'Battered pets': non-accidental physical injuries found in dogs and cats

Records of 243 cases of non-accidental injury (NAI) in dogs, and 182 cases in cats, submitted by a sample of small animal practitioners in the UK, revealed a wide range of injuries. These included bruises, fractures, repetitive injuries, burns and scalds, stab and incised wounds, poisoning, asphyxiation and drowning (which showed remarkable similarities to NAI in children), as well as sexual abuse and injuries specifically caused by firearms. Traumatic skeletal injuries in the dogs were more commonly found in the anterior part of the skeleton, in comparison with those resulting from road traffic accidents. Young male dogs and young cats were particularly at risk of NAI. A moderately increased risk was identified in the Staffordshire bull terrier, cross-breed dogs and the domestic shorthaired cat, whereas the Labrador retriever showed a decreased risk. No single injury or group of injuries, when divorced from the circumstances surrounding a suspect case, could be considered to indicate, conclusively, NAI. Repetitive injuries, however, were highly suggestive of NAI.

H. M. C. MUNRO*† AND
M. V. THRUSFIELD*

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*Department of Veterinary Clinical Studies, University of Edinburgh, Royal (Dick) School of Veterinary Studies, Easter Bush Veterinary Centre, Easter Bush, Roslin, Midlothian EH25 9RG

†Department of Veterinary Pathology, University of Edinburgh, Royal (Dick) School of Veterinary Studies, Summerhall, Edinburgh EH9 1QH

INTRODUCTION

This is the second in a series of papers describing a study of veterinarians' experience of physical abuse (non-accidental injury, NAI) of companion animals (primarily dogs and cats) – so-called 'battered pets'. The first part of the study described the features that raised suspicion, or allowed recognition, of NAI (Munro and Thrusfield 2001). One of these features, summarised in that paper, was the type of injury involved. The second part of the study, described here, details *all* the injuries that were reported in the dog and cat, with the exception of sexual abuse and firearms injuries; these are conventionally categorised separately from NAI, and are therefore the subjects of future publications. This part of the study also comments on those injuries considered to be of particular importance, drawing parallels with NAI in children. Additionally, the age, gender and breed profiles of suspect cases are explored.

Background

Study of the evolution of recognition of injuries associated with NAI in children is both instructive and rewarding in the context of NAI in companion animals. Until the publication of the landmark paper, 'The battered-child syndrome' (Kempe and others 1962), NAI was simply not acknowledged by the medical profession, despite mounting published evidence (Lynch 1985). However, as Gillham (1994) notes, 'The scale and speed of the popular and professional response to this paper were remarkable, particularly in the United States', and a rapid expansion of research on child abuse followed.

Deliberate physical injury of children is now accepted as a fact, and the extensive information available on the categories of injury provides useful guidance when studying NAI in the dog and cat because, unsurprisingly, the injuries inflicted on these animals fall into a similar classification. The physical actions of violence are the same, after all, whether the victim is animal or human. This is an area where the call for 'one medicine' could not be more appropriate (Anon. 1999).

Certain forms of injury are particularly associated with NAI in children, and some are virtually diagnostic. The latter include fingertip bruising (especially where it is multiple), cigarette burns and lash marks. In addition, torn lingual frenula, unexplained subdural haematomata, and retinal haemorrhages are highly suggestive (Speight 1997). It was therefore postulated that this study, involving a sample of small animal practitioners, might highlight injuries that fell into such 'highly suggestive' or 'virtually diagnostic' groups in the dog and cat, or that a pattern, or patterns, of injuries might emerge.

MATERIALS AND METHODS

Sampling of veterinarians

A full account of the sampling of the small animal veterinarians who participated in the study, and the structure of

the questionnaire that was supplied to them, is given by Munro and Thrusfield (2001). Briefly, an anonymous questionnaire, soliciting details of veterinarians' perceptions of NAI, was distributed to a sample of 1000 veterinarians randomly selected from a list of members of the British Small Animal Veterinary Association resident in the UK. The four sections of the questionnaire recorded information on: (1) acknowledgement and recognition of NAI; (2) individual cases (species, breed, age, gender, reasons for suspicion/recognition, nature of injuries, and outcome to the animal); (3) experience of putative characteristic features (eg, history inconsistent with injury); and (4) any salient comments. Data were stored on a custom-built database, using Access 97 (Microsoft, Redmond, WA).

Characteristics of injuries

Retaining, as far as possible, the terms used by respondents, the injuries recorded in the questionnaire were grouped according to a child NAI classification scheme (Hobbs and others 1999a), modified to encompass veterinary lesions, into:

- superficial lesions (including eyes);
- deeper lesions;
- fractures/other locomotor findings;
- internal thoracoabdominal lesions;
- intracranial/spinal conditions;
- tail lesions;
- miscellaneous findings (including administration of drugs/poisons);
- behavioural findings.

Many animals suffered more than one injury, involving a variety of sites of the body. Consequently, the number of times findings were reported in each of the above groups (*not* number of animals) was tabulated.

Classification of lacerations (split wounds), incised wounds (cuts) and stab wounds followed standard forensic terminology (Gee and Watson 1989a). The skull was defined according to Getty (1975). Accordingly, no differentiation between cranial and facial (including mandibular) regions was made.

Table 1. Superficial injuries and signs of non-accidental injury (NAI) in 217 dogs

Location	Number of occasions recorded
Head/neck	
Bruising	10
Swelling	7
Incised wounds	6
Grazes/abrasions	4
Burns/scalds*	3
Lacerations	3
Elastic band constriction	3
Collar wound (constriction)	1
Head injury (unspecified)	1
Stab wound(s)	1
Eyes	
Scleral/conjunctival haemorrhage†	14
Enucleation/puncture/rupture/loss	5
Swelling around eyes	4
Intraocular haemorrhage†	3
Anisocoria/pupils fixed/dilated	3
Eyelid oedema (strangulation)	2
Bruising	2
Burns‡	2
Blepharospasm, with keratitis	1
Eyelid abrasions	1
Thorax	
Bruising	14
Stab wounds	8
Burns/scalds§	8
Incised wounds	7
Linear lacerations (on back)	2
Footprint visible	1
Rectangular piece of skin missing	1
Abdomen	
Bruising	14
Burns/scalds¶	5
Abdominal pain	3
Lacerations	2
Incised wounds	2
Stab wounds	1
Limbs	
Bruising	6
Grazes/abrasions	4
Burns/scalds	3
Incised wounds	3
Oedema	2
Stab wound	2
Scratches, medial tibia, bilateral	1
Swollen	1
Feet	
Burns**	2
Pads excoriated	2
Broken nails, with scuffed pads	1
Generalised	
Multiple puncture wounds (industrial staple gun)	1
Miscellaneous	
Strangulation/hanging††	2
Burns/scalds, unspecified area	1
Incised wound, unspecified area	1
Ocular/skin trauma specific pattern, plus 'suffocation'	1
Shoe tread-marks, on 'bottom'	1

*Includes chemical burns (×1)
†Includes strangulation (×1)
‡Includes chemical burns (×1)
§Includes cigarette burns (×2)
¶Includes cigarette burns (×1)
**Chemical burns (×1), suspected cigarette burns (×1)
††First described as 'strangulation marks' on the neck, and second as 'hanged from a tree', with no further detail given

Table 2. Deeper injuries and signs of NAI in 217 dogs

Location	Number of occasions recorded
Mouth	
Teeth	
Fracture	2
Tooth almost knocked from socket	1
Gums	
Bleeding	1
Bruising	1
Chemical burns	1
Incised wounds, tongue, gums	1
Lips	
Bruising	1
Oedema (strangulation)*	1
Tongue	
Swelling (strangulation)*	1
Neck	
Crush injury, trachea (strangulation)*	1
Laryngeal oedema (strangulation)*	1
Fracture of hyoids (strangulation)*	1
Swollen and oedematous (strangulation)†	1
Head	
Subcutaneous/muscle bruising	2
Mandibular swelling	1
Thorax	
Axillary haematoma	1
Abdomen	
Bruising, lumbar muscles	1
Lumbar muscles	
Stab wound	1
Limbs	
Haematoma, hindlimb	1

*These findings were all present in one dog, who also had eyelid oedema and conjunctival/intraocular haemorrhage (Table 1)
†This finding, plus eyelid oedema (Table 1), was present in a second dog

Table 3. Fractures and locomotor injuries and signs of NAI in 217 dogs

Location	Number of occasions recorded
Head/neck	
Skull fracture*	21
Thorax	
Fractured ribs	20
Fractured thoracic/lumbar vertebrae	3
Limbs/pelvis	
Fractures	
Femur	26
Humerus	8
Tibia	6
Elbow	2
Hock	2
Metacarpus	2
Carpus	1
Tibia/fibula	1
Pelvis (acetabulum)	1
Scapula	1
Old fractures	
Radius/ulna	3
Rib	3
Tibia	2
Unspecified semi-healed fractures	1
Unspecified fractures	
Limbs	6
Forelimb(s)	3
Forelimb crush injuries (tied to railway)	1
Hindlimbs	1
Foot	1
Multiple fractures, different ages	1
Other locomotor injuries	
Lame	4
Carpal damage/subluxation	3
Elastic band, left forelimb	2
Severe gait abnormality/stiff gait	2
Stifle ligament injury	1
Unspecified limb injury	1

*Includes a litter of five puppies with crushed skulls; counted as one case

Table 4. Internal thoracoabdominal injuries and signs of NAI in 217 dogs

Location	Number of occasions recorded
Thorax	
Pneumothorax	5
Intrapulmonary haemorrhage	2
Diaphragmatic hernia/ruptured mediastinum	1
Haemothorax	1
Abdomen	
Spleen rupture	4
Liver rupture	4
Bladder rupture	3
Haematuria	3
Kidney rupture/retroperitoneal bruising	2
Haemorrhage, abdomen	1
Mesenteric haemorrhage/ strangulated bowel	1
Stab wound	1

Statistical analysis

The age distribution of cases (under two years versus over two years of age), in pets in which age was recorded, was compared with the age distribution of the UK general canine and feline populations (which was recorded in two-yearly intervals) (Thrusfield 1989), using the 2*I*-test, with the distribution approximated by the χ^2 distribution (Sokal and Rohlf 1995). The gender distribution of cases was similarly compared. Results were interpreted at the 5 per cent level of statistical significance.

Breed-specific risk of NAI was assessed by comparing the breed-specific frequency of the cases in which breed was documented with the breed profile of a control population comprising approximately 21,000 dogs and 7000 cats recorded in the primary-care database of the University of Edinburgh's veterinary school small animal clinic (Stone and Thrusfield 1989). Contingency tables were constructed for the crude relationships between NAI and breed of dog. Associations were identified using Fisher's exact two-tailed test (Sokal and Rohlf 1995), interpreted at the 5 per cent level of significance. The magnitude of the association was estimated by the exposure odds ratio (Thrusfield 1997). Exact 95 per cent confidence intervals for the odds ratios were calculated by a test-based method (Fisher 1962). The potential confounding effects of age and gender were controlled by computing conditional maximum likelihood estimates of the summary (ie, adjusted) odds ratio (Gart 1970) with their exact 95 per cent confidence intervals (Mehta and others 1985), in a stratified analysis, for those breeds in which the significance level in the crude analysis was less than 0·25. The validity of the summary measure was indicated by an exact test for homogeneity of the stratum-specific odds ratios (Zelen 1971), interpreted at the 5 per cent level. Cases lacking details of breed, age and gender were excluded from the stratified analysis ('complete-subject analysis'; Rothman and Greenland 1998). There were insufficient data to repeat this procedure for cats.

Analyses were conducted using the PEPI v.3.*: pre-release (Abramson & Gahlinger/ USD, Stone Mountain, GA) and StatXact v.4.0.1 (CYTEL Software Corporation, Cambridge, MA) statistical packages.

RESULTS

Questionnaires were returned by 404 respondents: a response rate of 40·4 per cent.

Injuries were reported in individual cases in 225 dogs and 168 cats (section 2 of the questionnaire). Details of individual breeds were recorded for 177 dogs and 99 cats; age was recorded for 199 dogs and 132 cats; and the gender of animals was documented for 194 dogs and 122 cats. Information on breed, age and gender was available for 172 dogs and 87 cats.

A further 48 cases (18 dogs, 14 cats, one rabbit and 15 unspecified species) were recorded in section 3 of the questionnaire, which was devoted to experience of putative characteristic features, and in section 4, containing free-text comments. These cases contained insufficient information for inclusion in the statistical analysis. However, the injuries recorded in cases in these two sections were included in the tables of injuries.

Types of injury

Non-accidental injury (excluding sexual abuse and firearms injuries) was reported in 217 dogs and 121 cats.

Tables 1 to 5 and 6 to10 list the injuries recorded in the dog and cat, respectively.

Table 5. Other injuries and signs of NAI in 217 dogs

Location	Number of occasions recorded
Intracranial/spinal conditions	
Comatose/loss of consciousness	2
Paraplegia	2
Brain damage, with collapse	1
Concussion	1
Epidural haemorrhage	1
Haemorrhage from ears	1
Subdural haematoma	1
Tail lesions	
Tip amputated (by garden secateurs)	1
Fracture (owner wanted docked puppy)	1
Miscellaneous	
Given drug/poison*	9
Generalised bruising/wounds	3
Non-sexual trauma, male genitalia†	3
Emaciated/thin	2
Microwave injuries‡	2
Tumble-drier injuries (not specified)	1
Behavioural signs	
Depression/dullness	3
'Psychological damage'	1
'Very timid with humans'	1

*Described as: cannabis (× 2); LSD; heroin (injected); amphetamine; 'hallucinogenic drug'; 'signs of toxicity'; poison (× 2). One of the two 'poison' reports was also recorded by the respondent to involve Munchausen syndrome by proxy abuse (animal *and* child)
†Injuries incurred during kicking/beating
‡Two cases reported here: one survived (burns to ears, toes and tail); one reported only as a death, and injuries not recorded

Table 6. Superficial injuries and signs of NAI in 121 cats

Location	Number of occasions recorded
Head/neck	
Epistaxis	8
Burns/scalds*	3
Bruising	3
Swelling	3
Elastic band constriction	1
Head trauma	1
Grazes/abrasions	1
Laceration	1
'Multiple injuries'	1
Eyes	
Scleral/conjunctival haemorrhage	7
Conjunctivitis†	1
'Bloodshot eyes/conjunctivae'	1
Intraocular haemorrhage	1
'Ocular contusion'/blepharospasm	1
Blindness	2
Prolapse	2
Pupils dilated	2
Anisocoria/'swollen'	1
Hyphaema	1
Pupils constricted	1
Thorax	
Burns/scalds†	4
Bruising	4
Abdominal/inguinal	
Bruising	9
Stab wound	1
Suspected burns	1
Limbs	
Burns/scalds	3
Bruising	1
Elastic band constriction	1
Grazes/abrasions	1
Pressure sores (baling twine)	1
Feet	
Suspected avulsion of claws	2
Generalised findings	
Bruising	4
Scalding	1

*Includes cigarette burn (×1); caustic chemical burn (×1)
†Associated with multiple burns
‡Includes caustic chemical burn (×1)

Table 7. Deeper injuries and signs of NAI in 121 cats

Location	Number of occasions recorded
Mouth	
Teeth (broken/damaged)	3
Lip (avulsion of lower)	2
Tongue (avulsion of one-third)	1
Bruising	1
Head	
Decapitated	1
Haematoma, top of head	1
Abdomen	
Abdominal/inguinal muscle rupture*	4
Limbs	
Bilateral gluteal muscle tearing ('swinging a cat')	1

*One respondent reported details of one case, but also noted having seen two other similar cases. Kicking suspected; counted as one report

Table 8. Fractures and locomotor injuries and signs of NAI in 121 cats

Location	Number of occasions recorded
Head/neck	
Skull fracture*	17
Dislocation, jaw	1
Thorax	
Fractured ribs	3
Displacement of sternebrae	1
Limbs/pelvis	
Fractures	
Femur	14
Pelvis	5
Humerus	3
Radius/ulna	2
Tibia (one case bilateral)	2
Metatarsus	1
Unspecified fractures	
Limbs	5
Forelimbs†	3
Hindlimbs	2
Four or more episodes of fractures	2
Multiple fractures	1
Locomotor injuries	
Stifle ligament injury	2
Subluxation, right hind	1
Forelimbs amputated, mid-humerus	1
Lame	1
Pelvic damage	1
Stiff and bruised (thrown out of third floor window)	1

*Includes a litter of nine kittens with fractured skulls; counted as one case
†One case involved two kittens; counted as one case

Tables 11 and 12 document cases (16 dogs and 13 cats, respectively) in which repetitive injury was a particular feature. Table 13 details five dogs in which respondents stated that the actual age of injuries caused suspicion.

Traumatic injuries whose characteristics might pose a problem in differentiating between NAI and a road traffic accident (RTA) – that is, excluding such clearly identifiable intentional insults as injuries caused by firearms and burns and scalds – were recorded in 147 dogs and 89 cats.

Nature of the acts of deliberate injury

The actual nature of the acts of violence that resulted in the injuries listed in Tables 1 to 13 was not supplied in every case; however, the following types (both known and suspected) were recorded by respondents:

- kicking;
- throwing (eg, against a wall/across a room/downstairs/out of a window or off a balcony);
- blows to body (an implement was sometimes specified: eg, broom, hammer, iron bar, bottle, golf club);
- burning/scalding;
- stab wounds and incised wounds;
- sexual abuse injuries;
- administration of drugs/poisons;
- swinging (by tail or legs);
- putting into domestic microwave;
- asphyxiation by manual strangulation or ligature;
- drowning ('inflicted submersion injury');
- miscellaneous (eg, multiple puncture wounds caused by an industrial staple-gun; forcible avulsion of claws; putting into domestic tumble drier; elastic-band ligatures).

Some unfortunate animals suffered more than one type of trauma (for example, Table 12, case 6).

Table 9. Internal thoracoabdominal injuries and signs of NAI in 121 cats

Location	Number of occasions recorded
Thorax	
Ruptured diaphragm	5
Possible collapsed lung	2
Pulmonary haemorrhage	1
Pneumonia (attempted drowning)	1
Pleural effusion	1
Abdomen	
Liver, rupture	2
Spleen, rupture	1
Small intestine, rupture	1
Kidney, perirenal haemorrhage	1
Abortion (after being squeezed)	1

Table 10. Other injuries and signs of NAI in 121 cats

Location	Number of occasions recorded
Intracranial/spinal	
Brain damage	2
Comatose	2
Concussion	2
Ataxia	1
Paresis	1
Spasticity of limbs	1
Radial paralysis	1
Tail	
Burns/scalds	3
Dislocation*	2
Degloving (possible firework injury)	1
Incised wound	1
Miscellaneous	
Attempted drowning	3
Given drug/poison†	2
Microwave injuries	2
Hanged, and nailed to fence	1
Internal injuries	1
Thoracic/abdominal injuries, unspecified	1
Behavioural signs	
'Distressed'	1
Fear	1

*One case involved a series of cats swung by the tail; counted as one case
†The first involved several cats (from the same household) presented with signs of paracetamol poisoning; most died. Second involved several cats 'poisoned' in the same street
‡Two cases noted here: the first had ear tip burns, sore toes and vomiting/diarrhoea for 48 hours post-trauma; the second was noted to have suffered 'no major harm' because 'caught in time'

Table 11. Cases of repetitive injury in 16 dogs

Case	Age	Gender	Details reported by respondent	Outcome
1	3 to 6 months	M	Multiple fractures of forelimbs over four weeks: (1) left humoral condyle; (2) right humoral condyle; (3) left humerus. Swollen left face and scleral haematoma. Owners denied human involvement and claimed a larger dog 'sat on it'	Survived
2	3 to 6 months	M	The number of fractures over a short period of time made the respondent suspicious. A neighbour reported seeing the owner kick the puppy. (Fracture of tibia, with old fracture of radius detected at the same time, and fracture of femur three weeks later)	Survived
3	3 to 6 months	M	Intrapulmonary haemorrhage, which the owner said was due to the dog 'tripping over'. An unexplained foot fracture followed within three weeks	Survived
4	3 to 6 months	M	Successive injuries caused suspicion: (1) fracture of carpus; (2) cuts on head and two fractured ribs, right, caudal; (3) two fractured ribs, pneumothorax and fracture of left femur	Survived
5	3 to 6 months	M	Fractured jaw (bilateral), fractured ribs and scleral haemorrhages. Previous fractured scapula of unknown cause. Owner volunteered information on second occasion	Survived
6	7 months to 2 years	M	Three episodes of chemical burns to mouth/eyes/paws. The owner eventually implicated her boyfriend, but was too frightened to confront him	Survived
7	7 months to 2 years	M	Dog had just had one fracture repaired when sustained another leg fracture. (Fracture of tibia/fibula, then fractured femur, on opposite sides)	Survived
8	7 months to 2 years	M	Repeated accidents (fractures of femur and humerus) caused suspicion	Died under third anaesthetic
9	7 months to 2 years	M	Sudden death (ruptured spleen and liver). History of epileptiform convulsions when looked after by a lodger. Previous fractured leg. Lodger admitted injuring dog	Died
10	> 2 years	M	Three episodes of leg fractures. Kicking suspected by respondent. Respondent recorded that it was the history offered – which was not specified – that had caused suspicion of NAI	Survived
11	> 2 years	M	Recurring presentation of small, deep, clean, surgical-like wounds over thorax and abdomen	Survived
12	> 2 years	MN	Repeated fractures of right carpus/metacarpus, then separate episodes of bruising of thorax/abdomen and severe bruising of hindlimbs, with scratches to medial tibiae. Depressed dog with poor appetite. Owner eventually realised the injuries occurred when the dog was alone with her boyfriend	Survived
13	3 to 6 months	F	Fractured femur, twice, less than three months apart, and carpal damage. (Alcohol abuse by owner)	Survived
14	7 months to 2 years	F	Respondent reported that a series of incidents over a number of years led to a finding of 'Munchausen syndrome' (sic)	NR
15	> 2 years	NR	Dragged by lead 'caught in car door' on at least four occasions in a two- to three-month period. Severe abrasions and shear injuries of all four feet and lower limbs. Abrasions on chin and around eyelids	Survived
16	NR	NR	Series of fractures occurred in a breeder's small pedigree dogs over a five-year period. Ceased when the breeder's husband died. Breeder then admitted her husband's actions	NR

M Male, F Female, N Neutered, NR Not recorded

Table 12. Cases of repetitive injury in 13 cats

Case	Age	Gender	Details reported by respondent	Outcome
1	<12 weeks	M	Kitten lost consciousness for at least 30 minutes 'after being dropped'. Considered to be unlikely by respondent who felt that cats invariably landed on their feet. Occurred days after a leg injury episode (metatarsal fractures), in which 'kitten was stepped on'	Survived
2	3 to 6 months	M	Suspicion raised by recurrence of similar injuries spontaneously, without trauma or a history of apparent relevance. Housed kitten, with no bone pathology on radiographs. First visit: fracture of left femur. Kitten 'woke up like that'. Second visit: fracture of right tibia. Respondent spoke to owner about the injuries and was again told that the kitten 'woke up like that'	Survived
3	3 to 6 months	M	Several visits for injuries, apparently from falls. Injuries included a limb fracture, a torn lower lip and epistaxis. Survived, but owner claimed kitten re-homed shortly afterwards. A second kitten of the same age belonging to the same person died of thoracic and abdominal injuries caused, the owner claimed, by being 'sat upon' by a boyfriend	Survived
4	7 months to 2 years	M	Fracture of distal femur six months after fracture of forelimb. No evidence of a road traffic accident or fall. Children reported a neighbour who 'hated' cats	Survived
5	> 2 years	MN	Repeated injuries: (1) fractured jaw, with broken upper canine teeth; (2) conjunctival haemorrhages on several occasions; (3) fractured femur (twice) of same leg, in which, on the second occasion, the unremoved pin split out of the femoral shaft. Owners most reluctant to return for postoperative care, even though the surgery was within a very short distance of the home address. Cat very frightened of men	Survived
6	NR	MN	Repeated injuries : (1) fracture of hindlimb after being thrown against a wall; (2) severe bruising and dislocated tail; (3) attempted drowning in kitchen sink. Teenage son implicated by mother. History of injuring other animals in household and also his mother	Survived
7	<12 weeks	F	History of persistent episodes of epistaxis over a short period. For financial reasons, no haematological investigation carried out. Same owners then had a second cat with multiple fractures	Died
8	<12 weeks	F	First of two kittens from the same household with clinical signs suggesting NAI and no relevant history. First visit: slightly dazed, with small haematoma on top of head. History given: 'Speaker fell on the kitten's head'. Second visit: comatose; fractures of zygomatic arch and frontal bones; massive conjunctival and intraocular haemorrhage. History given: 'Just collapsed'. A second kitten of the same age was presented moribund one month later, with a history of 'sudden collapse'. Fractures of the mandible and palatine bones present, with clinical evidence of brain damage. When questioned at a later date the owner claimed that he/she had 'tripped' on the kitten, contradicting the initial history of 'sudden collapse'	Died
9	<12 weeks	F	The frequency and unusual presenting signs raised suspicion. First occasion: ataxia, apparent blindness and suspected head trauma. Second occasion: avulsion of lower lip. (Kitten later re-presented for follow-up treatment by previous owner who had taken kitten back after report of abuse)	Survived
10	<12 weeks	F	Repeated visits (up to four daily) by owner and companion for reported smoke inhalation and diarrhoea in other animals, with no clinical evidence. During consultation, kitten handled roughly by the companion, who also showed intimidating behaviour towards the staff. Kitten finally presented comatose, with epistaxis and extreme bruising and swelling of the head	Euthanased because of injuries
11	3 to 6 months	F	Three separate episodes of fractures	Survived
12	7 months to 2 years	F	Cat presented with serious abdominal muscle rupture. Road traffic accident assumed at the time. Ten days later presented with very severe pelvic injury. On questioning the owner, the respondent was astonished to find the cat was never allowed out. The owner had no explanation for either injury and the owner's boyfriend was reported not to like cats. Two weeks later, at another surgery, the cat was presented with a fractured femur	Survived
13	3 to 6 months	NR	Kitten had three or more fractured limbs acquired over some months	Survived

M Male, F Female, N Neutered, NR Not recorded

Table 13. Cases of NAI in dogs in which the age of injuries caused suspicion

Case	Age	Gender	Details reported by respondent	Outcome
1	3 to 6 months	M	Sudden death. Postmortem examination revealed three fractured ribs, haemothorax and evidence of other fractures, which were semi-healed	Died
2	7 months to 2 years	M	Fresh fracture (unspecified) and several healing rib and limb fractures of differing ages	Euthanased because of injuries
3	<12 weeks	F	Inconsistent history given. Puppy had been 'missing' after a road traffic accident. Fractures of femur, tibia, humeral condyles, radius and ulna, and hock present, all more than seven days old. Old healing fracture, for which no explanation given, present in other tibia. Skull fracture (age not recorded) also present	Euthanased because of injuries
4	3 to 6 months	F	Puppy was referred for postmortem examination which revealed: ruptured liver and kidney; abdominal haemorrhage; head trauma; bruising of thorax, right hindlimb and lumbar muscles; old fractures of ribs 4, 5, 6 and 7. Same owner/family had another animal which had also died	Died
5	>2 years	FN	Presented with fractured humerus. History of road traffic accident but evidence of older, healing rib injury on radiography. No evidence of primary bone pathology	Survived

M Male, F Female, N Neutered, NR Not recorded

Table 14. Age distribution of cases of NAI in 199 dogs and 132 cats

Age	Number of cases	
	Dogs	Cats
Under 12 weeks	13	36
3 to 6 months	38	17
7 months to 2 years	74	40
Over 2 years	74	39

Table 15. Gender distribution of cases of NAI in 194 dogs and 122 cats

Gender	Number of cases	
	Dogs	Cats
F	46	36
FN	12	22
M	129	33
MN	7	31

M Male, F Female, N Neutered

Table 16. Number of cases of NAI in 177 dogs, according to breed

Breed	Number of cases
Border collie	8
Border terrier cross	1
Borzoi	1
Boxer	2
Boxer cross	1
Bull mastiff	1
Bull terrier	2
Chihuahua	2
Cocker spaniel	2
Collie	3
Collie cross	9
Corgi	1
Cross-breeds (miscellaneous)	40
Dalmatian	1
Dobermann	2
English bull terrier	4
English setter	1
German shepherd dog	13
German shepherd dog cross	4
Golden retriever	2
Golden retriever cross	1
Greyhound	3
Irish setter	1
Italian greyhound	1
Japanese Akita	1
Jack Russell terrier	6
Jack Russell terrier cross	2
Labrador retriever	4
Labrador retriever cross	2
Lurcher	3
Manchester terrier	1
Miniature schnauzer	1
Old English sheepdog	1
Pit bull terrier	1
Pomeranian	1
Retriever	3
Rottweiler	4
Rough collie	1
Schnauzer	1
Shetland sheepdog	1
Springer spaniel	4
Staffordshire bull terrier	11
Staffordshire bull terrier cross	4
Terrier cross	5
Toy poodle	1
Weimaraner	2
West Highland white terrier	3
Whippet	1
Yorkshire terrier	6
Yorkshire terrier cross	1

Table 17. Significant associations between breed and NAI in dogs*

Breed	Number of cases†	Crude odds ratio (ψ)	Exact 95% CI for ψ	Fisher's two-tailed P-value (crude analysis)	Summary odds ratio (ψ summary)	Exact 95% CI (ψ summary)	Fisher's two-tailed P-value (summary analysis)	Test for homogeneity P-value
Cross-breeds (miscellaneous)	40 (31)	2·1	1·5, 3·0	<0·001	2·0	1·3, 3·0	<0·001	0·190
English bull terrier	4 (3)	5·0	1·3, 13·5	0·006	3·9	0·8, 12·2	0·095	0·093
Labrador retriever	4 (4)	0·2	0·04, 0·4	<0·001	0·2	0·1, 0·5	<0·001	0·144
Labrador retriever cross	2 (1)	0·2	0·03, 0·9	0·022	0·1	0·003, 0·8	<0·001	0·503
Staffordshire bull terrier	11 (10)	7·2	3·5, 13·4	<0·001	8·1	3·7, 15·8	<0·001	0·828
Staffordshire bull terrier cross	4 (3)	48	11, 181	<0·001	—	— —	—	0·040‡

*Crude odds ratios, and summary odds ratios, adjusted for age and gender, and their 95 per cent confidence intervals (CIs)
†Numbers in brackets: cases used in computation of summary odds ratios
‡P<0·05; summary odds ratio not recommended

Age profile

Dogs

The proportion of affected dogs under two years of age (125 of 199 dogs of known age status; 63 per cent) (Table 14) was significantly greater than the proportion of dogs under two years of age in the general dog population (24 per cent) (χ^2 = 133·1; P<0·001).

Cats

The proportion of affected cats under two years of age (93 of 132 cats of known age status; 71 per cent) (Table 14) was significantly greater than the proportion of cats under two years of age in the general cat population (21 per cent) (χ^2 = 146·2; P<0·001).

Gender profile

Table 15 summarises the distribution of canine and feline NAI cases according to gender.

Dogs

The proportion of affected male dogs (136 of 194 dogs of known gender; 70 per cent) was significantly greater than the proportion of male dogs in the general dog population (50 per cent) (χ^2 = 31·4; P<0·001).

Cats

There was no significant difference in the proportion of affected male cats (64 of 122 cats of known gender; 53 per cent) compared with the proportion of male cats in the general cat population (47 per cent) (χ^2 = 1·3; P=0·264).

Breed profile

Dogs

Table 16 lists the cases of NAI in dogs, according to breed. Breeds showing a statistically increased crude risk, at the 5 per cent level of significance (Table 17), were miscellaneous cross-breeds (P<0·001; odds ratio = 2·1, 95 per cent CI = 1·5 to 3·0), English bull terrier (P=0·006; odds ratio = 5·0, 95 per cent CI =1·3 to 13·5), Staffordshire bull terrier (P<0·001; odds ratio = 7·2, 95 per cent CI = 3·5 to 13·4) and Staffordshire bull terrier cross (P<0·001; odds ratio = 48, 95 per cent CI = 11 to 181). In contrast, breeds showing significantly reduced risks were the Labrador retriever (P<0·001; odds ratio = 0·2, 95 per cent CI = 0·04 to 0·4) and Labrador retriever cross (P=0·022; odds ratio = 0·2, 95 per cent CI = 0·03 to 0·9). These relationships were maintained after adjustment for age and gender, with approximately similar interval estimates of the odds ratio, for all breeds except the English bull terrier (P=0·095; adjusted odds ratio = 3·8, 95 per cent CI = 0·8 to 12·2) where the adjustment rendered the relationship non-significant.

The Italian greyhound showed a significant crude relationship at the 8·2 per cent level, but was discounted from stratified

analysis for two reasons: first, because the breed was not specified in the control population and, secondly, because it was represented by only one case.

Cats

The breed of cat was recorded in 98 of the 168 feline cases as one Birman, one Persian, two domestic longhaired and 94 domestic shorthaired cats. The domestic shorthaired cat was the only breed to show an increased crude risk at the 5 per cent level (P=0·002; odds ratio = 3·6; 95 per cent CI = 1·5 to 11·3). There was insufficient data to compute summary odds ratios either for this breed or for the other breeds.

DISCUSSION

The diagnosis of NAI is not an exact science either in children or in the family dog or cat. In the first paper in this series (Munro and Thrusfield 2001) it was stressed that, as in children, suspicion of NAI in pets is raised by a variable combination of features, of which actual injuries are only one. Therefore, this discussion will, where appropriate, use case examples quoted by respondents to illustrate how injuries link up with other features to arouse suspicion.

Types of injury

Attention is drawn to particular categories of injury: notably, bruising, fractures, repetitive injuries, burns and scalds, ocular injuries, internal thoracic and abdominal injury, administration of drugs or poisons, inflicted submersion injury (drowning) and asphyxiation, as well as a small number of other specific injuries.

Bruising

Bruising is a feature that is obviously less easy to see in an animal than in a person. Nevertheless, it was frequently mentioned by respondents (Tables 1 and 6). No particular pattern or distribution was discernible, but it was noted more frequently over the thorax, abdomen and head/neck than over the limbs. Two respondents, however, each reported a dog in which bruising in the shape of a shoe was visible: one footprint on the thorax and one on the 'bottom'.

Linear bruising, associated with beating by a stick, and particularly visible in pigs, is a recognised feature in farmed animals, most often identified in the carcase after slaughter. It seems likely that the same pattern will be present in companion animals, and that other patterns – unrecognised so far – may also occur. Such patterns and distribution of bruising are now well documented in children. For example, forceful gripping of the cheek results in a 'fingertip' pattern; human bite marks are crescent-shaped; and linear bruises are associated with beating with a stick (Hobbs and others 1999a). In the present study, there were two reports of linear lacerations on dogs' backs (Table 1: Thorax). One of the respondents who recorded this finding wrote that the lesions were 'consistent with being beaten'. The second respondent noted that the lesions were 'unexplained'.

Postmortem examination, especially when performed by an experienced veterinary forensic pathologist, often reveals that bruising is much more extensive than originally thought on clinical examination. Where there is suspicion of NAI, it is essential to reflect the skin over the entire body. If this is not done, crucial bruising may be missed. In live animals, the shaving of suspected areas (where feasible) may reveal bruising, even in very dark animals such as black Labrador retrievers.

Fractures

The intriguing (and lengthy) debate that surrounded the eventual recognition of NAI as a cause of bony lesions in children is described succinctly by Lynch (1985). Nevertheless, 37 years after the publication of Kempe's paper on the 'Battered child syndrome', Hobbs and others (1999a) can write that 'Injury to almost every bone has been described in abuse, but certain patterns have emerged and our understanding of the relationship between cause and effect has improved.' For example, it is now known that multiple fractures, in different stages of healing, possibly with no bruises or soft tissue injuries, is one such important pattern, and that some fractures (eg, fractures of different ages) carry higher specificity for abuse than others (Hobbs 1997a).

It is interesting, therefore, to see that respondents in the present study reported fractures of many bones – in particular, fractures of the skull, rib and femur in the dog, and skull and femur in the cat (Tables 3 and 8, respectively). Moreover, some animals suffered two or more fractures on the same occasion (eg, case 5, Table 11), others incurred repetitive fractures (eg, case 4, Table 11, and case 2, Table 12), and fractures at different stages of healing were found in five dogs (Table 13).

Repetitive injuries

A repetitive pattern of injury (with parents possibly using different hospitals to avoid detection) is one of the pointers for NAI in children (Hobbs and others 1999a). Tables 11 and 12 document a disturbing catalogue of 16 dogs and 13 cats which suffered repetitive injuries. Fractures, frequently multiple, predominated, but injuries to soft tissue and internal organs also occurred. Not only were these animals injured more than once (some three or four times), but also the injuries were severe, and resulted in the death of five animals: one dog who died under a third anaesthetic, two cats and one dog who died from injuries, and one kitten who required euthanasia. Repetitive injury was also implicated in the five dogs in which the age of the injury caused suspicion (Table 13); these animals were presented with major injuries (mostly fractures) but other older injuries (all of which were fractures) also came to light on clinical examination.

General burns and scalds

Burn/scald injuries (Tables 1 and 6) are particularly distressing. In children, it is known that this form of physical abuse is

under-recognised because diagnosis may be difficult (Hobbs 1997b), and so it is interesting that several respondents in the present study reported suspected NAI because the history offered by the owner did not match the injury. For example, the owner of one small dog, with extensive full-thickness thoracic burns, claimed that the burns had occurred because 'the dog sat too close to the radiator'. Another respondent reported an indoor cat presented with a 'skin problem' and no history, but examination showed a sloughing eschar on the cat's back. However, a further respondent, reporting a dog with multiple extensive hot oil/fat burns of the head, back, flanks and limbs, considered that the injuries were 'clearly deliberate', and that the 'morphology and distribution of the lesions were diagnostic'.

Cigarette burns

Four respondents reported cigarette burns: three in dogs and one in a cat. There is, apparently, no published definitive morphological description of these burns in animals, although the lesions in children are well described. According to Knight (1989), when fresh, a cigarette burn appears as a red, circular mark, 6 to 8 mm in diameter, although an occasional wedge-shaped burn can result when the cigarette is placed obliquely. Hobbs and others (1999b) also describe them as circular, with a diameter of 0·5 to 1·0 cm, and say that, in abuse, they are often full-thickness and cratered, leaving circular, depressed, paper-thin scars; conversely, when accidental, they are superficial and eccentric, with a tail from the brushed contact. These authors also add that the length of time it takes to produce a deep, cratered, full-thickness burn is not known but is suspected to be a second or two, or possibly longer. It is clear that a comparative description of confirmed veterinary cases is needed, particularly when the haired areas of an animal's body are involved. As in children, the differentiation between cigarette burns and other skin lesions must be borne in mind.

Chemical burns

Hobbs and others (1999b) consider that deliberate burning of children with caustic substances is uncommon. Such burns were infrequent in the present study, too (Tables 1 and 6). However, one case involved repetitive abuse (case 6, Table 11).

Ocular injuries

The majority of conjunctival injuries are traumatic in origin, with closed trauma usually a result of blunt injury (Crispin 1993), and so it is unsurprising that subconjunctival/scleral haemorrhages head the list of eye injuries (Tables 1 and 6).

Levin (1997) records that ocular injury is the presenting sign in 4 to 6 per cent of NAI cases in children, and considers that all suspect cases should be given a full examination by an ophthalmologist. Retinal haemorrhages, for example, are one of the cardinal signs of the 'shaken baby syndrome', in which a baby is shaken violently (Levin 1997).

It is interesting that *intraocular* haemorrhage was recorded in only three dogs and one cat (Tables 1 and 6, respectively). Two of these four cases were reported by a single respondent. The numbers may be low because full ophthalmological examination of veterinary patients is not, generally, routine practice. Bearing in mind Levin's opinion, study of the results of ophthalmological examination of further cases of NAI in the dog and cat would be valuable.

Internal thoracic and abdominal injuries

These injuries were less commonly reported than other injuries (Table 4 compared with Tables 1 to 3, and Table 9 compared with Tables 6 to 8), but they were severe, and some were fatal (for example, case 9, Table 11 and case 4, Table 13). This is similar to the situation in children, where abdominal injuries, although less commonly recognised than either fractures or head injuries, are the second most common cause of death (Hobbs and others 1999a). These injuries usually result from a kick or punch, and both hollow and solid organs may be affected. The authors also point out that the high case fatality in children is partly attributable to frequent diagnostic delay, which occurs because there may be no external signs of injury, such as bruising. It could be postulated that the same occurs in companion animals.

In this study, blunt abdominal trauma resulted in ruptures of the liver, spleen, kidney and bladder. Some of the owners of these animals admitted injuring their pets. One, for example, said he had kicked the dog because it had been barking (the dog died from a ruptured spleen and bladder), while another owner, whose dog had a ruptured bladder, said he had kicked the dog, but 'only gently'. Yet another said he had kicked his dog (who also had a ruptured bladder) because she was 'in his way'.

Hollow organ injury was reported in only two animals: a dog and a kitten. The dog presented with vomiting and severe abdominal pain. Foreign body obstruction was initially suspected until laparotomy revealed mesenteric haemorrhages and a strangulated loop of bowel (Table 4). The respondent suspected a kick was the cause. The kitten, which came from a household with 'rumbustious children', had suffered what the respondent noted was an 'unusual injury' – a ruptured small intestine (Table 9) – for which the owner could provide no explanation.

Rupture of the diaphragm is commonly assumed to be the result of a RTA. It is notable, therefore, that this injury was recorded in the study (Tables 4 and 9). The owner of one cat admitted having thrown the animal 'in the direction of the litter tray'. Two cats were seen being kicked or stamped on, and the owner of one cat, who, the respondent noted, had no 'broken claws or damage to limbs, etc', later implicated a neighbour. A fifth cat had no evidence of trauma or a RTA, and the respondent considered the injury was suspicious because it was unexplained. The single injury recorded in a dog occurred because the owner's father had thrown the animal out of a window.

Administration of drugs or poisons

A poison has been defined as any substance which, when absorbed by a living body, will kill or gravely harm it (Garmonsway 1965). Thus, the differentiation between a 'drug' and a poison is blurred. The administration of drugs or poisons was included as a form of abuse in the original description of the 'Battered-child syndrome' (Kempe and others 1962), and Meadow (1997) gives an extensive list of substances (eg, cannabis, salt, laxatives, corrosives) that have been administered to children. In this context, it is interesting that respondents reported the administration of a variety of drugs or poisons to dogs and cats (Tables 5 and 10). One respondent commented that '. . . our most obvious and regular NAI is the dosing of pets with recreational drugs "for a laugh" '. Another wrote that 'Abuse through owners giving illegal chemical substances . . . is also unfortunately fairly common.' It is worth noting that Rogers and others (1976) considered that, in children, bizarre symptoms and signs, with no apparent pathological explanation, merited toxicological analysis.

Drowning

While it is acknowledged that the abhorrent practice of drowning newly born kittens is still practised, the three cases noted in this study (Table 10) did not involve neonates. In two of these cases, the perpetrators were teenagers who carried out the acts in their own homes. Significantly, attempted drowning (also termed 'inflicted submersion injury') is a recognised form of NAI in children (Kemp and others 1994).

Asphyxiation

Asphyxiation is anoxic anoxia caused by lack of oxygen in the inspired air or mechanical obstruction to respiration (Gee and Watson 1989b). There were three reported cases of asphyxiation by strangulation in dogs (Tables 1 and 2), and two by hanging – one dog (Table 1) and one cat (Table 10).

The features of asphyxiation by strangulation or hanging are not well documented in animals, and detailed descriptions were provided for only two of the four cases in this study. Both had been the subjects of attempted strangulation. The first of these dogs was under two years old, and had sustained an unexplained crushing injury of the trachea. Clinical findings included oedema of the lips and eyelids, subconjunctival haemorrhages and small internal eye haemorrhages. (Crispin [1993] describes bilateral subconjunctival haemorrhages associated with strangulation in dogs.) Severe laryngeal oedema and lingual swelling were also present, and radiography revealed fractures of the hyoid bone. In the second case, involving a dog over two years old, the owner admitted causing the injuries. Swelling and oedema of the neck had resulted in breathing difficulties, oedema was present around the eyes, and the head and lips were bruised.

These two cases show some similarities to findings in human cases of asphyxiation by strangulation. Injury to the laryngeal cartilages is important in human cases, as is 'puffiness' of the face, and petechiae are seen in 'asphyxial' sites (Polson and others 1985). Hyoid fracture is common in human victims of manual strangulation after appreciable calcification of the bone has occurred, which is generally after 40 years of age (Polson and others 1985). General ossification in the dog is said to be complete by 10 to 12 months (Fox 1966), and hyoid fractures were found on radiographs of the first dog, which was between seven months and two years of age. The absence of radiographic evidence of hyoid fractures, however, should be viewed with caution; Polson and others (1985) point out that radiographic examination, although advisable, may be disappointing in humans, even in cases when dissection subsequently shows a fracture.

Other (specific) injuries

Certain injuries, though small in number, are worthy of particular mention, because it is possible that other veterinarians may recognise them.

Two respondents each reported a case in which they suspected that a kitten's claws had been forcibly removed (Table 6). Hobbs and others (1999a) document a similar injury in children, in which fingernails or toenails are pulled out.

A single respondent reported a case of bilateral femoral neck fractures, and associated gluteal muscle tearing, considered to be caused by 'swinging a cat' (Table 7). Four others reported injuries caused by swinging a cat by the tail: one cat with a fractured femur; two with fractured skulls after being swung against a hard surface (one of these cats also suffered partial avulsion of the tongue [Table 7]); and a series of cats, all from the same area, with tails dislocated near the sacrum (Table 10).

Four respondents reported cats with rupture of the abdominal wall (Table 7). Two of these respondents (one of whom reported having seen three similar cases in total) stated they considered this was caused by kicks. The third noted the injury as part of serious repetitive injury (case 12, Table 12), while the fourth respondent wrote that the 'owner's story' had raised suspicion.

Two respondents recorded unilateral stifle injuries (in two cats and one dog) in which the ligaments were stretched and torn (Tables 3 and 8). In the dog, the history of trauma did not match the injury, and a family member was known to be abusive. The first cat's owner, who was agitated, and whose partner had a history of violence, actually asked if the injury had been inflicted by a person, while the second cat's owner showed no surprise when possible NAI was discussed.

Differential diagnosis

It is clearly essential to differentiate between injuries caused deliberately and those occurring for other reasons. Respondents identified three categories of the latter: skeletal disorders, blood dyscrasias and RTAs. In the present study, for

example, one respondent recorded a housed kitten with repetitive fractures, and noted that radiographic examination showed no bone pathology to explain the fractures (case 2, Table 12). Another reported a dog presented with subconjunctival haemorrhages, no history of a RTA, and haematology negative for coagulopathy. When given these facts, the owner said that a boyfriend had 'shaken the dog'. (There had also been an unexplained death in their other dog one month previously.)

Road traffic accidents in the dog and cat are common, and veterinarians may be concerned about the differentiation of injuries caused by a RTA and those associated with NAI. Fractures are of particular concern, because they are a frequent result of a RTA, and this study shows that the same is true in NAI (Tables 3, 8, 11, 12 and 13).

In a study of 600 RTA cases in dogs, Kolata and Johnston (1975) found that, of the 357 dogs who had suffered skeletal injuries, the greatest number of these injuries (302) occurred in the half of the body caudal to the 13th thoracic vertebra. The pelvis was the most frequently injured skeletal structure (103). In contrast, in the current study, only one pelvic fracture was reported in the 147 cases of NAI where traumatic physical injury might potentially have been confused with a RTA. Accordingly, if a dog is presented with a fractured pelvis, the veterinarian may feel justified in favouring a RTA to NAI, although again, as with other features (Munro and Thrusfield 2001), this possibility should be considered *with other supporting evidence.*

In the 89 cats where traumatic physical injury might be confused with a RTA, there were five pelvic fractures and three rib fractures (Table 8). Kicks were reported to have caused two of the pelvic fractures. Unfortunately, there are no comparative data on RTAs in cats. However, three respondents in this study considered that the lack of wounds that they would otherwise have associated with a RTA was significant. Thus, one recorded the case of two cats, from the same address, who separately suffered similar injuries (suspected collapsed lungs), necessitating euthanasia. This respondent wrote, 'Suspected as non-RTA. Nails not broken and no external injury.' A second respondent, who treated a cat with a diaphragmatic rupture, resulting from a kick (which had been witnessed), noted that there were 'No RTA signs'. A third respondent, who also reported a cat with a ruptured diaphragm, again noted that the 'usual signs of broken claws or damage to head and limbs' were absent.

Age profile

There were significantly more suspected NAI cases in dogs (63 per cent of cases) and cats (71 per cent of cases) of less than two years of age than would have been expected compared with the proportion of animals of similar age in the general population. Young animals (like young children) may be less manageable than older animals, and therefore provoke the potentially aggressive owner into violence.

Gender profile

The gender profile of suspected cases shows interesting differences between dogs and cats. The proportion of male dogs with suspected NAI (70 per cent) is significantly higher than the proportion of dogs in the general population (50 per cent). In contrast, the proportions are not significantly different in cats. It is possible that potentially violent owners may prefer male dogs. Alternatively, male dogs might be less manageable (or more aggressive) than females, again provoking the aggressive owner into violence.

Breed profile

The evidence for breed-specific associations is weaker than demonstrated for age and, in dogs, gender. The precision of the estimates of the breed-specific odds ratios was decreased by the paucity of cases in each breed, many only being represented by one animal. Complete subject analysis further limited the precision of the adjusted odds ratios in the stratified analysis. However, this procedure was considered justifiable and valid because it was not unreasonable to assume that subjects with missing values were random samples of all animals in the study (Little and Rubin 1989). Moreover, more sophisticated alternatives, based on either prediction of missing values using pattern analysis, or weighting incomplete records (Little and Rubin 1989), were considered impractical because of the small data-set. Another alternative, involving creating a special category for missing variables, is known to induce bias, especially when dealing with potential confounders (Vach and Blettner 1991), and was therefore rejected.

The cases and controls were selected from different populations; that is, case details submitted by the respondents and animals attending the University of Edinburgh's small animal clinic, respectively. However, cases were drawn from a random sample of veterinarians throughout the UK, and the Edinburgh dog population is known to be demographically similar to the general dog population of the UK (Thrusfield 1989); furthermore, there are no known regional variations in canine demographic variables in the UK. Thus, the case and control series should have generated unbiased estimates of the breed relationships that were studied, with the justifiable assumption that Edinburgh's small animal clinic records are representative of the UKs 'veterinarian-using' small animal population.

There is evidence ($P<0{\cdot}001$) that Staffordshire bull terriers are at increased risk (point estimate of the crude and summary odds ratios = 7·2 and 8·1, respectively), although this may only be moderate (lower 95 per cent CIs for the crude and summary odds ratios = 3·5 and 3·7, respectively) (Table 17). The reasons for this increased risk are unknown at present, but one could speculate that the breed may be favoured by pugnacious owners. A similar relationship appears to be present for the Staffordshire bull terrier cross

(P<0·001), although the imprecision of the estimate of the crude odds ratio, and lack of a reliable summary value, weakens this inference.

There is also evidence for an increased risk in miscellaneous cross-breeds (P< 0·001), but the lower CI for the adjusted odds ratio (1·3) is very close to the null value (1·00), suggesting that the increased risk could be minimal. Such an increase might be ascribed to cross-breeds being favoured by owners of low socioeconomic status (the former are generally cheaper than purebred dogs), and it is known that NAI in children is more common in this social category (Gillham 1994).

The English bull terrier demonstrates an increased risk in the crude analysis (P=0·006), but this falls below the conventional 5 per cent level of interpretation in summary adjustment (P=0·095). However, the paucity of data for this breed, in which only four cases were suspected, renders the results equivocal.

The Labrador retriever shows a significantly decreased risk of NAI (P<0·001), with the upper CIs of the crude and summary odds ratios' being less than 1 (0·4 and 0·5, respectively). This could be explained by the breed generally encompassing 'good-natured', and amenable, family dogs. No credence should be attached to the results for the Labrador retriever cross because of the low numbers involved.

The modest crude increase in risk in the domestic shorthaired cat (point estimate of the odds ratio = 3·6, lower CI = 1·5) could be ascribed to the under-representation of purebred cats in the case series which, again, may be a reflection of the socioeconomic status of owners of cases.

Conclusions

This study has presented extensive information on the types of injuries found in cases of NAI in dogs and cats, as well as providing details of the relationship between NAI and the age, gender and breed of cases. Repetitive injury is highly suggestive of NAI. Currently, no single injury, or groups of injuries, *when considered in isolation from other circumstances of the case,* can be taken as providing definitive evidence of NAI. A further paper in this series will explore this issue in more detail.

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