**Urinary incontinence in bitches under primary veterinary care in England: prevalence, risk factors and outcomes**

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## **Running title**:

Urinary incontinence in bitches

## Key Words:

VetCompass, epidemiology, urethra, bladder, dog

## Abbreviations:

CI; confidence intervals, EPR; electronic patient record, PMS: practice management system, USMI; urethral sphincter mechanism incompetence,

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## Structured Summary

### *Objectives*

Urinary incontinence is a reportedly common and distressing disorder in bitches. This study aimed to estimate the prevalence and demographic risk factors in bitches under primary veterinary care in England.

### *Methods*

The study population included all bitches within the VetCompass Programme database from September 1st, 2009 to July 7th, 2013. Electronic patient records were searched for urinary incontinence cases and additional demographic and clinical information was extracted.

### *Results*

The study population comprised 100,397 bitches attending 119 clinics in England of which xxx were diagnosed with UI? (or subsample I guess). The prevalence of urinary incontinence was 3.14% (95% CI 2.97-3.33). Medical therapy was prescribed to 344/754 (45.6%) cases. Multivariable modelling identified the Irish setter (OR: 8.09, 95% CI 3.15-20.80, *P* < 0.001) and Dobermann (OR: 7.98, 95% CI 4.38-14.54, *P* < 0.001) as breeds with the highest odds. Bitches weighing at or above the mean adult bodyweight for their breed had 1.31 times the odds of UI diagnosis (95% CI 1.12-1.54, *P* < 0.001). Bitches aged 9 to < 12 years showed 3.86 (95% CI 2.86-5.20, *P* < 0.001) times the odds, neutered bitches had 2.23 (95% CI 1.52-3.25, *P* < 0.001) times the odds and insured bitches had 1.59 (95% CI 1.34-1.88, *P* < 0.001) times the odds. Increasing adult bodyweight was associated with increasing risk of urinary incontinence.

### *Clinical Impact*

UI was identified as a relatively common condition of bitches and for high risk breeds up to 15-30% of females were affected. There were major welfare impacts for many of the bitches diagnosed and in over 15% of assisted (?) deaths UI was considered a contributory factor in the decision to euthanase…?. Small animal practitioners can now assist their clients with reliable statistics on the expected overall frequency and breeds at greatest risk for urinary incontinence . …..? not sure just something actually from the results… aniI.

## Introduction

Urinary incontinence (UI) is defined as involuntary leaking of urine from the bladder during the storage phase of micturition and can result from anatomical or functional abnormalities ([Coit and others 2008](#_ENREF_6), [Schaer 2010](#_ENREF_29)). UI is most commonly caused by urethral sphincter mechanism incompetence (USMI) in the adult bitch and ectopic ureters in the juvenile female dog ([Gregory 1994](#_ENREF_11), [Holt 1985](#_ENREF_12), [Thrusfield and others 1998](#_ENREF_36)). A complete diagnostic workup is recommended to investigate bitches with UI to discriminate between congenital and acquired disease, functional versus mechanical problems and to identify anatomical abnormalities ([Sam and Craig 2000](#_ENREF_28)). For bitches with acquired UI, a presumptive diagnosis of USMI is often made based on patient history, absence of abnormalities on clinical examination and response to medical treatment, including oestrogen or alpha adrenergic receptor agonist medication individually or in combination, with improvement or complete response supporting the diagnosis ([Gregory 1994](#_ENREF_11)). UI is often a distressing disorder for both owners and their pets, and negatively impacts the interaction between them ([de Bleser and others 2011](#_ENREF_7)). Effective treatment is important to canine welfare to avoid sequelae such as ascending urinary tract infection, urinary scalding of the skin and euthanasia of affected dogs ([Schaer 2010](#_ENREF_29)).

Reliable and up-to-date data on the prevalence of UI that are generalisable to the UK dog population are limited. Prevalence values for UI from 2% and 16% have been reported in neutered bitches, varying across the study designs and denominator populations investigated ([Forsee and others 2013](#_ENREF_10), [Okkens and others 1997](#_ENREF_24), [Thrusfield and others 1998](#_ENREF_36)). However, many of these reports have generally focused on the prevalence of USMI and are either dated, lack reliable counts and precision, or cannot estimate the true prevalence of the condition because they did not include all animals in the underlying population ([Holt 1985](#_ENREF_12), [Thrusfield and others 1998](#_ENREF_36)). Extrapolation of data between groups of dogs from different continents may also be unreliable ([Forsee and others 2013](#_ENREF_10)).

Risk factors reported for UI in bitches include breed, age, bodyweight, obesity,, neutering status, time of neutering, hormonal factors and tail docking ([Arnold 1997](#_ENREF_2), [de Bleser and others 2011](#_ENREF_7), [Forsee and others 2013](#_ENREF_10), [Gregory 1994](#_ENREF_11), [Holt and Thrusfield 1993](#_ENREF_13), [Power and others 1998](#_ENREF_27), [Spain and others 2004a](#_ENREF_31), [Thrusfield and others 1998](#_ENREF_36)). In the UK, Dobermann and old English sheepdog are reported as predisposed breeds, with Rottweiler, Weimaraner, Springer spaniel and Irish setter also considered at risk ([Holt and Thrusfield 1993](#_ENREF_13)). In other European countries, Boxers ([Arnold 1997](#_ENREF_2)) and Bouvier des Flanders ([Okkens and others 1997](#_ENREF_24)) have been reported at higher risk. The risk of UI is reported to increase with increasing age ([de Bleser and others 2011](#_ENREF_7), [Stöcklin-Gautschi and others 2001](#_ENREF_33), [Thrusfield and others 1998](#_ENREF_36)) and increasing weight ([Angioletti and others 2004](#_ENREF_1), [de Bleser and others 2011](#_ENREF_7), [Forsee and others 2013](#_ENREF_10), [Okkens and others 1997](#_ENREF_24), [Stöcklin-Gautschi and others 2001](#_ENREF_33)). Obesity has not been definitively confirmed as a cause of USMI ([Angioletti and others 2004](#_ENREF_1)), but it may worsen the degree of incontinence whereas bodyweight loss has been reported to improve clinical signs of incontinence ([Holt 2012](#_ENREF_14)).

It is widely believed that ovariohysterectomy increases the risk of UI in female dogs ([de Bleser and others 2011](#_ENREF_7), [Forsee and others 2013](#_ENREF_10), [Spain and others 2004a](#_ENREF_31), [Stöcklin-Gautschi and others 2001](#_ENREF_33), [Thrusfield and others 1998](#_ENREF_36)) despite a weak evidence base for these conclusions that was reported in a systematic review of the effect of neutering on UI ([Beauvais and others 2012](#_ENREF_5)). The evidence for an association between early neutering and UI is controversial and appears to be weak; one study showing a reduced risk following neutering before the first season ([Stöcklin-Gautschi and others 2001](#_ENREF_33)) but evidence of increased risk of UI in bitches neutered before 3 months of age seems stronger ([Beauvais and others 2012](#_ENREF_5), [Kustritz 2007](#_ENREF_18), [Spain and others 2004b](#_ENREF_32)).

The primary objectives of this study were to estimate the prevalence of UI in the general population of bitches under primary veterinary care in England and to evaluate demographic risk factors for urinary incontinence, with a particular focus on breed effects. These results will assist clinicians to identify individuals at risk in order to improve the diagnosis and management of this condition and to support decision-making advice to owners of at-risk individuals regarding neutering and weight management.

## Materials and methods

The VetCompass Programme ([VetCompass 2017](#_ENREF_37)) collates anonymised electronic patient record (EPR) data from primary-care veterinary practices in the UK for epidemiological research ([O'Neill and others 2014b](#_ENREF_22)). Collaborating practices were a convenience sample selected by their willingness to participate and their recording of clinical data within an appropriately configured practice management system (PMS). Practitioners can record summary diagnosis terms from an embedded VeNom Code list during episodes of care ([The VeNom Coding Group 2017](#_ENREF_35)). Information collected relates mainly to the owned dog population and includes patient demographic (species, breed, date of birth, sex, neuter status, insurance status and bodyweight) and clinical information (free-form text clinical notes, summary diagnosis terms, treatment and deceased status with relevant dates) data fields. EPR data are extracted from PMSs using integrated clinical queries and uploaded to a secure VetCompass relational database ([O'Neill and others 2016](#_ENREF_23)).

In this study, a cohort study design was used to estimate UI prevalence and a nested cross sectional? (sorry don’t know what an incidence study is – are we likely to confuse readers? Or just leave as cohort – we can look at risk factors from a cohort study anyway) study was used to evaluate risk factors for UI diagnosis ([Pearce 2012](#_ENREF_26)). The sampling frame included all bitches with at least one EPR (clinical note, VeNom summary term, bodyweight or treatment) uploaded to the VetCompass database from September 1st, 2009 to July 7th, 2013. Sample size calculations estimated that a study population of 73,901 bitches would be required to estimate the prevalence of a disease with an expected frequency of 2% within confidence limits of +/- 0.1% with a 95% confidence level and assuming a UK population of four million bitches ([Asher and others 2011](#_ENREF_3), [Epi Info 7 CDC 2015](#_ENREF_9))). Ethical approval of the project was granted by the RVC Ethics and Welfare Committee (reference number 00/2014).

The inclusion criteria for a UI case required a final diagnosis of urinary incontinence recorded in the EPR or prescription of a specific urinary incontinence therapy (product containing phenylpropanolamine or estradiol). UI recorded as occurring secondary to seizure activity was excluded. Case-finding involved initial screening of all EPRs for candidate UI cases by searching the clinical free-text field ( search terms included *incont, usmi, incompet, urethral sp, nocturia, wetting, wet the bed, dribbling urin, leaking urin*), the VeNom term field (*incont*) and the treatment field (*propal, incurin, enurace, urilin, proin*). Findings from these searches were merged and the full clinical notes of a random subset were manually reviewed for case inclusion by one author (AR). Randomisation used the *RAND* function in Microsoft Excel (Microsoft Office Excel 2007, Microsoft Corp.). Additional data were extracted on all confirmed UI cases to define each case as pre-existing (first recorded prior to the study period) or incident (first recorded during the study period), whether the animal died during the study period and, if so, the date and method of death (euthanasia or unassisted) and whether UI was recorded as a contributory factor for the death. For incident cases, the date of the first diagnosis and whether medication was prescribed to control UI were also extracted. All bitches that were not identified as candidate UI cases during the initial screening were included as non-cases in the risk factor analysis.

A *breed* variable included any individual breeds with 10 or more UI cases, a grouped category of all remaining breeds and a general grouping of crossbred bitches. A *purebred* variable categorised all bitches with a recognisable breed name as ‘purebred’ and the remaining bitches as ‘crossbred’ ([Irion and others 2003](#_ENREF_16)). A Kennel Club (KC) *KC breed group* variable classified breeds recognised by the KC into their relevant breed groups (gundog, hound, pastoral, terrier, toy, utility and working) and all remaining bitches were classified as non-KC recognised ([The Kennel Club 2017](#_ENREF_34)). *Neuter* described the recorded status of the dog (neutered or entire) at the final EPR. *Insurance* described whether a dog was recorded as insured at any point during the study period. *Age* described the age at the date of first recorded diagnosis for incident UI cases and described the age at the mid-point between the dates of the first and final EPRs recorded during the study period for all other animals. *Age* (years) was categorised into six groups (< 3.0, 3.0-5.9, 6.0-8.9, 9.0-11.9, ≥ 12.0, not recorded). *Adult bodyweight* described the maximum bodyweight recorded during the study period for bitches older than nine months and was categorised into six groups (0.0-9.9 kg, 10.0-19.9 kg, 20.0-29.9 kg, 30.0-39.9 kg, ≥ 40.0 kg, not recorded). Mean adult bodyweight was calculated for each breed in the study and used to generate a *breed relative bodyweight* variable that characterised bitches as either below or equal/above the mean adult bodyweight for their breed. This variable allowed the effect of adult body weight *within* each breed to be assessed. The *time* contributed to the study for each dog described the period from the dates of the earliest to the latest EPR.

Following data checking and cleaning in Excel (Microsoft Office Excel 2013, Microsoft Corp.), analyses were conducted using Stata Version 13 (Stata Corporation). The period prevalence with 95% confidence intervals (CI) described the probability of having UI at any time during the study period and included bitches that were diagnosed with UI prior to the study period (pre-existing cases) as well as those diagnosed for the first time during the study period (incident cases). The case count that would have been identified if the entire set of candidate cases had been manually verified was calculated by weighting the verified case numbers by the inverse of the proportion of candidate cases that was manually verified ([O'Neill and others 2016](#_ENREF_23)). The overall and breed prevalence of UI could be thus estimated based on a denominator of all study bitches either overall or by breed respectively. The CI estimates were derived from standard errors, based on approximation to the normal distribution ([Kirkwood and Sterne 2003](#_ENREF_17)). Descriptive statistics characterised the breed, neuter status, insurance status, age, adult bodyweight and time contributed to the study for the incident cases and non-case bitches. The medical management regimes were reported for incident cases only. Mortality results were reported on all UI cases.

Binary logistic regression modelling was used to evaluate univariable associations between risk factors (*breed, purebred, KC breed group, adult bodyweight, breed relative bodyweight, age, neuter* and *insurance*) and incident cases of urinary incontinence. Breed was a factor of primary interest for the study. The *purebred*, *KC breed group* and *adult bodyweight* variables were correlated with the *breed* variable and were therefore not simultaneously considered in multivariable modelling. Instead, the results for these correlated variables were derived by individually replacing the *breed* variable from the final breed multivariable model.

Risk factors with liberal associations in univariable modelling (*P* < 0.2) were taken forward for multivariable evaluation. Model development used manual backwards stepwise elimination. Clinic attended was evaluated as a random effect and pair-wise interaction effects were evaluated for the final model ([Dohoo and others 2009](#_ENREF_8)). The Hosmer-Lemeshow test statistic and the area under the ROC curve were used to evaluate the quality of model fit (non-random effect model) ([Dohoo and others 2009](#_ENREF_8), [Hosmer and Lemeshow 2000](#_ENREF_15)). Statistical significance was set at *P* < 0.05.

## Results

The overall dataset comprised 100,397 bitches attending 119 clinics in England. Overall, 4,559 animals were identified as candidates for urinary incontinence. Of 1,637 (35.9%) candidates that were manually checked, there were 1,116 bitches that met the case definition for UI, comprising 754 (67.56%) incident and 362 (32.44%) pre-existing cases. The median (interquartile range [IQR], range) time contributed to the study for each study bitch from the first to the final EPR was 0.6 years (0.0-2.1, 0.0-5.0).

Data completeness were?: breed 99.9%, age 99.7%, adult bodyweight 65.6%, insurance 57.8% and neuter status 47.0%. Of the overall UI cases with information available, 871 (78.1 %) were purebred, 870 (95.92%) were neutered and 484 (53.3%) were insured. The median adult bodyweight was 22.6 kg (IQR: 13.6-30.9, range: 1.9-75.0) and the median age at diagnosis was 10.6 years (IQR: 5.8-13.1, range: 0.3-19.0) (Figure 1). The most common breeds diagnosed with UI were the Labrador retriever (n = 92, 8.2%), B?order collie (59, 5.3%), German shepherd dog (56, 5.0%), West Highland white terrier (51, 4.6%) and Staffordshire bull terrier (48, 4.3%), along with 244 (21.9%) crossbreds.

Of the non-case bitches with information available, 73,877 (77.1%) were purebred, 35,037 (80.3%) were neutered and 21,091 (38.8%) were insured. The median adult bodyweight was 16.4 kg (IQR: 9.5-26.4, range: 0.7-99.0) and the median age was 3.9 years (IQR: 1.3-8.0, range: 0.0-28.8). The most common breeds among the non-case bitches were the Staffordshire bull terrier (8,074, 8.4%), Labrador retriever (7,906, 8.3%), Jack Russell terrier (6,432, 6.7%) and Cocker spaniel (3,516, 3.7%) along with 21,895 (22.9%) crossbreds.

After accounting for the sampling approach, the estimated prevalence for UI in bitches overall was 3.14% (95% CI 2.97-3.33). Breeds with the highest prevalence included the Irish setter (32.3%, 95% CI 23.6-41.6), Dobermann (21.6%, 95% CI 17.4-26.6), B?earded collie (16.5%, 95% CI 11.6-22.8), R?ough collie (95% CI 16.3%, 95% CI 12.1-20.9) and Dalmatian (15.8%, 95% CI 12.2-19.7). The prevalence in crossbreds was 3.1% (95% CI 2.8-3.3) (Table 1).

Medical therapy directed specifically at managing UI was prescribed to 344/754 (45.6%) of the incident cases. During the study period, 407/1,116 (36.5%) of the studied? UI caseload died and 366/387 (94.6%) deceased bitches with a recorded mechanism of death were euthanased? euthanasia. The median age at death was 13.7 (IQR 21.1-15.0, range 1.1-18.9) years. UI was recorded as either contributory or the main reason for death in 68/407 (16.7%) incontinent bitches that died.

The risk factor analysis included 754 incident UI cases and 95,838 non-cases. Univariable logistic regression modelling identified seven variables liberally associated (*P* < 0.20) with urinary incontinence: (*breed, KC breed group, adult bodyweight, breed relative bodyweight, age, neuter* and *insurance*) (Table 2). Following evaluation using multivariable logistic regression, the final breed model comprised five risk factors: *breed, breed relative bodyweight, age, neuter* and *insurance*. No biologically significant interactions were identified. The final model was improved by inclusion of the clinic attended as a random effect (*P* < 0.001, rho = 0.032, indicating that the clinic attended accounted for 3.2% of variation) and the latter was retained in the final model?d. For the final non-clustered breed model, the Hosmer-Lemeshow test indicated adequate (or no evidence of poor fit..) model fit (P = 0.777) and the area under ROC curve (0.848) indicated excellent UI discrimination (Hosmer and Lemeshow 2000).

After accounting for the effects of the other variables evaluated, 10 breeds showed increased odds of UI compared with crossbred bitches. Breeds with the highest odds included the Irish setter (OR: 8.09, 95% CI 3.15-20.80, *P* < 0.001), Dobermann (OR: 7.98, 95% CI 4.38-14.54, *P* < 0.001), B?ull mastiff (OR: 6.24, 95% CI 2.67-14.58, *P* < 0.001) and R?ough collie (OR: 3.75, 95% CI 1.96-7.18, *P* < 0.001). The Jack Russell terrier, Yorkshire terrier and C?ocker spaniel showed reduced odds. Bitches weighing at or above the mean adult bodyweight for their breed had 1.31 times the odds (95% CI 1.12-1.54, *P* < 0.001) of UI compared with bitches weighing below their breed mean. Increasing age was associated with increasing risk of developing urinary incontinence; the odds of UI increased sequentially with each category of increasing age. Bitches aged 9 to 12 years showed 3.86 (95% CI 2.86-5.20, *P* < 0.001) times the odds of UI compared with those aged less than 3 years. Neutered bitches had 2.23 (95% CI 1.52-3.25, *P* < 0.001) times the odds and insured bitches had 1.59 (95% CI 1.34-1.88, *P* < 0.001) times the odds of UI compared with entire and uninsured bitches respectively (Table 3).

Additionally, *KC breed group* and *adult bodyweight* were significant risk factors when replacing the breed variable in the final breed model. There was no evidence for an association between purebred status and UI. Of the KC breed groups, Working (OR 3.07, 95% CI 2.29-4.11, *P* < 0.001) and Pastoral (OR 1.87, 95% CI 1.47-2.39, *P* < 0.001) group bitches showed higher odds of UI compared with KC non-recognised breeds, whilst toy breeds had reduced odds of UI (OR 0.69, 95% CI 0.50-0.95, P=0.025). Increasing adult bodyweight was associated with increasing risk of urinary incontinence; the odds of UI increased sequentially with each body weight category. Bitches weighing over 30kg had 2.94 times the odds (95% CI 2.27-3.80, *P* < 0.001) of UI compared with bitches weighing under 10 kg (Table 4).

## Discussion

This study investigated bitches attending 119 primary-care practices in England by analysing a database containing the clinical records of 100,397 female dogs. Investigating such large numbers supports the reporting of a precise prevalence of 3.14% for UI diagnosed in this population. This result is likely to be more accurate and generalisable than smaller studies and those focusing on either at-risk dogs or referral populations ([Bartlett and others 2010](#_ENREF_4), [O'Neill and others 2014a](#_ENREF_21)). Irish setter, Dobermann, bull mastiff, rough Collie, Dalmatian and boxer breeds had the highest odds of UI with approximately 1/3 of all Irish Setters being diagnosed with the condition….and Jack Russell and Yorkshire terriers had reduced odds. The risk of UI increased with age and weight. Neutered bitches and insured animals were both at increased risk of UI.

Direct comparisons between the results of the current study with previous reports are complicated by the differing aims and study populations of the available studies. Many previous investigations aimed to specifically investigate the USMI subset of cases rather than the more general caseload of UI cases undertaken by the current study ([Gregory 1994](#_ENREF_11), [Holt 1985](#_ENREF_12)). These earlier studies also often focused entirely on a particular risk group (e.g. neutered bitches) rather than the total population and often did not include a control group which may bias the reported demographic, prevalence, incidence and risk factor findings ([Arnold 1997](#_ENREF_2), [de Bleser and others 2011](#_ENREF_7), [Forsee and others 2013](#_ENREF_10), [Thrusfield and others 1998](#_ENREF_36)). However, despite these constraints, many of the breeds identified at higher odds in the current study are consistent with results from previous studies, including the Irish setter, Dobermann, Weimaraner and S?pringer spaniel ([Holt and Thrusfield 1993](#_ENREF_13)) and the Boxer ([Arnold 1997](#_ENREF_2)). Boxers were the most commonly diagnosed breed in a UK urinary incontinence study (four of 18 cases overall) ([Thrusfield and others 1998](#_ENREF_36)) and we found that this breed has an increased odds of just over 3 times the crossbred controls nearly two decades later. However, by contrast, the old English sheepdog has also previously reported at increased risk ([Holt and Thrusfield 1993](#_ENREF_13)) but was not identified with increased odds of UI in the current study. This may result from true changing risk for these breeds over time, a changing breed demographic over time or insufficient breed counts in the current study for statistical power.

The current study identified that bitches of adult bodyweight over 10kg have approximately double the risk of UI, concurring with several previous reports ([Angioletti and others 2004](#_ENREF_1), [de Bleser and others 2011](#_ENREF_7), [Okkens and others 1997](#_ENREF_24), [Stöcklin-Gautschi and others 2001](#_ENREF_33)). Bitches weighing over15kg were reported as having seven times the odds of UI, although this study included only neutered females ([Forsee and others 2013](#_ENREF_10)). Bigger breed dogs have been reported to have increased risk of UI ([Thrusfield and others 1998](#_ENREF_36)){Forsee, 2013 #17}. Of the ten breeds identified in our study with increased odds of UI in the multivariable analysis, only the English springer spaniel did not represent a large or giant breed. Bodyweight and breed are highly related factors whereby individual breed standards often describe bodysize characteristics ([The Kennel Club 2017](#_ENREF_34)). Consequently, statistical modelling methods can struggle to clarify which of these correlated breed or bodyweight variables represents the major association..? the primary association, confounding or interactive ([Dohoo and others 2009](#_ENREF_8)). However, the finding of the current study that individuals within particular breeds weighing at or above the breed average have 1.3 times the risk of UI compared with bitches below the breed average may assist in addressing this question somewhat and supports the conclusion that bodyweight in addition to breed is a substantial risk factor for UI.

The current study identified that the odds of developing UI rise substantially with age. Although the current study included all causes of urinary incontinence and it is generally accepted that congenital and anatomical causes tend to present at younger age, the association with increased age suggests that the majority of UI in bitches is acquired and that a higher proportion of USMI develops later in life This association with increased age is supported by the very similar odds ratios for the age categories that were also reported in a specific USMI study of UK neutered bitches ([de Bleser and others 2011](#_ENREF_7)). It is worth noting that = if some bitches with congenital or anatomic causes (e.g. ectopic ureters) were not be diagnosed until later in life this might limit this conclusion ([McLoughlin and Chew 2000](#_ENREF_20)). Nb can we say from the notes though that most had no evidence of a congenital or anatomic cause…? Could also comment that given most were age x or above – and without evidence of incontinence from an early age that the likelihood of many being congenital / anatamoic would be small? Finish on that?

Neutered bitches were shown to be at increased risk in our study, independent of relative bodyweight and age. Neutering is widely considered to be a risk factor for UI in female dogs ([de Bleser and others 2011](#_ENREF_7), [Forsee and others 2013](#_ENREF_10), [Spain and others 2004a](#_ENREF_31), [Stöcklin-Gautschi and others 2001](#_ENREF_33), [Thrusfield and others 1998](#_ENREF_36)). However, a systematic review of the effect of neutering on UI concluded that the evidence base for such assertions was weak ([Beauvais and others 2012](#_ENREF_5)). Neutering of bitches is reported to increase the ratio of collagen to muscle in the urethra, is associated with obesity which can worsen the signs of UI even if it is not truly a cause, and also leads to lower blood oestrogen levels which may reduce urethral smooth and striated muscle tone ([Coit and others 2008](#_ENREF_6), [de Bleser and others 2011](#_ENREF_7)). In the current study, neutered bitches had 2.2 times the odds of UI on multivariate analysis compared with entire animals which would appear to support an association between neutering and urinary incontinence. However, data were not available on the age at neutering or the time from neutering to the onset of UI and therefore this limits the study to reporting associations for neutering rather than assigning casualty ([Pandis 2011](#_ENREF_25)). There are many interactions likely between the timing of neutering, both absolute in terms of age and relative in terms of puberty, method of neutering, and other factors including breed and bodyweight that would require prospective cohort study designs for full elucidation ([Coit and others 2008](#_ENREF_6), [Dohoo and others 2009](#_ENREF_8)).

This report identifies some important welfare implications for bitches diagnosed with UI. Of the 407 affected bitches with UI that died during the study period, the UI condition contributed either partly or wholly to 16.7% of the deaths. Many of these patients are likely to have suffered morbidity as a result of UI sequelae including urinary scalding and urinary tract infection Ref needed. UI can also have a negative impact on the owner-pet relationship resulting from house soiling, emotional stress and malodour ([de Bleser and others 2011](#_ENREF_7)). The current study also shows that 45.6% of incident cases received specific medical management for UI which may impose financial and potentially emotional strain on owners.

The study had some limitations. Not all of the candidate cases identified in the original search strategy were manually reviewed in detail and therefore the prevalence estimates were calculated based on the subset that were examined. However, the subset of candidate animals reviewed should reflect the study population overall as a result of their randomised selection and the sizeable number of cases (n = 1,503) manually identified. As previously reported, these data were not recorded primarily for research purposes and thus were limited by some missing and incomplete data as well as also relying on the clinical acumen and record-keeping of the clinicians ([Mattin and others 2015](#_ENREF_19), [O'Neill and others 2016](#_ENREF_23), [Shoop and others 2015](#_ENREF_30)). It was sometimes not possible to discriminate in the EPRs between incontinence of faecal or urinary origin, especially where no treatments or additional specific information was included in the clinical notes; these uncertain incontinence cases were excluded from the current UI analysis and therefore the true prevalence may be higher than we were able to report. The study included all cases diagnosed with UI and did not attempt to categorise these into congenital, anatomic or acquired subsets.

## Conclusion

This is the largest study describing the prevalence and risk factors for UI in dogs to date. UI is shown to be commonly diagnosed in primary-care practice, affecting just over 3% of bitches, but up to as much as 15-30% of bitches in a number of high risk breeds???. The prevalence and risk factors identified can assist clinicians by improving the evidence base supporting clinical recommendations on neutering and weight control, especially in breeds identified here such as the Irish setter, Dobermann, R?ough collie, Dalmation and Boxer.

## Figures

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Figure 1. Age at diagnosis of urinary incontinence in 754 incident cases of urinary incontinence in bitches attending primary-care veterinary practices in England.

## Tables

Table 1: Estimated prevalence and 95% confidence interval (CI) of urinary incontinence in bitches of commonly diagnosed dog breeds attending primary-care veterinary practices in England.

|  |  |  |
| --- | --- | --- |
| Breed | Prevalence | 95% CI |
| Irish Red Setter | 32.3 | 23.6-41.6 |
| Dobermann | 21.6 | 17.4-26.6 |
| Bearded Collie | 16.5 | 11.6-22.8 |
| Rough Collie | 16.3 | 12.1-20.9 |
| Dalmatian | 15.8 | 12.2-19.7 |
| Weimaraner | 10.7 | 7.7-14.4 |
| Bull Mastiff | 10.4 | 7.0-14.7 |
| Miniature Poodle | 9.5 | 6.5-13.6 |
| Boxer | 7.3 | 5.9-8.8 |
| English Springer Spaniel | 6.8 | 5.6-8.1 |
| Border Collie | 6.6 | 5.6-7.6 |
| Greyhound | 6.4 | 5.1-8.1 |
| West Highland White Terrier | 6.0 | 5.1-7.1 |
| German Shepherd Dog | 4.8 | 4.1-5.6 |
| Golden Retriever | 4.4 | 3.4-5.5 |
| Rottweiler | 3.8 | 2.8-5.0 |
| Labrador Retriever | 3.2 | 2.8-3.6 |
| Crossbreed | 3.1 | 2.8-3.3 |
| Cocker Spaniel | 2.0 | 1.6-2.6 |
| Cavalier King Charles Spaniel | 1.8 | 1.3-2.5 |
| Yorkshire Terrier | 1.7 | 1.3-2.2 |
| Staffordshire Bull Terrier | 1.6 | 1.4-2.0 |
| Jack Russell Terrier | 1.5 | 1.2-1.8 |

Table 2: Univariable logistic regression results for risk factors associated with incidence of urinary incontinence in 96,592 bitches attending primary-care veterinary practices in England.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Variable | Category | Odds ratio | 95% CI | Category *P*-value | Variable *P*-value |
| Purebred status | Crossbred | Base |  |  | 0.569 |
|  | Purebred | 0.95 | 0.80-1.13 | 0.567 |  |
| Common breeds | Crossbreed | Base |  |  | < 0.001 |
|  | Irish Red Setter | 6.18 | 2.49-15.35 | < 0.001 |  |
|  | Dobermann | 5.35 | 3.01-9.51 | < 0.001 |  |
|  | Rough Collie | 4.91 | 2.64-9.13 | < 0.001 |  |
|  | Dalmatian | 4.01 | 2.22-7.26 | < 0.001 |  |
|  | Bearded Collie | 3.49 | 1.42-8.60 | 0.006 |  |
|  | Weimaraner | 3.15 | 1.60-6.19 | 0.001 |  |
|  | Bull Mastiff | 2.83 | 1.24-6.45 | 0.013 |  |
|  | Boxer | 2.31 | 1.50-3.55 | < 0.001 |  |
|  | Greyhound | 2.19 | 1.36-3.54 | 0.001 |  |
|  | West Highland White Terrier | 1.86 | 1.29-2.67 | 0.001 |  |
|  | English Spaniel Springer | 1.74 | 1.14-2.68 | 0.011 |  |
|  | Border Collie | 1.71 | 1.18-2.47 | 0.004 |  |
|  | German Shepherd Dog | 1.34 | 0.93-1.92 | 0.119 |  |
|  | Miniature Poodle | 1.30 | 0.41-4.10 | 0.653 |  |
|  | Golden Retriever | 1.29 | 0.78-2.12 | 0.325 |  |
|  | Labrador Retriever | 0.99 | 0.74-1.32 | 0.946 |  |
|  | Rottweiler | 0.94 | 0.48-1.84 | 0.857 |  |
|  | Cavalier King Charles Spaniel | 0.68 | 0.37-1.24 | 0.208 |  |
|  | Other breed-types | 0.67 | 0.54-0.84 | < 0.001 |  |
|  | Cocker Spaniel | 0.59 | 0.36-0.97 | 0.039 |  |
|  | Staffordshire Bull Terrier | 0.59 | 0.42-0.84 | 0.003 |  |
|  | Yorkshire Terrier | 0.53 | 0.31-0.91 | 0.022 |  |
|  | Jack Russell Terrier | 0.49 | 0.33-0.75 | 0.001 |  |
| Kennel Club Breed Groups | Not KC-recognised | Base |  |  | < 0.001 |
|  | Gundog | 1.29 | 1.05-1.58 | 0.017 |  |
|  | Hound | 1.20 | 0.85-1.71 | 0.299 |  |
|  | Pastoral | 2.03 | 1.60-2.59 | < 0.001 |  |
|  | Terrier | 0.98 | 0.77-1.25 | 0.850 |  |
|  | Toy | 0.55 | 0.40-0.76 | < 0.001 |  |
|  | Utility | 0.78 | 0.56-1.08 | 0.137 |  |
|  | Working | 1.79 | 1.35-2.37 | < 0.001 |  |
| Adult bodyweight (kg) | < 10.0 | Base |  |  | < 0.001 |
|  | 10.0-19.9 | 1.80 | 1.43-2.28 | < 0.001 |  |
|  | 20.0-20.9 | 2.42 | 1.93-3.04 | < 0.001 |  |
|  | 30.0-30.9 | 3.26 | 2.56-4.15 | < 0.001 |  |
|  | ≥ 40.0 | 3.18 | 2.28-4.44 | < 0.001 |  |
| Breed relative bodyweight | Lower | Base |  |  | < 0.001 |
|  | Equal/Higher | 1.53 | 1.31-1.78 | < 0.001 |  |
| Age (years) | < 3.0 | Base |  |  | < 0.001 |
|  | 3.0 - < 6.0 | 3.67 | 2.74-4.94 | < 0.001 |  |
|  | 6.0 - < 9.0 | 4.69 | 3.48-6.33 | < 0.001 |  |
|  | 9.0 - < 12.0 | 8.02 | 6.01-10.72 | < 0.001 |  |
|  | ≥ 12.0 | 19.74 | 15.15-25.72 | < 0.001 |  |
| Neuter status | Entire | Base |  |  | < 0.001 |
|  | Neutered | 4.87 | 3.37-7.03 | < 0.001 |  |
| Insurance | Non-insured | Base |  |  | < 0.001 |
|  | Insured | 1.69 | 1.44-1.97 | < 0.001 |  |

Table 3: Breed-focused mixed-effects multivariable logistic regression results for risk factors associated with urinary incontinence diagnosis in bitches attending primary-care veterinary practices in England. \*CI confidence interval

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Variable | Category | Odds ratio | 95% CI\* | Category *P*-value | Variable *P*-value |
| Common breeds | Crossbreed | Base |  |  | < 0.001 |
|  | Irish Red Setter | 8.09 | 3.15-20.80 | < 0.001 |  |
|  | Dobermann | 7.98 | 4.38-14.54 | < 0.001 |  |
|  | Bull Mastiff | 6.24 | 2.67-14.58 | < 0.001 |  |
|  | Rough Collie | 3.75 | 1.96-7.18 | < 0.001 |  |
|  | Dalmatian | 3.26 | 1.76-6.06 | < 0.001 |  |
|  | Boxer | 3.03 | 1.95-4.72 | < 0.001 |  |
|  | Weimaraner | 2.65 | 1.32-5.32 | 0.006 |  |
|  | Bearded Collie | 2.22 | 0.87-5.67 | 0.096 |  |
|  | Greyhound | 2.05 | 1.26-3.35 | 0.004 |  |
|  | English Spaniel Springer | 1.65 | 1.07-2.57 | 0.025 |  |
|  | Rottweiler | 1.63 | 0.82-3.23 | 0.160 |  |
|  | German Shepherd Dog | 1.62 | 1.12-2.35 | 0.011 |  |
|  | West Highland White Terrier | 1.23 | 0.85-1.78 | 0.280 |  |
|  | Border Collie | 1.22 | 0.84-1.78 | 0.302 |  |
|  | Labrador Retriever | 0.90 | 0.67-1.20 | 0.474 |  |
|  | Miniature Poodle | 0.88 | 0.27-2.82 | 0.825 |  |
|  | Golden Retriever | 0.83 | 0.50-1.37 | 0.462 |  |
|  | Staffordshire Bull Terrier | 0.83 | 0.58-1.18 | 0.292 |  |
|  | Cavalier King Charles Spaniel | 0.64 | 0.34-1.18 | 0.152 |  |
|  | Cocker Spaniel | 0.57 | 0.34-0.94 | 0.029 |  |
|  | Yorkshire Terrier | 0.47 | 0.27-0.81 | 0.007 |  |
|  | Jack Russell Terrier | 0.43 | 0.28-0.65 | < 0.001 |  |
| Breed relative bodyweight | Lower | Base |  |  | < 0.001 |
|  | Equal/Higher | 1.31 | 1.12-1.54 | < 0.001 |  |
| Age (years) | < 3.0 | Base |  |  | < 0.001 |
|  | 3.0 - < 6.0 | 1.88 | 1.39-2.55 | < 0.001 |  |
|  | 6.0 - < 9.0 | 2.20 | 1.62-2.99 | < 0.001 |  |
|  | 9.0 - < 12.0 | 3.86 | 2.86-5.20 | < 0.001 |  |
|  | ≥ 12.0 | 12.65 | 9.61-16.65 | < 0.001 |  |
| Neuter status | Entire | Base |  |  | < 0.001 |
|  | Neutered | 2.23 | 1.52-3.25 | < 0.001 |  |
| Insurance | Non-insured | Base |  |  | < 0.001 |
|  | Insured | 1.59 | 1.34-1.88 | < 0.001 |  |

Table 4: Results for Kennel Club (KC) breed group and adult bodyweight as risk factors for urinary incontinence diagnosis in bitches attending primary-care veterinary practices in England. These variables each individually replaced the breed variable in the original mixed-effects multivariable logistic regression modelling. \*CI confidence interval

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Variable | Category | Odds ratio | 95% CI | Category *P*-value | Variable *P*-value |
| KC Breed Group | Not KC-Recognised | Base |  |  | < 0.001 |
|  | Utility | 0.95 | 0.68-1.32 | 0.749 |  |
|  | Toy | 0.69 | 0.50-0.95 | 0.025 |  |
|  | Working | 3.07 | 2.29-4.11 | < 0.001 |  |
|  | Pastoral | 1.87 | 1.47-2.39 | < 0.001 |  |
|  | Gundog | 1.17 | 0.94-1.45 | 0.157 |  |
|  | Hound | 1.33 | 0.93-1.91 | 0.113 |  |
|  | Terrier | 1.04 | 0.81-1.34 | 0.739 |  |
|  |  |  |  |  |  |
| Adult bodyweight (kg) | < 10.0 | Base |  |  | < 0.001 |
|  | 10.0-19.9 | 1.61 | 1.27-2.05 | < 0.001 |  |
|  | 20.0-20.9 | 2.24 | 1.77-2.83 | < 0.001 |  |
|  | 30.0-30.9 | 2.94 | 2.27-3.80 | < 0.001 |  |
|  | ≥ 40.0 | 3.65 | 2.56-5.22 | < 0.001 |  |

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