dogs, thus ensuring that waves of dog bites do not follow strict COVID-19 public health measures.

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Author Contribution: JT, SM, MR, and CW conceptualised and designed the study. SM and VP collected, cleaned and anonymised the data. JT and RC designed and performed the data analysis. JT and CW drafted the initial manuscript. All authors reviewed and revised the manuscript, and approved of the final submitted manuscript.

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Patient consent for publication: Not required.

Ethics approval: The study was defined as clinical audit and as such Research Ethics Committee Review was not necessary. The audit was approved by the Alder Hey Children's NHS Foundation Trust (Audit Reference Number: 6193).

Data availability statement: Data are available on reasonable request.

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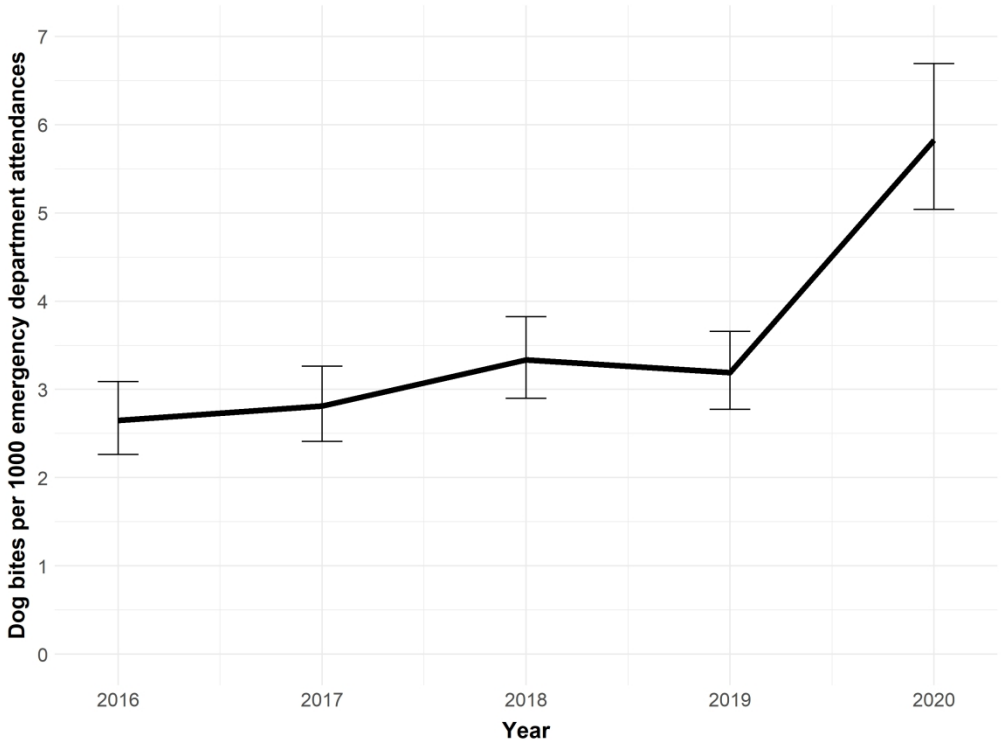
Figure Legends

Figure 1 – Annual dog bite attendance rates (cases per 1000 attendances) to a UK paediatric emergency department (2016-2020)

Figure 2 – Monthly attendance numbers, for all attendances and dog bite victims, in a UK paediatric emergency department (2016-2020). Blue line = dog bites, Red line = total attendances.

Figure 3 – Monthly dog bite attendance rates (cases per 1000 attendances) for a UK paediatric emergency department (2016-2020). Blue line = Raw data, Red line = predicted data for 2020 based on 2016-2019 data.



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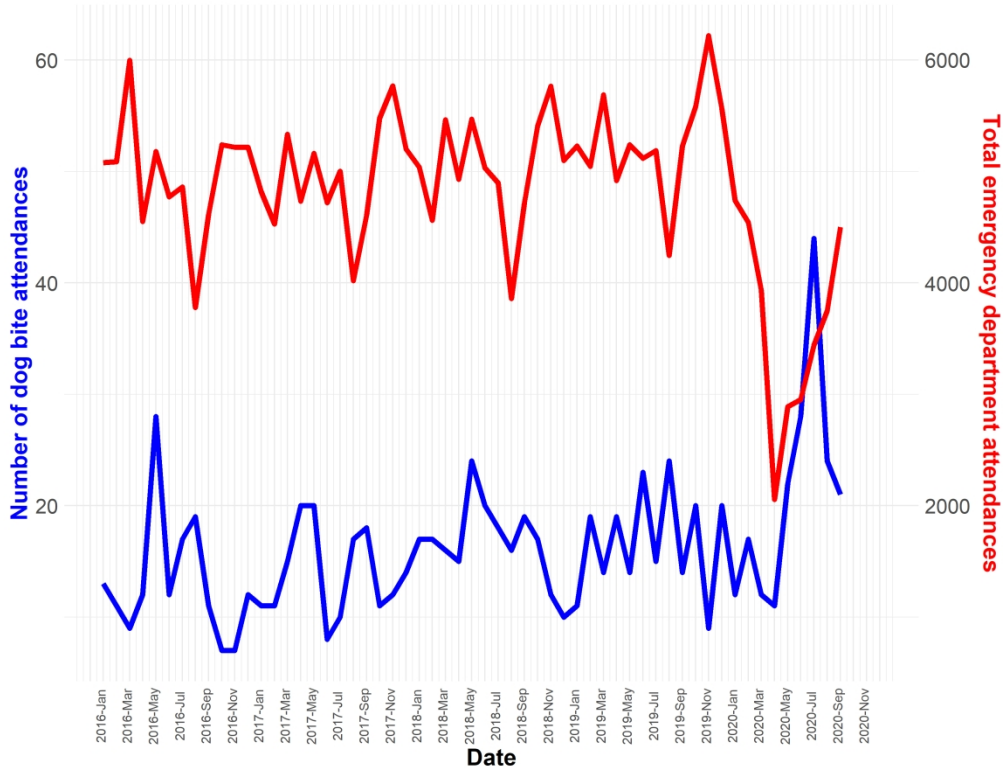

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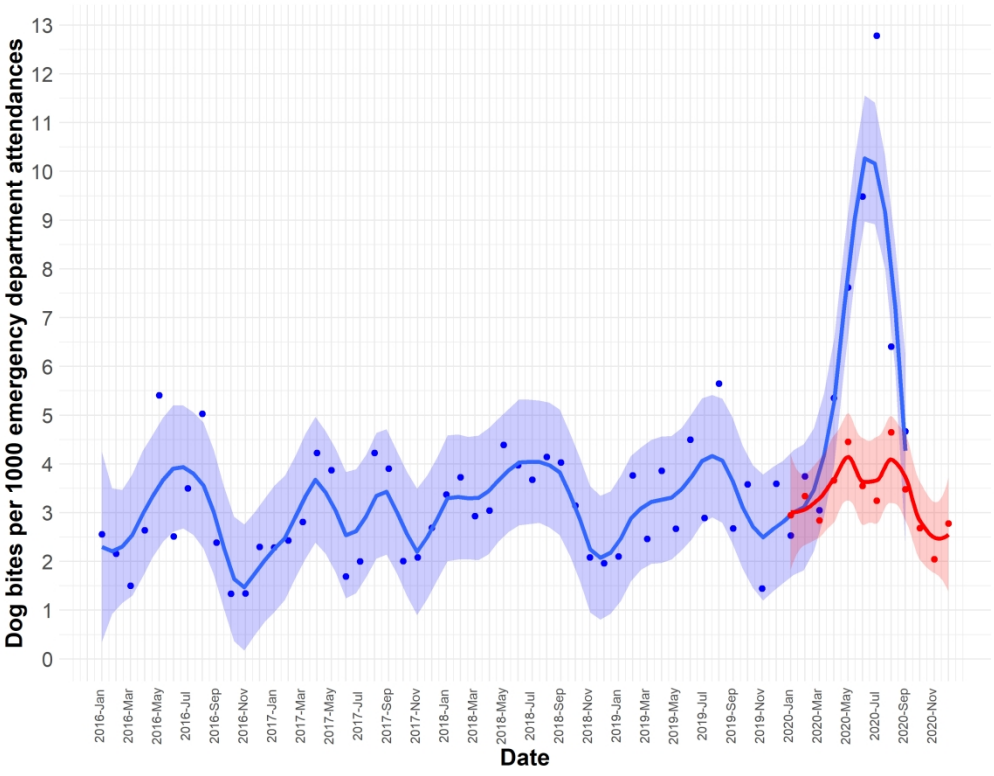

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Title: Paediatric Emergency Department dog bite attendance during the COVID-19 pandemic: an audit at a tertiary children's hospital

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Abstract

Background

Responses to the COVID-19 pandemic include strict public health measures, such as national lockdowns. During these measures paediatric emergency department attendances have declined and the prevalence of presenting complaints has changed. This study sought to identify whether dog bite attendance and victim demographics changed during COVID-19 public health measures.

Methods

An audit was conducted of emergency department attendance data from a United Kingdom tertiary paediatric hospital between January 2016 and September 2020. Dog bite attendance and victim demographics were explored using Chi^2 tests, and multivariable Poisson regression. The mean monthly percentage of attendance due to dog bites in 2020 were compared against predicted percentages based on previous years data.

Results

Dog bite attendance rose in conjunction with the introduction of COVID-19 public health measures and reached a peak in July 2020 (44 dog bites, 1.3% of all attendances were due to dog bites). This was a three-fold increase in dog bite attendance. By September 2020 attendance had returned to normal. The demographic profile of child dog bite victims remained the same. Boys had the highest attendance rates in 7-12 year olds, girls in 4-6 year olds. Girls showed higher attendance rates in the summer, whilst boys attendance rates were constant throughout the year. COVID-19 public health measures were associated with a 78% increase in attendance for boys, and an 66% increase in girls.

Conclusions

COVID-19 national public health measures were associated with an increase in paediatric emergency department dog bite attendance, and may be due to increased child exposure to dogs via 'stay at home' orders and school closures. National lockdowns are likely to continue globally throughout the COVID-19 pandemic; this is likely to result in more dog bites. Urgent public health communication and injury prevention strategies are needed to help prevent these avoidable injuries.

What is known about the subject:

- Children are frequent dog bite victims.
- Most children are bitten in the home, by a dog that they know.
- In adults, men are more likely to be bitten than women.

What this study adds:

- Emergency attendance for dog bites to children were three times higher than expected during COVID-19 public health measures, (from a monthly mean of 15 cases, to a peak of 44 cases in July 2020).
- The victim profile, regarding the age and sex of the child, did not change.
- COVID-19 public health measures, such as lockdowns and school closures, may result in increased dog bites.

Introduction:

The COVID-19 global pandemic, caused by SARS-CoV-2 (severe acute respiratory syndrome coronavirus 2), has affected medicine and public health in a multitude of unforeseen ways. One of these was the significant reduction in patient attendance at paediatric emergency departments during COVID-19 national lockdowns.[1,2] Absolute attendance reduced between 27-72%,[2,3] though this reduction was not seen across all presenting complaints. For example, attendance for trauma has increased and decreased, dependent upon the reporting hospital.[1–3] One trauma of increasing concern is dog bites.

Dog bite hospital admission rates across England have tripled in adults between 1998 and 2018, yet remained stable in children, with a mean child annual admission rate of 14.4 dog bite hospital admissions per 100,000 population per year.[4] Both sexes have their highest admission rates in childhood, peaking between 5-14 years old for boys and 5-9 years old for girls.

The majority of dog bite injuries to children occur to the head;[5–8] 73.3% in English hospital admissions. In Canadian paediatric emergency departments, 25% of bites were classified as severe, 15% of victims were admitted, 7% needed operations, and 0.3% resulted in fatalities.[9] Children are overrepresented in fatal dog attacks; in the USA 55.6% of victims were less than 10 years old,[10] in Canada 86% were under twelve years old,[11] whilst in Europe 16% were less than 10, with 3% less than a year old.[12] United Kingdom (UK) fatality numbers are unknown. Even with excellent management of wounds, the physical and psychological consequences may be long-lasting,[13,14] with 70% of parents of dog bite victims having reported behavioural concerns in their children as a sequalae of the bite.[14]

During the COVID-19 pandemic, many public health measures directly affected children, primarily the implementation of national lockdowns, 'stay at home' orders, the restriction of socialisation outside their household unit, and the closure of schools.[15,16] Such measures resulted in children spending more time than usual at home. Previous research has demonstrated that dogs provided people and families with many positive benefits in lockdown by reducing loneliness, and improving well-being.[17] However, it is known that the majority of child dog bite victims are bitten inside the home, ranging from 41-91%,[4,8,18,19] and most dogs involved are known to the victim.[9,18] We, and others, have theorised that the increased time at home, and resultant increased contact time with a pet dog, could lead to more dog bites and a subsequent increase in dog bite attendances at paediatric emergency departments.[20,21] The aim of this study was to understand the impact that English COVID-19 public health measures had on emergency department dog bite attendance in a paediatric hospital.

Methods

An audit of emergency department records was performed at Alder Hey Children's Hospital to identify trends in the number of dog bites and the percentage of attendances due to dog bites, to explore patient demographics between the 1st of January 2016 and the 30th September 2020, and identify any impact associated with the COVID-19 public health measures. Alder Hey Children's Hospital has one of the busiest paediatric emergency departments in the UK. It primarily serves the children of Liverpool and surrounding areas, but major traumas are received from North-West England, North Wales, and the Isle of Man.

Anonymised data were collected from hospital patient electronic health records. These contain standard information regarding clinical and safeguarding aspects of the child presenting to the emergency department. The following variables were captured for all attendees of the emergency department; date of attendance, age, sex, and whether a dog bite was their reason for attendance (as a binary term). Monthly dog bite attendance counts were plotted, alongside overall attendance figures. The mean monthly number of dog bites prior to, and during, the COVID-19 public health measures were compared using a Chi-squared test, and a linear trend with age further evaluated using a Chi-squared test for trend (also known as a Cochran-Armitage test for trend).

The monthly percentage of attendances due to dog bites were calculated, for the whole audit period, with associated confidence intervals calculated using Byar's method. Monthly attendance percentages were smoothed using LOESS (locally estimated scatterplot smoothing) methods.[22] Monthly attendance percentages for 2020 were predicted based on monthly data from 2016-2019, using the ETS (Error, trend and seasonality) method.[23–25]

For this analysis, a binary variable ('COVID-19 Public Health Measures') was assigned to each patient to indicate whether any national COVID-19 public health measures were in place at the time of attendance; this variable was assigned the value 1 for attendances within the months March-September 2020,[15,16] and the value 0 otherwise. To compare the demographics (sex and age) of dog bite victims during and outside of COVID-19 public health measures, Chi-squared tests were performed. Age groups were defined as infants (<12 months old), toddlers (1-3 years old), early childhood (4-6 years old), middle childhood (7-12 years old), and adolescents (13-17 years old).[26]

Interrupted Poisson regression time series were performed to assess the following variables association with monthly attendances for dog bites; time (a linear term, with each unit equating to an individual month), month of the year, sex, age group, and COVID-19 public health measures. The number of dog bite victims per month was used as the numerator, whilst the dominator was the emergency department attending population. Sex specific multivariable models were created. Interaction between age and sex often occurs when analysing health care data. Thus, presenting sex stratified models provided clarity to our results, in addition to delivering clear sex dis-aggregated data as recommended by the World Health Organization.[27] Each model used attendance data for each specified sex as their dominator. Substantive knowledge was used to select the models with the best fit (only these will be presented). All models were checked for the presence of any interaction terms. Goodness-of-fit Chi-squared tests for Poisson models were used to assess model performance.

All statistical analyses were carried out using R language (version 3.5.3). Results were deemed statistically significant where $p<0.05$. Patients or the public were not involved in this research.

Results

Between the 1st January 2016 and the 30th September 2020, 919 individuals attended Alder Hey Children's Hospital's emergency department for a dog bite; over the study period 0.33% (95% CI 0.31-0.36) of all attendances were due to dog bites.

Prior to March 2020 the mean monthly total emergency department attendance was 5035 (95% CI 4899-5171). The lowest monthly total number of attendances was recorded in April 2020 (n=2056), this represents a 2.45 times reduction (Fig 1). The mean monthly dog bite attendance was 15 cases (95% CI 14-16), the highest monthly dog bite attendance was in July 2020 (n=44), an almost three-fold increase (ratio: 2.93) compared to mean monthly dog bite attendance. Overall, there was a significant increase in the mean monthly number of dog bite attendances from before the COVID-19 public health measures and during them (Table 1).

	COVID-19 Public Health Measures Absent (Jan 2016-Feb 2020)	COVID-19 Public Health Measures Present (March 2020-Sept 2020)	p value
Sex			p=0.68
Male	51.9% (n=393)	53.7% (n=87)	
Female	48.1% (n=364)	46.3% (n=75)	
Age			χ^2 p=0.42 trend χ^2 p = 0.71
Infant (<12 months)	3.6% (n=27)	1.9% (n=3)	
Toddler (1-3 years)	26.6% (n=201)	26.5% (n=43)	
Early Child (4-6 years)	21.9% (n=166)	27.2% (n=44)	
Middle Child (7-12 years)	33.4% (n=253)	33.3% (n=54)	
Adolescent (13-17 years)	14.5% (n=110)	11.1% (n=18)	
Total	757	162	
Mean number of dog bites per month (95% CI)	15.14 (14.09-16.25)	23.14 (19.78-26.92)	p<0.001

Table 1 Demographics of paediatric dog bite victims stratified by the presence of national COVID-19 public health measures.

There was no significant difference in the proportion of males and females attending based on whether they attended during COVID-19 public health measures or not (χ^2=0.17, p=0.68), nor was there a difference in the proportion of ages attending (χ^2=3.92, p=0.42) or evidence of a linear effect of age (Trend χ^2 = 0.13, p=0.71)

The monthly percentage of attendances due to dog bites prior to 2020 revealed a consistent yet fluctuating pattern, ranging from 0.13% to 0.57%, with a mean monthly percentage of 0.31 (95% CI 0.28-0.34) (Fig 2). The monthly percentages in 2020 deviated from the projected data from May through to August, peaking in July with 1.28% (95% CI 0.94-1.70) of all attendances due to dog bites. This peak reflected a quadrupling (ratio: 4.13) of the average monthly percentage of attendances due to dog bites.

COVID-19 public health measures were independently associated with a 66% increase in dog bite attendance rates in females, and a 78% increase in males (Table 2).

	Univariable Analysis		Female Multivariable Model		Male Multivariable Model	
Variable	**ARR (95% CI)**	**p-value**	**ARR (95% CI)**	**p-value**	**ARR (95% CI)**	**p-value**
COVID-19 Public Health Measures (Ref=Absent)						
Present	2.29 (1.93-2.71)	<0.001	1.66 (1.18-2.32)	<0.001	1.78 (1.29-2.44)	<0.001
Time (Linear)	1.01 (1.01-1.02)	<0.001	1.00 (1.00-1.01)	0.38	1.01 (1.00-1.01)	0.03
Year (Ref=2016)						
2017	1.06 (0.85-1.32)	0.59	N/A		N/A	
2018	1.26 (1.02-1.55)	0.03	N/A		N/A	
2019	1.20 (0.98-1.48)	0.08	N/A		N/A	
2020	2.20 (1.78-2.71)	<0.001	N/A		N/A	
Month (Ref = January)						
February	1.23 (0.88-1.72)	0.23	1.69 (1.02-2.88)	0.05	0.95 (0.60-1.48)	0.81
March	0.97 (0.69-1.37)	0.87	1.27 (0.75-2.19)	0.38	0.60 (0.37-0.96)	0.04
April	1.41 (1.02-1.97)	0.04	1.66 (0.99-2.84)	0.06	1.08 (0.70-1.67)	0.73
May	1.76 (1.29-2.40)	<0.001	2.26 (1.41-3.76)	<0.01	1.10 (0.73-1.67)	0.65
June	1.57 (1.14-2.17)	<0.01	1.68 (1.01-2.86)	0.05	1.12 (0.74-1.70)	0.60
July	1.73 (1.27-2.37)	<0.001	2.05 (1.26-3.42)	<0.01	1.11 (0.74-1.69)	0.61
August	1.98 (1.45-2.72)	<0.001	2.28 (1.39-3.83)	<0.01	1.26 (0.83-1.93)	0.28
September	1.36 (0.99-1.90)	0.06	1.75 (1.06-2.96)	0.03	0.75 (0.48-1.17)	0.20
October	0.99 (0.69-1.41)	0.94	1.28 (0.73-2.27)	0.39	0.84 (0.52-1.34)	0.47
November	0.68 (0.45-1.00)	0.05	1.08 (0.60-1.93)	0.81	0.48 (0.27-0.82)	0.01
December	1.03 (0.72-1.48)	0.86	1.05 (0.57-1.91)	0.87	1.06 (0.67-1.66)	0.81
Sex (Ref=Female)						
Male	0.91 (0.80-1.03)	0.14	N/A		N/A	
Age (Ref = Toddler, 1-3 years old)						
Infant (<12 months)	0.19 (0.13-0.28)	<0.001	0.17 (0.09-0.29)	<0.001	0.21 (0.12-0.35)	<0.001
Early Childhood (4-6 years old)	1.75 (1.45-2.10)	<0.001	1.89 (1.46-2.45)	<0.001	1.53 (1.17-2.00)	<0.01
Middle Childhood (7-12 years old)	1.70 (1.44-2.01)	<0.001	1.44 (1.13-1.85)	<0.01	1.83 (1.46-2.31)	<0.001
Adolescent (13-17 years old)	1.30 (1.05-1.61)	0.01	0.94 (0.68-1.30)	0.72	1.65 (1.23-2.19)	<0.001

Table 2 – Univariable and multivariable Poisson analysis of monthly paediatric dog bite attendance rates in an emergency department (COVID-19 Public Health Measure were present March 2020 to September 2020. ARR=Attendance Rate Ratio. CI = Confidence interval)

Females had the highest dog bite attendance rates from May through to September. In contrast, male attendance rates were similar throughout the year except in March and November which displayed significantly lower rates. Female attendance rates showed similar attendance rates between toddlers and adolescents, with early and middle childhood showing the highest rates (peaking in early childhood), and infants the lowest. Male age attendance rates peaked in middle childhood. All male age groups had significantly higher rates than toddlers except infants who were significantly lower. To achieve final model fit the 'year' variable was excluded from both models.

Both male and female models had good model fits with small residual differences (male model p=0.66, female model p=0.94). No interaction terms were identified.

Discussion

This study highlights that COVID-19 public health measures were associated with an increase in the number paediatric dog bite emergency department attendances, potentially due to children spending more time at home, with greater exposure to dogs. Additionally, the demographics of children at risk of dog bites have remained the same during this period. These results can be used to underpin the need for an evidence-based approach to dog bite injury prevention strategies targeted at children and their guardians during this pandemic, and future ones.

Following four years of stable monthly patterns dog bite attendance, there was a sharp increase in dog bites and attendance percentage between April and July 2020. An effective tripling in dog bite attendances, and quadrupling in percentage of attendances. This is confirmed by a clear statistical association between the period of COVID-19 public health measures and a rise in dog bite attendances.

The national lockdown (March-May 2020),[15,16] saw a rapid reduction in overall emergency attendance levels, which reached their lowest in April. It was expected that overall attendance levels would decline as patients and parents were fearful of hospital acquired COVID-19 and were told not to seek medical aid unless absolutely necessary.[1–3] However, children continued to attend Alder Hey for dog bites, with no clear decrease in attendance, despite overall attendance numbers dramatically decreasing (Fig 1).

Dog bites numbers did not dramatically increase until May, over a month into the lockdown period. The initial stable level of dog bites during lockdown was unexpected given another study reported a rapid increase in dog bite attendance as soon as their lockdown began.[20] During the initial period, life satisfaction and happiness in adults declined, with anxiety levels raised.[28] Rates of self-harm and domestic violence also rose.[29,30] These studies highlight that in some households the normal emotional palette had been disrupted, and this could feasibly include dogs, who are viewed as family members. Dogs' routines also changed drastically during the first lockdown with 80% spending more time with children, and having less socialisation with other dogs and less exercise.[31] Dog owners reported behavioural changes in their dogs and many reported a hesitancy to walk their dog due to COVID-19 infection risks.[32] The observed time lag in attendances for bites may be due to a lag in household risk or a lag in attending hospitals.

Bite risk may not have increased immediately due to a range of reasons. It may have taken some time for dogs to exceed their tolerance threshold for behaviours directed towards them, and/or due to the accumulative effect of separate triggering experiences,[33] particularly where there was greater activity occurring within homes during lockdown. Parental supervision of their children with dogs within the home is often limited,[34] and this may have been further impacted during lockdown with parents having to juggle multiple conflicting demands on their time. In lockdown there was also a fear of attending hospitals,[35] so it is possible that less severe dog bite injuries were managed at home.

From May through to July the number of dog bite attendances increased faster than overall attendance number, leading to a higher percentage of attendances being due to dog bites. During this period, relaxation of public health restrictions and summer weather meant there was potentially more opportunity for children to be exposed to non-household dogs, providing another source of risk perhaps more absent previously. There may also have been increased exposure due to proliferation of dog adoptions and acquisition of 'pandemic puppies' as 2020 progressed.[36,37] Further, according to UK Kennel Club research, many new puppies were bought on impulse with little research.[38] Compounded by difficulty accessing professional advice due to 'emergency only' veterinary provision,[39] and closure of training classes, many dogs acquired during 2020 may have had inadequate training and socialisation, which may result in a greater likelihood to biting.

August and September saw declining dog bite attendances and the percentage of attendances due to dog bites lowered, both measures returned to the normal range in September coincident with schools reopening,[15,16] and likely resulted in children spending less time at home with dogs. In a study in Colorado, dog bite attendance numbers were not assessed beyond cessation of their lockdown,[20] and it is possible that, as public health measures eased attendance rates would have returned to normal as our data has.

This study found that the sex and age profile of dog bite victims remained the same during the COVID-19 public health measures, in line with available international trauma data.[1,3] Our data confirms dog bite seasonality,[4,8,19] but to the best of our knowledge, this work is the first to describe sex differences related to dog bite seasonality, with dog bites to girls increasing during the summer, but not to boys; research is needed to understand why.

Limitations

The main limitation of these data is how representative they are of the wider UK population. Alder Hey Children's Hospital is one of Europe's largest paediatric hospitals, and the community it serves has one of the largest hospital admission rates for dog bites in the country.[4] This research needs to

be repeated at a national scale. For this audit, only case count and basic demographic information of the victims was captured. Further work exploring the association of COVID-19 public health measures with severity and anatomical location of the bites, and the context of the bite, is critically important if we are to understand why dog bites increased. The variable 'COVID-19 Public Health Measures' encompasses a complex range of measures varying in timing and likely impact. It is likely that multiple confounding and interacting factors led to the increase in dog bite attendance rates. It was felt that the pragmatic decision to choose a broad definition was justified. All our hypotheses as to why dog bites rose are speculative, and more research is needed.

Conclusions

On the 5th January 2021 the UK was once again told to 'Stay at Home'; this third COVID-19 lockdown is expected to last at least two months. Lockdowns across the world will continue until public health measures are successful in bringing the COVID-19 pandemic to an end. Until that time, lockdowns and school closures are likely to be associated with a rise in paediatric dog bites. The victims who attend emergency departments probably have the most severe injuries and represent only a portion of the bitten population. There will be potentially thousands of children who receive preventable and life changing physical and psychological injuries. Urgent public health communication and education is needed to raise awareness of increased dog bite risk and promote safe interactions with dogs, thus ensuring that waves of dog bites do not follow strict COVID-19 public health measures.

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Patient and public involvement: Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication: Not required.

Ethics approval: The study was defined as clinical audit and as such Research Ethics Committee Review was not necessary. The audit was approved by the Alder Hey Children's NHS Foundation Trust (Audit Reference Number: 6193).

Data availability statement: Data are available on reasonable request.

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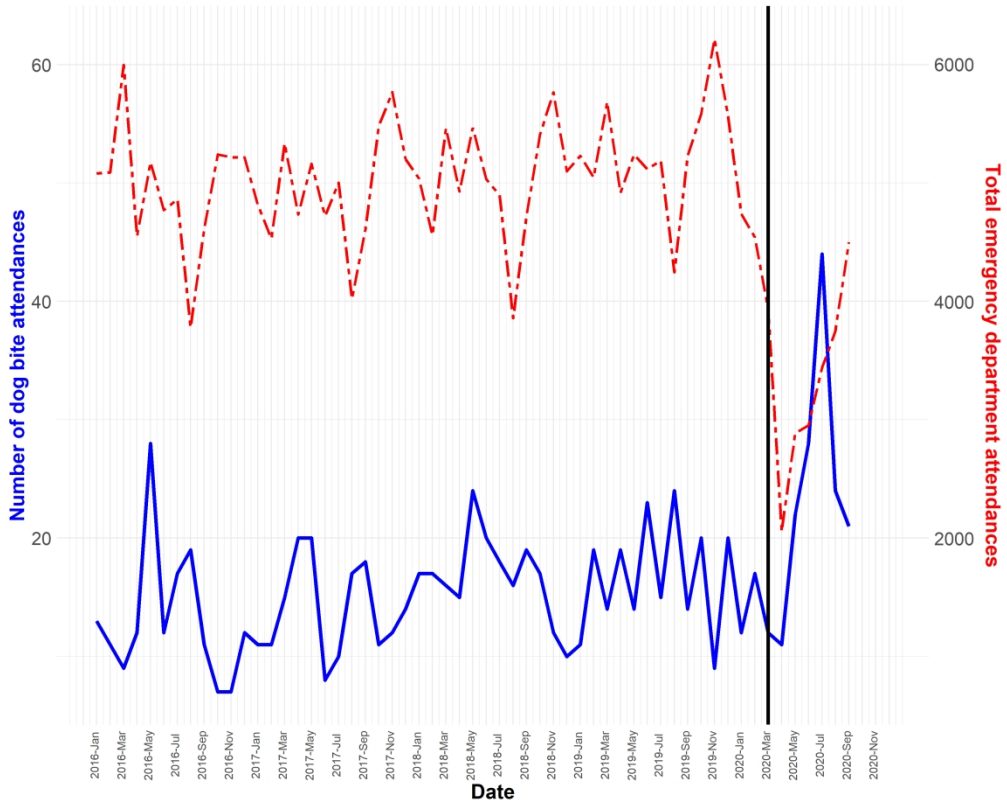
Figure Legends

Figure 1 – Monthly dog bite attendance and overall emergency department attendance, in a UK paediatric hospital (2016-2020). Blue line, and left-hand axis = dog bite attendance. Red dashed line, and right-hand axis = total emergency department attendance. Vertical black line = Start of COVID-19 public health measures

Figure 2 – Percentage of monthly emergency department attendances due to dog bites for a UK paediatric hospital (2016-2020). Blue line = Raw data, Red line = predicted data for 2020 based on 2016-2019 data. Vertical black line = Start of COVID-19 public health measures



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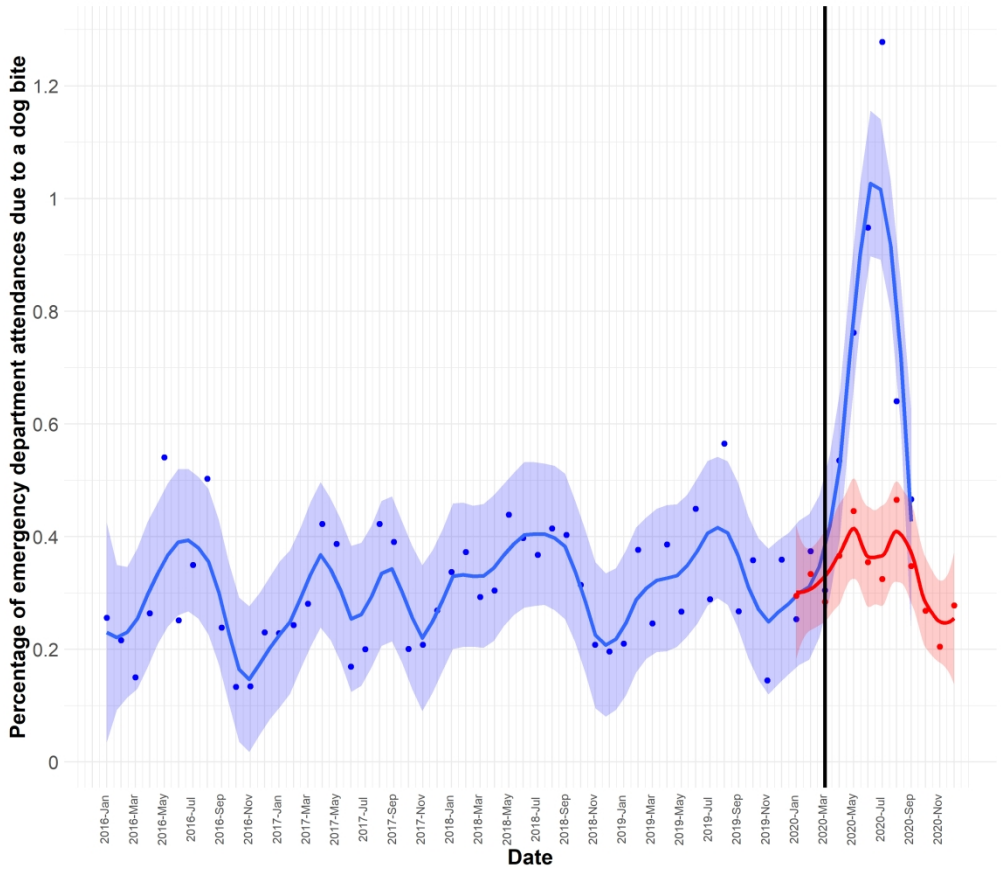

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