Risk factors for road traffic accidents in cats up to age 12 months that were registered between 2010 and 2013 with the UK pet cat cohort ('Bristol Cats')

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Abstract

Road traffic accidents (RTAs) are a common cause of death and injury in domestic cats, and a concern to many owners. This study assessed potential risk factors for RTAs in cats up to 12 months of age within a UK cat cohort known as 'The Bristol Cats Study'. Data were obtained from three questionnaires, completed by cat owners when their cats were approximately 8-16 weeks old, six months old and 12 months old. Information was gathered regarding environmental conditions, cat characteristics and owner management factors. Univariable and multivariable logistic regression models were used to assess associations between these factors and RTAs. Of 1264 eligible study cats, 49 (3.9%) had been involved in an RTA, of which 71.4% (35/49) were known to result in fatal injuries. Rural locations were associated with a higher odds of RTAs than towns, cities or suburban locations. An increased odds of an RTA was also associated with cats that were reported by their owners to hunt at the roadside, as well as cats whose owners classified the road by their house as being a 'long straight section of road'. No significant associations were found between coat colour, breed, sex or neuter status and the odds of an RTA.

Introduction

Road traffic accidents (RTAs) are a common cause of death and injury in cats. One study found that RTAs were the fourth most common cause of death recorded by veterinary practices for cats in Britain (Rochlitz and others 2001). A more recent study investigating mortality of cats in English veterinary practices found trauma to be the most frequently reported cause of death in cats under five years of age, with RTAs accounting for most cases of trauma-related deaths (O'Neill and others 2015). Cats that survive an RTA can suffer from severe injuries, including skeletal injuries or neurological deficits, and may require extensive veterinary treatment (Rochlitz 2004a, b). Recent estimates of the size of the UK owned cat population are between 7.9 and 10.5 million (PDSA 2013; PFMA 2014; Murray and others 2015a), with approximately 90 per cent of UK pet cats having unrestricted outdoor access for at least part of the day (Murray & Gruffydd-Jones 2012). This amounts to around 7.1 to 9.5 million cats at daily risk of being involved in an RTA.

A study in France noted that the lifestyle and management of domestic cats made them three times more likely than dogs to be involved in an RTA (Moreau and others 2003). Whilst the minority of dogs (21%) in a regional UK study of dogs were reported to be exercised outside their garden 'off lead' most or all of the time (Westgarth and others, 2009), in the UK many domestic cats are free to roam outside their owner's house and garden (McDonald and others, 2015). Differences in management of domestic cats regarding outdoor access has been noted across different countries (Murray and others, 2015b) so care must be taken when comparing likelihood of involvement in an RTA between countries. Anecdotally, there are a number of factors that are considered to increase or decrease the risk of a cat being involved in an RTA. For example it has been suggested that black cats are more likely to be involved in an RTA due to being less visible to drivers. However, previous studies have not found any conclusive evidence to support this claim (Rochlitz 2003a). In addition, some animal rescue organisations will not rehome cats to houses situated on busy roads, or will recommend that cats are kept indoors at night to reduce the risk of an RTA (e.g., Wythall Animal Sanctuary 2013; RSPCA Stafford, Wolverhampton & District Branch 2014; Leeds Cat Rescue 2014; Cheltenham Animal Shelter 2015). However, there is currently very little scientific evidence to support these practices and recommendations.

Most studies conclusively find that cats are at greater risk of RTAs when they are younger, with Rochlitz concluding that cats between 7 months and 2 years of age have the highest risk, with the risk decreasing thereafter as the cats age (Rochlitz 2003a). O'Neill and others found that 47.3 per cent of cats that died aged less than five years died as a result of trauma. In cats aged five years and over trauma accounted for only 5.8 per cent of deaths. Of all the trauma cases, 60 per cent resulted from an RTA (O'Neill and others 2015). Younger cats of around six months of age are more likely to be exposed to roads for the first time, as owners will tend to keep kittens indoors until they have been neutered, which is often at around 6 months of age (Welsh and others 2013). This may explain the finding by Rochlitz (2003a).

Previous research (Childs and Ross 1986; Rochlitz 2003a) has found that male cats are more likely than female cats to be involved in an RTA. The reason for this finding is not clear, as although it might be hypothesised to be due to entire male cats having larger home ranges, only 18/435 male cats were entire in Rochlitz' study.

The research to date does have its limitations, in part due to the fact that the studies were retrospective and therefore may have been susceptible to recall bias. In addition, Rochlitz' studies (2003a,; 2004,b) did not include cats that had died as a result of their RTA and were not presented to a veterinary clinic, as well as those not presented due to minor, or an absence of, injuries. A similar issue arises from the Childs and Ross research (1986), which only included cats involved in fatal accidents and collected by animal wardens. This excluded all cats that survived or were removed by the owner or another member of the public. A large-scale prospective study allows inclusion of all cats known to be involved in an RTA, whether or not they were presented or their accident reported to a veterinary practice. It also enables better understanding of risk factors due to a reduced risk of case-control differential reporting as data such as local road conditions are collected prior to classification of case cats (involved in an RTA) and control cats (not involved in an RTA).

Due to the large numbers of cats at risk of being involved in an RTA, and the serious consequences of such an accident, it is important to understand the risk factors associated with RTAs. This information could enable rehoming centre staff and cat owners to use scientific evidence to make better assessments of the risk of an RTA so that cats are either rehomed to suitable homes, or managed more effectively to reduce the risk of being involved in an RTA.

The aim of the present study was to use prospectively collected data to identify and quantify the strength of associations between risk factors relating to environmental conditions, cat characteristics, and management practices and the odds of an RTA by 12 months of age (the outcome variable) for a cohort of cats living in the UK.

Materials and Methods

Data Collection

Data for the study were collected prospectively as part of the 'Bristol Cats' (BC) study, a long-term longitudinal study which has ethical approval from the University of Bristol (Reference: UIN/13/026). Cat owners in the UK were recruited onto the BC study between May 1st 2010 and December 31st 2013. During 2010, registration was restricted to owners with a 'BS' (Bristol) postcode, but in order to increase the number of registered cats, registration was extended to the whole of the UK from January 1st 2011.

Owners were asked to complete a questionnaire at recruitment, when their cats were 8-16 weeks old (Q1). Further questionnaires were completed when the cats reached the ages of six months (Q2), 12 months (Q3), 18 months (Q4), two and a half years (Q5), four years (Q6) and then at annual time points. Data for this study were taken from the first three questionnaires (Q1-3).

Questionnaires were available to participating owners either in an online format via a link sent out to participants in an email, or in a paper format. Completed paper questionnaires were later converted into the online format. Most questions were presented in a multiple-choice format and the questionnaires took approximately 10-15 minutes to complete. Information was collected on the participating cats' characteristics, environmental conditions, and owner management of the cat. Copies of the questionnaire can be found at https://smvsfa.onlinesurveys.ac.uk/bristol-cats-study-questionnaire-1-kitten-aged-8-16-wks-2C (Q1), https://smvsfa.onlinesurveys.ac.uk/bristol-cats-study-questionnaire-2-6-month-old-cats-c (Q2) and https://smvsfa.onlinesurveys.ac.uk/bristol-cats-study-questionnaire-3-12-month-old-cats-c (Q3).

Descriptive statistics

The demographic profile of cats and owners included in this study were described (number, percentage) in terms of the following variables: cat sex (male/female) and breed status (pure breed/mixed breed), source of cat (seven categories), neuter status (at Q2, age approximately 6.5 months)and owner's annual household income (5 categories: <£10,000, £10,000 to <£15,000, £15,000 to <£20,000, £20,000 to <£30,000, £30,000 to <£40,000, £40,000 to <£50,000, £50,000 or more) (Table 1). The number, percentage and 95% confidence intervals of cats in the cohort reported by their owner to have been involved in an RTA by 12 months of age were calculated. The number, percentage and 95% confidence intervals of RTAs that occurred at night-time versus during the day, and the extent of injuries incurred were summarised.

A nested case-control study was conducted on data collected prospectively from the longitudinal 'Bristol Cats' study cohort. Figure 1 details the numbers of cats included in the case-control study and reasons for exclusion of cats.

Case and Control Selection

Cases were defined as cats that were reported by their owners to have been involved in an RTA by the age of 12 months, whether or not the accident was fatal. The age of 12 months was chosen for the outcome measure as previous studies have shown younger cats to be more at risk (Rochlitz 2003a; O'Neill and others 2015). In addition to this, at the time the study was conducted all cats in the BCS had reached 12 months of age. Cases were identified from questionnaire completion after the accident or from email or telephone correspondence with owners after their cat had been withdrawn from the study.

Controls were selected to represent subjects that could have been cases if the outcome had occurred. Therefore, controls consisted of all cats in the study with outdoor access whose owners had completed the 12 month questionnaire and had reported that the cat had not been involved in an RTA. Cats were excluded from analysis if their owner had answered "don't know" to the question "Has your 'Bristol Cats' study cat been hit by a vehicle since you have owned him/her?" or if the owner had not reported the cat's outdoor access. Details of cats' inclusion in the study is shown in figure 1.

If owners reported that their cat had been killed in an RTA they were still asked to complete the subsequent questionnaire. This meant that a small amount of data was collected after the cat's involvement in an RTA and therefore may have been susceptible to recall bias (Kopec and Esdaile, 1990). Five cats were involved in an RTA prior to the completion of questionnaire two and a further 23 cats were involved in an RTA before their owner completed questionnaire three. The owners of the remaining twenty case cats did not complete any questionnaires after the accident. Most variables of interest were collected in questionnaire two (Table 2) and all data relating to significant risk factors were collected prospectively for all except five cats.

Potential Risk Factors

Relevant variables that were considered possible risk factors were extracted from each of the three questionnaires (Table 2). Responses were recoded where necessary, such as if the answer was given in free-text. Some variables were compressed into fewer categories for analysis, by combining similar categories in situations where one or more categories had few cats and combination was logical.

Logistic Regression Analysis

Potential risk factors were tested for association with the outcome under investigation (RTA) using univariable and multivariable logistic regression models.

In situations where one category contained no cases (Garden Q1/Q2/Q3, Outdoor access Q2/Q3, Traffic reaction Q3), the model was prevented from detecting significant associations. In these circumstances, one control was selected at random using a random number generator (http://www.randomizer.org) and re-coded as a case. The model was then rerun in order to allow the model to test for significant associations. These data were re-coded back to their original 'control status' after each alteration.

A multivariable model was constructed in order to identify and quantify the strength of independent associations between variables associated with the odds of an RTA within our dataset. Only variables with $p<0.2$ in the univariable analysis were considered for inclusion in the model. No variables with $p<0.2$ in the univariable analysis were highly correlated ($|r|>0.9$), so all variables were taken forward to the multivariable model building process. The multivariable model was built using backward elimination and variables with $p<0.05$ were retained in the model. Interactions between factors were also tested for, where a biologically plausible explanation existed.

The fit of the model was assessed by the Hosmer and Lemeshow Test. Nagelkerke's R^2 was used to estimate the extent to which the outcome under investigation was explained by the final multivariable model.

Power of the Study

A range of variables were being tested for association with the odds of an RTA, including the hypothesis that black cats would be more likely to be involved in an RTA than cats with other coat colours. Examination of our dataset revealed that 12 per cent of cats registered with our study were black (data not shown). A sample size of 46 cases (cats reported to have been involved in an RTA) and 138 controls (cats without a report of an RTA) was calculated to have 80 per cent power to detect odds ratios of three or more for the outcome of an RTA with a 95 per cent level of confidence and assuming that at least 20 per cent of RTA cats were exposed to the variables of interest (Epi Tools, Epi Info v. 6).

The statistical package IBM SPSS Statistics V. 21 was used for data analysis.

Results

Of the cats included in this study, 52.2 per cent were male and 77.1 per cent were mixed breed (Table 2). Whilst 8.9 percent of owners of study cats lived in households with an annual income of less than £10,000, 27.0 percent lived in households with an annual income of £50,000 or more (Table 1).

RTA's were reported for 3.9 per cent (95% confidence intervals: 2.9-5.1 per cent) of cats in the study (49/1264) by 12 months of age. Over 85 per cent of these RTAs were reported to have occurred when the cat was between six and 12 months of age (Table 3).

Timing of the RTAs in relation to daylight

Cat owners were only able to report whether the RTA took place during daylight or darkness for 28 RTAs. Of these, 46.4 per cent (13/28) took place during daylight hours and 53.6 per cent (15/28) took place in the dark.

Extent of injuries

Excluding two cases where no information on the extent of the injuries caused by the RTA was available, owners reported that 74.5 per cent (35/47) of RTAs resulted in fatal injuries and a further 17.0 per cent (8/47) resulted in serious injuries requiring veterinary treatment. No owner reported an absence of injuries following an RTA (Table 4).

Univariable logistic regression

The univariable logistic regression analysis is summarised in Table 5. This analysis identified ten variables with $p<0.2$, which were taken forward to the model building process in the multivariable analysis.

Multivariable logistic regression

Three variables were retained in the final multivariable model (Table 6). Within our dataset, cats living in households reported by their owners to be in a rural location were associated with a 2.66 increased odds of an RTA (95% confidence intervals (CI) 1.02-6.94), compared to cats living in more urban locations. Cats with increased odds of an RTA were significantly more likely to live in houses situated on long straight roads than cats whose owners did not report an RTA (OR= 2.84, 95% 1.23-6.58). An increased odds of an RTA was also associated with cats that were reported to hunt at the roadside (OR=3.30, 95% CI 1.31-8.31) compared to cats whose owners did not report this behaviour. The Hosmer and Lemeshow test indicated that the model was a good fit for the data (P=0.82). Nagelkerke's R^2 value of 0.074 suggested that only about 7.4% of the variation of the odds of an RTA was explained by the three variables included in the final multivariable model.

Discussion

Previous studies investigating RTAs in UK pet cats have been cross-sectional in design (Rochlitz 2004a, b) and have been susceptible to information bias resulting from differential reporting related to case-control status of respondents. This is the first study to use data from a prospective cohort study of owned pet cats to identify risk factors for RTAs in cats up to 12 months of age.

As previously discussed, unlike the previous study of RTAs involving cats in the UK (Rochlitz 2003a,b), the present study included for analysis all cats that were reported by their owners to be involved in an RTA, rather than only those which were reported to veterinarians. Rochlitz (2003a, 2003b) based her analysis on just six veterinary practices in Cambridgeshire, whereas our study included cats from across the United Kingdom. Both of these factors are likely to increase the external validity of our results to UK cat owners and feline welfare organisation rehoming staff.

The proportion of cats (with outdoor access) in the study that were reported to have been involved in an RTA by 12 months of age was 3.9 per cent. This is a smaller proportion of RTAs than previous studies have stated. Rochlitz (2003a) found that 12 per cent of owners reported that their cat had been in at least one RTA. Rochlitz's study,

however, included cats of all ages which might explain the differing results. Additionally, it is possible that the percentage reported here is an under-estimate due to the fact that of the 64 cats that left the study prior to reaching 12 months of age (figure 1), nine of these were reported to have gone missing. It is plausible that some or all of these cats may have been involved in an RTA. Similarly, one or more of the 8 cats whose owners did not know if they had been involved in an RTA (figure 1) may have been cases.

The results of our study showed that the greatest proportion of cats involved in an RTA were between six and 12 months of age (85.71%), rather than prior to six months of age. This goes some way towards supporting the finding by Rochlitz that cats between 7 months and 2 years of age have the highest risk (Rochlitz 2003a). Due to the fact that this study only focused on cats up to 12 months of age, it was not possible from the data available to assess how increasing age affected the risk of an RTA beyond 12 months. It would be beneficial, in future, to assess the risk factors for RTAs at all ages. This would better enable risk factors to be linked with different age groups and would also provide the opportunity to support previous research which suggests that younger cats are more at risk of an RTA (Rochlitz 2003a; O'Neill and others 2015).

In the present study, rural locations were shown to be associated with higher odds of RTAs than urban or semi-urban locations. The increased risk of rural areas identified in this study may be because rural-dwelling cats are used to quiet country roads and are unprepared for unexpected, and potentially fast-moving cars. Additionally, urban roads need to provide for safe travel on foot and bicycle as well as for motorised traffic and therefore we speculate that they tend to have lower speed limits than those applied on rural roads (Department for Transport, 2013). Urban roads also might be more likely to have pavements, which could provide a safe area for cats.

This study showed that cats reported to hunt at the roadside had an increased likelihood of being involved in an RTA. Hunting at the roadside may increase risk due to these cats spending more time near a road, or because they are focused on their hunting activity and do not pay attention to traffic. Hunting is likely to be more common on roads in rural locations where prey is present in hedges and on verges.

The finding that cats living in homes that were situated on long straight sections of road, were at increased odds of being involved in an RTA was unexpected as it might be speculated that on long straight roads drivers will be better able to notice cats in the

road. Furthermore, the results showed that the presence of one or more sharp bends in the road was not significantly associated with the odds of an RTA. These outcomes suggest that the visibility of a cat is not related to the risk of an RTA. It is likely that vehicles are moving more quickly on long, straight sections than on roads with obstacles or sharp bends, and drivers therefore may be unable to stop in time, should they come across a cat in the road. Staff from rehoming organisations should incorporate the evidence produced by this study into their assessment of the risk of an RTA associated with specific roads, as long, straight roads have been shown to represent a higher risk of RTAs to cats.

The proportion of male to female cats involved in RTAs was almost equal, and neuter status was also not shown to have any association with odds of an RTA. There was therefore no evidence from this study to suggest that male cats were more at risk than female cats. This is in contrast to previous findings (Rochlitz 2003a; Childs and Ross 1986) which found significantly more males (entire and neutered) were involved in RTAs than female cats (entire and neutered). The population assessed in the study by Childs and Ross contained a large proportion of unowned, entire male cats which is in contrast to the current study, and may account for the difference in results relating to sex. Further research, based on a larger sample size, is recommended in order to provide additional evidence about the absence or presence of an association between sex of the cat and the risk of an RTA.

Despite an anecdotal belief that black cats are more likely to be involved in RTAs, this study found no evidence of an association between coat colour and odds of an RTA. It is possible that this belief may have arisen due to high numbers of black cats involved in RTAs, as opposed to a high proportion. The perceived increased risk of RTAs for black cats may, in part, contribute to the increased length of time it takes to rehome black cats from rehoming centres. Cats Protection, (the UK's leading feline welfare charity), have stated that approximately 23 per cent of cats in their care are black and that these cats are harder to re-home than cats with other coat colours (Cats Protection 2012). Similarly, Wood Green Animal Charity states that black cats take, on average, one to two days longer to rehome than cats of other colours (Wood Green 2014). The lack of evidence of a significant association between coat colour and the odds of an RTA may help to encourage potential adopters to consider black cats. However, it should be noted that the final sample size in the multivariable model was smaller than had been

calculated to provide 80% power to detect odds ratios of 3.0 or more, hence a larger sample size with greater associated statistical power is warranted.

No significant association was found in this study between whether or not cats had 24 hour access to the outdoors and the odds of an RTA. Unfortunately, the questionnaires focussed on the means of outdoor access, rather than the timing of this access (except for 24 hour access via a cat flap), and hence it was not possible to determine whether or not cats had outdoor access at night time. The proportion of accidents that were known to occur in daylight (26.5%) and the number known to have occurred in the dark (30.6%) were very similar and based on this small sample (n=28) did not suggest a trend towards accidents being more likely to occur in the dark. However, the large amount of missing data (42.9%) where owners either didn't know or failed to answer what time of day their cat was hit reduces the reliability of this finding.

No significant association was found between the average number of vehicles estimated to pass per hour and the odds of an RTA. This might be due to the fact that this variable was based on owner perception, and these estimations may not always be representative of actual levels of traffic. Further work, using objective measures of traffic density and speed, are needed.

The results of this study in relation to road conditions contradict the anecdotal belief that busy roads or built up areas represent a higher risk of RTAs for cats. This may enable a better understanding of suitable homes for a cat with a view to decreasing the risk of RTAs. No data were gathered on the characteristics of the road on which the accidents actually occurred, but rather the road closest to the owner's home. This is an area that may benefit from further research in the future. However, previous research by Rochlitz found that 48 per cent of accidents with a known location occurred just outside, or very near to, the owner's home (Rochlitz 2003b) so data collected on the owner's own road is no less valuable.

Despite a number of conclusive findings in the research, there are also some constraints to the study. Participants of a longitudinal study such as this one may not be representative of the 'average' cat owner. This is because a particular 'type' of owner may be more inclined to complete questionnaires about their cat. However, the risk factors identified by this study are independent of the owners' 'motivation' to participate in the study or complete questionnaires.

The data used in the study were owner-reported and therefore the study relied on owners answering truthfully and accurately. Although the study was prospective, some owners (n=28) whose cats were involved in an RTA prior to the questionnaire date were asked to complete the questionnaire retrospectively, after the accident had occurred. However, as mentioned previously, only five owners completed questionnaire two (from which most of the variables were extracted) after their cat was involved in an RTA.

It is also possible that, due to owner error, some cases may have been incorrectly classed as controls. This might have occurred if the owner was unaware of an RTA taking place. The results showed that no owners reported that their cat was left without injuries following an RTA. This may be due to the fact that all RTAs cause injuries by nature, or may be because owners were only aware of the RTA occurring if the cat presented with injuries believed to be consistent with an RTA. The reverse is also true and it is possible that some controls may have been incorrectly reported to be cases if the owner believed the cat to have been involved in an RTA, when in fact their injuries or death were the result of another, unknown cause. It is unlikely that this limitation can be entirely overcome, as an owner can only ever be entirely certain that the cat was involved in an RTA if they witnessed the accident themselves, or were notified about the accident by a witness. It is therefore necessary to rely on the interpretation of the injuries by the owner or their vet to determine whether or not a cat has been involved in an RTA.

Although there was evidence for good model fit (Hosmer and Lemeshow test result, P=0.82), only about 7.4% of the variation of the odds of an RTA in this study was explained by variables included in the final multivariable model. It can therefore be concluded that other factors, which were not measured in our study, were contributing and important factors in the risk of an RTA. Further work investigating RTAs in cats should be based on a larger sample size and include more detailed objective measures of traffic conditions and road characteristics in the area surrounding the homes of cats, in addition to data indicating the extent to which cats travel outside their gardens.

The only way to truly eliminate the risk of a cat being involved in an RTA is to keep them exclusively indoors. Owners will need to make an assessment of the risks to their individual cat(s) based on their individual road conditions and the amount of time the

cat is known, or thought, to spend on the roads. Examples of variables that we were unable to explore in this analysis may also influence the risk of an RTA. These variables include accurate measures of traffic speed, traffic density, as well as the density of cats from other households and the extent to which an owner's cat will fight with neighbouring cats. An indoor only lifestyle would not only remove the risk of an RTA, but would also protect cats from injuries resulting from fighting with cats from other households, as well as some forms of infectious diseases. Although if an owner restricted more than one cat to an indoor lifestyle, then there could be potential for increased agonistic behaviour to be shown between the household cats with an associated risk of injury. Cats with an indoor-only lifestyle should still be neutered if breeding is not planned, as benefits beyond population control and roaming are well-established (Murray and others, 2015b). In addition, keeping cats indoors may help to reduce the impact on local wildlife. However, despite these possible benefits to an indoor lifestyle, there are a number of health and welfare concerns associated with exclusively indoor cats, for example an increase in reported behavioural issues (Amat and others 2009), an increased risk of obesity (Rowe and others 2015) and increased signs of lower urinary tract disease (Willeberg 1984). It therefore should not be a decision that owners make lightly. Rather than keeping cats exclusively indoors, owners may decide to enclose their garden, or encourage their cat not to stray by creating a 'cat-friendly' garden (e.g. with elevation points and vegetation in which the cat can explore).

Conclusion

This study found that the proportion of cats with outdoor access involved in RTAs by the age of 12 months is relatively high to be 3.9% (95% CI 2.9-5.1) within this cohort of pet cats. This is the first study to use prospectively collected data to assess potential risk factors for RTAs in owned cats, and ten risk factors were identified during univariable analysis. Multivariable analysis revealed that rural locations were a higher risk area for RTAs than towns, cities or suburban locations. Cats that were reported by their owners to hunt at the roadside were at a greater odds of an RTA that those that were not reported to do so, and cats whose owners classified the stretch of road just by their house as being a 'long straight section of road' were also at a greater odds compared to cats whose owners did not classify the road by their house as such. The study highlights the risk of cats with outdoor access being involved in an RTA in the first 12 months of their lives.

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Tables and Figures

Figure 1: A flow chart detailing inclusion of cats from the Bristol Cats Study cohort in an analysis to identify risk factors for road traffic accidents (RTAs) based on questionnaire completion by owners between May 2010 and February 2015

Table 2: Variables included in the univariable analysis for risk factors for RTAs in cats aged ≤12 months in the Bristol Cats Study cohort.

Variable name	Variable description	Categories
Cat Characteristics		
Sex (Q1[a])	Sex of the cat (male/female)	Male, Female
Age of neuter	The age that the cat was neutered	≤ 6 months, 7-12 months, entire at 12 months
Breed (Q1)	Breed of cat	Mixed breed (domestic short hair, domestic long hair and all crossbreeds), Pure breed
Coat colour (Q1)	Colours reported to be present in the cat's coat	Black, White or White and another colour, Other
Cat Behaviour		
Traffic reaction (Q2[b], Q3[c])	The usual or most common reaction to traffic by the cat	Runs away, Freezes, Confident and sensible, Little awareness of danger
Time spent outdoors (Q2, Q3)	The amount of time that the owner estimates their cat spends outside when the cat has unrestricted access to the outdoors	Mostly indoors, Equal time indoors and outdoors, Mostly outdoors
Time spent on road - daylight (Q2, Q3)	How often the owner thinks that their cat goes onto the road during daylight hours	Every day, 2-3 times per week, Once a week or less, Never
Time spent on road - dark (Q2, Q3)	How often the owner thinks that their cat goes onto the road in the dark	Every day, 2-3 times per week, Once a week or less, Never
Hunt at roadside (Q2)	Whether or not the owner reported that their cat hunts at the roadside	Yes, No
Environmental Conditions		
Home location (Q1, Q2, Q3)	The location of the owner's home as reported by the owner	Remote/Rural, Village/Suburban, Town/City
Garden (Q1, Q2, Q3)	Whether or not the owner's home has a garden	Yes, No
Streetlights (Q2)	Whether or not streetlights are present on the stretch of road immediately outside the owner's home	Yes, No
Road classification (Q2)	The classification of road on which the owner's house is situated	A road, B road, Unclassified road

Speed limit (Q2)	The speed limit of the road on which the owner's house is situated	30mph or less, 40mph or over
Vehicles per hour - weekdays (Q2)	Owner perception of average number of vehicles per hour on weekdays on the stretch of road nearest the owner's house	Less than 6, 6-20, 21-60, More than 60
Vehicles per hour - weekends/bank holidays (Q2)	Owner perception of average number of vehicles per hour on weekends and bank holidays on the stretch of road nearest the owner's house	Less than 6, 6-20, 21-60, More than 60
Vehicles per hour - weeknights (Q2)	Owner perception of average number of vehicles per hour on weeknights on the stretch of road nearest the owner's house	Less than 6, 6-20, 21-60, More than 60
Vehicles per hour - weekend/bank holiday nights (Q2)	Owner perception of average number of vehicles per hour on weekend and bank holiday nights on the stretch of road nearest the owner's house	Less than 6, 6-20, 21-60, More than 60
Long straight section of road (Q2)	Whether or not the owner's home is situated on a long, straight section of road	Yes, No
Junction or roundabout (Q2)	Whether or not there is a junction or roundabout on the stretch of road that the owner's home is situated on	Yes, No
Sharp bend(s) (Q2)	Whether or not there are sharp bends on the road on which the owner's home in situated	Yes, No
Humpback bridge or natural rise (Q2)	Whether or not there is a humpback bridge or similar natural rise in the road on which the owner's home is situated	Yes, No
Vehicles or other temporary obstacles (Q2)	Whether or not vehicles or other temporary obstacles (e.g. skips) are often parked on the side of the road on which the owner's home is situated	Yes, No
<u>Cat Management</u>		
Wears nothing outdoors (Q2, Q3)	Whether the cat wears nothing outdoors, as opposed to a collar or other item(s)	Yes, No
Wears reflective collar (Q2, Q3)	Whether or not the cat wears a reflective collar when outdoors	Yes, No
Means of outdoor access (Q2, Q3)	The means by which the cat accesses the outdoors	Cat flap open 24hrs, Other

[a] Q1 - Questionnaire one for 8-16 week old cats

[b] Q2 - Questionnaire two for 6 month old cats

[c] Q3 - Questionnaire three for 12 month old cats

Table 1. Demographic data relating to cats and owners enrolled in the Bristol Cats study cohort (n=2203), and of cats reported to have been involved in an RTA by age 12 months (yes=cases, no=controls) included in an analysis to identify risk factors for road traffic accidents (RTAs) based on questionnaire completion by owners between May 2010 and February 2015.

	Cohort recruited (2010-2013) Number (%) of cats	Cases (RTA reported by age 12 months) Number (%) of cats	Controls (no RTA reported by age 12 months) Number (%) of cats
Breed			
Mixed breed	1636 (77.1)	39 (83.0)	936 (82.5)
Pure breed	487 (22.9)	8 (17.0)	198 (17.5)
Gender of cat			
Male	1131 (52.2)	25 (55.6)	616 (54.2)
Female	1034 (47.8)	20 (44.4)	521 (45.8)
Source of cat			
Accidentally bred by owner	64 (2.9)	2 (4.2)	26 (2.3)
Deliberately bred by owner	105 (4.8)	2 (4.2)	36 (3.2)
Pedigree breeder	406 (18.6)	6 (12.5)	154 (13.6)
Non-pedigree breeder / friend / neighbour	989 (45.3)	29 (60.4)	558 (49.3)
Pet shop	32 (1.5)	1 (2.1)	12 (1.1)
Rescue centre	404 (18.5)	6 (12.5)	255 (22.5)
Stray/Feral	159 (7.3)	1 (2.1)	91 (8.0)
Household income			
<£10,000 per annum	180 (8.9)	3 (7.5)	74 (7.0)
£10,000 to <£15,000	177 (8.8)	6 (15.0)	70 (6.7)
£15,000 to <£20,000	172 (8.5)	6 (15.0)	69 (6.6)
£20,000 to <£25,000	164 (8.1)	3 (7.5)	66 (6.3)
£25,000 to <£30,000	220 (10.9)	4 (10.0)	122 (11.6)
£30,000 to <£40,000	333 (16.5)	8 (20.0)	186 (17.7)
£40,000 to <£50,000	225 (11.2)	3 (7.5)	137 (13.0)
£50,000 or more	543 (27.0)	7 (17.5)	326 (31.0)
Cat neuter status[a]			
No	438 (23.7)	6 (14.3)	184 (17.3)
Yes	1410 (76.3)	36 (85.7)	880 (82.7)

[a] Data from Questionnaire 2 (cats aged 6.5 months old)

Table 3: The number and percentage of cats in a UK cat cohort reported to be involved in an RTA, and the age at which the cat was at the time of the RTA (<6 months, 6-12 months).

Age	Frequency	Percentage (95% confidence intervals)
No RTA reported	1215	91.5 (89.9-92.9)
RTA reported – cat aged <6 months	6	0.5 (0.2-1.0)
RTA reported – cat aged 6-12 months	42	3.2 (2.4-4.3)
RTA reported – age of cat not given	1	0.1 (0.01-0.4)
Missing data	64	4.8 (3.8-6.1)

Table 4: The extent of injuries that owners reported had resulted from RTAs in a UK cat cohort. (Missing data existed for two cats)

Extent of Injuries	Frequency	Percentage
No Injuries	0	0
Minor Injuries (not requiring veterinary treatment)	4	8.5
Serious Injuries (requiring veterinary treatment)	8	17.0
Fatal Injuries	35	74.5

Table 5: Univariable logistic regression model for risk factors of RTAs by 12 months of age in a UK cat cohort (P<0.2)

Variable	RTA reported	(%)	No RTA reported	(%)	*p*- value	Odds Ratio (95% Confidence Interval)
Coat colour						
Black	9	(19)	168	(14)	0.08	
White/White and another colour	22	(47)	417	(35)	0.97	0.99 (0.44-2.18)
Other	16	(34)	610	(51)	0.09	0.49 (0.21-1.13)
Time spent outdoors Q3						
Mostly indoors	3	(13)	331	(29)	0.23	
Equal in/out/mostly outdoors	21	(88)	809	(71)	0.09	2.86 (0.85-9.67)
Visits road daylight Q2						
Once a week or less/never	15	(52)	547	(75)		
Every day/2-3 times per week	14	(48)	184	(25)	0.01	2.78 (1.31-5.86)
Visits road dark Q2						
Once a week or less/never	18	(75)	631	(87)		
Every day/2-3 times per week	6	(25)	91	(13)	0.08	2.31 (0.89-5.98)
Visits road daylight Q3						
Once a week or less/never	3	(21)	493	(58)		
Every day/2-3 times per week	11	(79)	356	(42)	0.01	5.08 (1.41-18.33)
Hunts at roadside						
No	19	(70)	672	(90)		
Yes	8	(30)	78	(10)	<0.01	3.63 (1.54-8.57)
Home location Q1						
Rural	10	(21)	108	(9)		
Village/suburban/town/city	38	(79)	1093	(91)	0.01	0.38 (0.182-0.78)
Speed limit						
30mph or less	29	(74)	847	(93)		
40mph or over	10	(26)	61	(7)	<0.01	4.79 (2.23-10.28)
Streetlights						
Yes	26	(67)	799	(82)		
No	13	(33)	172	(18)	0.02	2.32 (1.17-4.61)
Long straight road						
No	22	(50)	767	(66)		
Yes	22	(50)	396	(34)	0.03	1.94 (1.06-3.54)
Vehicles/temporary obstacles						
No	36	(82)	703	(60)		
Yes	8	(18)	460	(40)	0.01	0.34 (0.16-0.74)

Table 6: Multivariable logistic regression model for risk factors for RTAs by 12 months of age in a UK cat cohort

Variable	RTA reported	(%)	No RTA reported	(%)	*p*-value	Odds Ratio (95% Confidence Interval)
Home Location						
Town/city or Village/suburban	20	(77)	676	(91)		1.00
Rural	6	(23)	68	(9)	0.05	2.66 (1.02-6.94)
Hunts at Roadside						
No	19	(73)	666	(90)		1.00
Yes	7	(27)	78	(11)	0.01	3.30 (1.31-8.31)
Long Straight Road						
No	9	(35)	427	(57)		1.00
Yes	17	(65)	317	(43)	0.02	2.84 (1.23-6.58)