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

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Structured Summary

Objectives

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

Methods

The study population included all bitches within the VetCompass 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

Of 100,397 bitches attending 119 clinics in England, an estimated 3,108 were diagnosed with urinary incontinence. The prevalence of urinary incontinence was 3.14% (95% CI 2.97-3.33). Medical therapy was prescribed to 45.6% cases. Predisposed breeds included 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, $P < 0.001$). Bitches weighing at or above the mean adult bodyweight for their breed had 1.31 times the odds (95% CI 1.12-1.54, $P < 0.001$). Increasing adult bodyweight was associated with increasing risk. 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.

Clinical Impact

Urinary incontinence affects just over 3% of bitches overall but affects over 15% of bitches in high risk breeds including the Irish Setter, Dobermann, Bearded Collie, Rough Collie and Dalmatian. These results provide an evidence base for clinicians to enhance clinical recommendations on neutering and weight control, especially in high-risk breeds.

Key Words:

VetCompass, epidemiology, urethra, bladder, dog

Abbreviations

CI; confidence intervals, EPR; electronic patient record, OR; odds ratio, PMS: practice management system, UI; urinary incontinence, USMI; urethral sphincter mechanism incompetence,

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, Schaer 2010). UI most commonly results from urethral sphincter mechanism incompetence (USMI) in the adult bitch and from ectopic ureters in the juvenile bitch (Gregory 1994, Holt 1985, Thrusfield and others 1998). A complete diagnostic workup is required 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). 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, Sam and Craig 2000). UI is often a distressing disorder for both owners and their pets, and may negatively impact the interaction between them (de Bleser and others 2011). Effective management 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).

Reliable and up-to-date data on the prevalence of UI that are generalisable to the dog population in England 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, Okkens and others 1997, Thrusfield and others 1998). However, many of these reports have focused on the prevalence specifically of USMI and are either dated, lacking in 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, Thrusfield and others 1998). Extrapolation of data between groups of dogs from different continents may also be unreliable (Forsee and others 2013).

Risk factors reported for UI in bitches include breed, age, bodyweight, obesity, neutering status, time of neutering, hormonal factors and tail docking (Arnold 1997, de Bleser and others 2011, Forsee and others 2013, Gregory 1994, Holt and Thrusfield 1993, Power and others 1998, Spain and others 2004a, Thrusfield and others 1998). 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). In other European countries, Boxers (Arnold 1997) and Bouvier des Flanders (Okkens and others 1997) have been reported at higher risk. The risk of UI is reported to rise with increasing age (de Bleser and others 2011, Stöcklin-Gautschi and others 2001, Thrusfield and others 1998) and increasing weight (Angioletti and others 2004, de Bleser and others 2011, Forsee and others 2013, Okkens and others 1997, Stöcklin-Gautschi and others 2001). Obesity has not been definitively confirmed as a cause of USMI (Angioletti and others 2004), but it may worsen the degree of incontinence whereas bodyweight loss has been reported to improve clinical signs of incontinence (Holt 2012).

Several studies have reported that neutering is associated with increased risk of UI in bitches (de Bleser and others 2011, Forsee and others 2013, Spain and others 2004a, Stöcklin-Gautschi and others 2001, Thrusfield and others 1998) although a weak evidence base for these conclusions was reported in a systematic review of the effect of neutering on UI (Beauvais and others 2012). The evidence for an association between early neutering and UI is controversial and appears to be weak; one study reported a reduced risk following neutering before the first season (Stöcklin-Gautschi and others 2001) but evidence of increased risk of UI in bitches neutered before 3 months of age seems stronger (Beauvais and others 2012, Kustritz 2007, Spain and others 2004b).

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 diagnosis with UI, 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 collates anonymised electronic patient record (EPR) data from primary-care veterinary practices in the UK for epidemiological research (O'Neill and others 2014b). 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 could record summary diagnosis terms from an embedded VeNom Code list during episodes of care (The VeNom Coding Group 2017). 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 2016a).

In this study, a cohort study design was used to estimate UI prevalence and to evaluate risk factors for UI diagnosis (Pearce 2012). 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 and that were deemed to be under veterinary care during this period. The epidemiological unit for this study was the bitch and each bitch was aimed to be included only once in the analysis by linking to its unique ID code in the PMS. 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 0.1% precision limits with a 95% confidence level, assuming a UK population of four million bitches (Asher and others 2011, Epi Info 7 CDC 2015)). 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 veterinary 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.). The count of candidate cases that were manually reviewed was based on the power analysis described earlier in the methods. Logistics constraints precluded manual review of all candidate cases. 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). 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). *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 so that the results reflect associations with the age at 'becoming' a UI case. It was assumed that the dates for first diagnosis of UI cases would be randomly spread throughout the study period and therefore *Age* described the age at the mid-point between the dates of the first and final EPRs recorded during the study period for the non-cases so that these ages would be as representative as possible of the expected ages for these dogs if they had received a diagnosis of UI. *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.

Following data checking and cleaning in Excel to assess the completeness, internal data consistency and validity of the demographic and clinical data extracted from the VetCompass database (Microsoft Office Excel 2013, Microsoft Corp.) (O'Neill and others 2016b), analyses were conducted using Stata Version 13 (Stata Corporation). No bitches were removed from the analyses during the data cleaning process. The period prevalence with 95% confidence intervals (CI) described the probability of having UI at any time during the study period and was based on complete examination of a subset of 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 2016a). The overall period prevalence of UI was estimated based on a denominator of all study bitches and the breed-specific period prevalence of UI was estimated for each breed based on a denominator of all bitches of that breed in the study. The CI estimates were derived from standard errors, based on approximation to the normal distribution (Kirkwood and Sterne 2003). Descriptive statistics characterised the breed, neuter status, insurance status, age and adult bodyweight for the incident cases and non-case bitches. The medical management regimes were reported for incident cases only because clinical records extending back to the original date of first diagnosis of UI may not have been available for many pre-existing cases. 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. Inclusion of all cases (pre-existent and incident) into risk factor analysis has the effect of evaluating risk factors for 'being' a case rather than for 'becoming' a case and therefore bias towards higher odds ratios for factors associated with longer survival with UI. For example, long-lived breeds are more likely to be included compared with short-lived breeds. The current study aimed to evaluate risk factors for 'becoming' a case and therefore elected to include only incident cases that were diagnosed with UI during the study period. 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). 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, Hosmer and Lemeshow 2000). 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. From 1,637 (35.9%) candidates that were manually checked, 1,116 bitches met the case definition for UI that comprised of 754 (67.56%) incident and 362 (32.44%) pre-existing cases. Data on all 1,116 UI cases were included in the demographic descriptive evaluation. Data on just the 754 incident UI cases were included in the medical management evaluation and the risk factor analysis. An estimated 3,108 cases would have been identified if all candidate animals were checked. 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), Bearded Collie (16.5%, 95% CI 11.6-22.8), Rough Collie (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).

Data completeness overall were: breed 99.9%, age 99.7%, adult bodyweight 65.6%, insurance 57.8% and neuter status 47.0%. Descriptive evaluation included 1,116 UI cases and 95,838 non-cases. The median (interquartile range [IQR], range) time between the first and final EPR across all study bitches was 0.6 years (0.0-2.1, 0.0-5.0). Of the 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) and the median age at diagnosis was 10.6 years (IQR: 5.8-13.1) (Figure 1). The most common breeds diagnosed with UI were the Labrador Retriever (n = 92, 8.2%), Border 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) and the median age was 3.9 years (IQR: 1.3-8.0). 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.

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

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. Modelling 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) so the clinic random effect was retained in the final model. For the final non-clustered breed model, the Hosmer-Lemeshow test indicated no evidence of poor 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), Bull Mastiff (OR: 6.24, 95% CI 2.67-14.58, *P* < 0.001), Rough Collie (OR: 3.75, 95% CI 1.96-7.18, *P* < 0.001), Dalmatian (OR: 3.26, 95% CI 1.76-6.06, *P* < 0.001) and Boxer (OR: 3.03, 95% CI 1.95-4.72, *P* < 0.001). The Jack Russell Terrier, Yorkshire Terrier and Cocker 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 less than 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 used to replace the breed variable in the final breed model. There was no evidence for an association between purebred status and UI (*P* = 0.938). 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 bitches that were not of KC recognised breeds. 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 odds of UI. 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 UI in bitches attending 119 primary-care practices in England by analysing a database containing the clinical records of 100,397 bitches. Access to such large counts of bitches supports the reporting of an estimated prevalence of 3.14% for UI diagnosed in this population and this result is likely to be more accurate and generalisable than earlier smaller studies and those focusing on either at-risk dogs or referral populations (Bartlett and others 2010, O'Neill and others 2014a). Irish Setter, Dobermann, Bull Mastiff, Rough Collie, Dalmatian and Boxer breeds had the highest odds of UI, with approximately one third of all Irish Setters being diagnosed with the condition. Jack Russell Terriers and Yorkshire Terriers had reduced odds. The risk of UI increased with age and weight. Neutered bitches and insured animals were also associated with 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 previously available studies. Many earlier investigations aimed to specifically investigate the USMI subset of UI cases rather than the more general UI caseload covered by the current study (Gregory 1994, Holt 1985). These earlier studies often also focused entirely on a particular risk group (e.g. neutered bitches) rather than the total bitch population and often did not include a control group which may bias the reported demographic, prevalence, incidence and risk factor findings (Arnold 1997, de Bleser and others 2011, Forsee and others 2013, Thrusfield and others 1998). 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 Springer Spaniel (Holt and Thrusfield 1993) and Boxer (Arnold 1997). Boxers were the most commonly diagnosed breed in a UK urinary incontinence study (four of 18 cases overall) (Thrusfield and others 1998) and we found an increased odds of over 3 times the crossbred controls for this breed nearly 2 decades later. However, by contrast, the Old English Sheepdog has also previously reported at increased risk (Holt and Thrusfield 1993) 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 adequate statistical power.

The current study identified that bitches of adult bodyweight over 10 kg have approximately twice the odds of UI, concurring with several previous reports (Angioletti and others 2004, de Bleser and others 2011, Okkens and others 1997, Stöcklin-Gautschi and others 2001). Bitches weighing over 15 kg were previously reported with 7 times the odds of UI, although this study included only neutered females (Forsee and others 2013). Bitches in the UK from heavier breeds were reported with increased risk of UI (Thrusfield and others 1998). 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 include reference to bodysize characteristics (The Kennel Club 2017). Consequently, statistical modelling methods can struggle to dissect and clarify which of these correlated breed or bodyweight variables represents the major association (Dohoo and others 2009). However, the finding of the current study that bitches *within* individual breeds weighing at or above the breed average have 1.3

times the odds 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 progressively and substantially with age. UI cases with congenital and anatomical aetiology tend to present at younger ages (Holt and Moore 1995). The current study included UI cases from all causes and the association with increased age shown here suggests that the majority of UI in bitches is acquired and likely to be USMI. Very similar odds ratios to the current study for the age categories were also reported in a specific USMI study of UK neutered bitches (de Bleser and others 2011). It is worth noting that it is possible that some bitches in the current with congenital or anatomic causes (e.g. ectopic ureters) may not have been diagnosed until later in life which might limit this conclusion (McLoughlin and Chew 2000). Other causes of UI that should also be considered include neoplasia, detrusor over-activity, pelvic bladder and neurological disease (Crawford and Adams 2002, Noël and others 2010, Norris and others 1992, Olby and others 2003).

Neutered bitches had increased odds of UI in our study, independently of relative bodyweight and age. This finding agrees with a number of other studies that report neutering as a risk factor for UI in bitches (de Bleser and others 2011, Forsee and others 2013, Spain and others 2004a, Stöcklin-Gautschi and others 2001, Thrusfield and others 1998). 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). 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, de Bleser and others 2011). In the current study, neutered bitches had 2.2 times the odds of UI on multivariable 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 just associations for neutering rather than assigning casualty (Pandis 2011). Associations between neutering and UI are likely to be very complex, with many and varied interactions related to the timing of neutering (both absolute in terms of age and relative in terms of puberty), method of neutering, and other factors including breed, age, bodyweight and obesity that would require prospective focused cohort study designs for fuller elucidation (Coit and others 2008, Dohoo and others 2009). Unfortunately, body condition score and obesity data were not available for the current study.

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, their 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 (Schaer 2010, Scott and others 2002). 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). 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 = 1,116) 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, O'Neill and others 2016a, Shoop and others 2015). The study included all cases diagnosed with UI and did not attempt to categorise into congenital, anatomic or acquired subsets.

Conclusion

This is the largest study describing the prevalence and risk factors for UI in dogs published to date. UI is shown to be commonly diagnosed in primary-care practice in England, affecting just over 3% of bitches overall but recorded in over 15% of bitches in a number of high risk breeds including the Irish Setter, Dobermann, Bearded Collie, Rough Collie and Dalmatian. The prevalence and risk factors identified can assist clinicians by improving the evidence base supporting clinical recommendations on neutering and weight control, especially in the high-risk breeds identified here.

Conflict of Interest

One author (DON) is supported at the RVC by a Kennel Club Charitable Trust award. The other authors have no conflicts of interest to declare.

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Figures

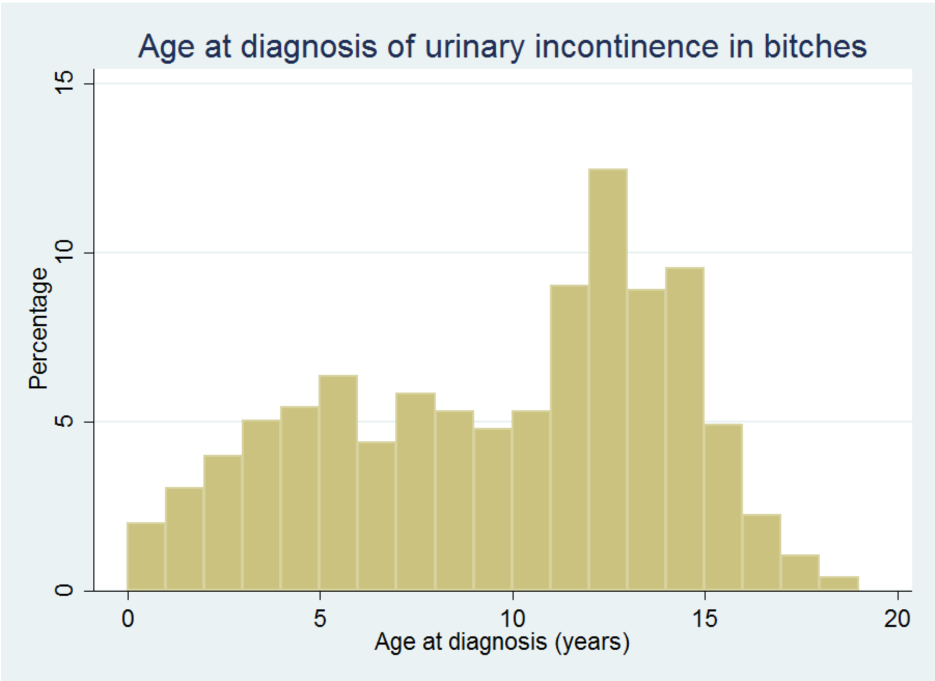

Figure 1. Age at diagnosis of urinary incontinence in 754 incident cases of urinary incontinence in bitches attending primary-care veterinary practices in England.

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. [†] $P < 0.05$.

Variable	Category	Non-case	Case	Odds ratio	95% CI	Category *P*-value	Variable *P*-value
Purebred status	Crossbred	21,895	179	Base			0.569
	Purebred	73,877	575	0.95	0.80-1.13	0.567	
Common breeds	Crossbreed	21,895	179	Base			< 0.001
	Irish Red Setter[†]	99	5	6.18	2.49-15.35	< 0.001	
	Dobermann[†]	297	13	5.35	3.01-9.51	< 0.001	
	Rough Collie[†]	274	11	4.91	2.64-9.13	< 0.001	
	Dalmatian[†]	366	12	4.01	2.22-7.26	< 0.001	
	Bearded Collie[†]	175	5	3.49	1.42-8.60	0.006	
	Weimaraner[†]	350	9	3.15	1.60-6.19	0.001	
	Bull Mastiff[†]	259	6	2.83	1.24-6.45	0.013	
	Boxer[†]	1,272	24	2.31	1.50-3.55	< 0.001	
	Greyhound[†]	1,059	19	2.19	1.36-3.54	0.001	
	West Highland White Terrier[†]	2,306	35	1.86	1.29-2.67	0.001	
	English Spaniel Springer[†]	1,684	24	1.74	1.14-2.68	0.011	
	Border Collie[†]	2,434	34	1.71	1.18-2.47	0.004	
	German Shepherd Dog	3,204	35	1.34	0.93-1.92	0.119	
	Miniature Poodle	282	3	1.30	0.41-4.10	0.653	
	Golden Retriever	1,618	17	1.29	0.78-2.12	0.325	
	Labrador Retriever	7,906	64	0.99	0.74-1.32	0.946	
	Rottweiler	1,171	9	0.94	0.48-1.84	0.857	
	Cavalier King Charles Spaniel	1,991	11	0.68	0.37-1.24	0.208	
	Other breed-types[†]	25,930	143	0.67	0.54-0.84	< 0.001	
	Cocker Spaniel[†]	3,516	17	0.59	0.36-0.97	0.039	
	Staffordshire Bull Terrier[†]	8,074	39	0.59	0.42-0.84	0.003	
	Yorkshire Terrier[†]	3,244	14	0.53	0.31-0.91	0.022	
	Jack Russell Terrier[†]	6,432	26	0.49	0.33-0.75	0.001	
Kennel Club Breed Groups	Not KC-recognised	29,499	211	Base			< 0.001
	Pastoral[†]	6,931	101	2.03	1.60-2.59	< 0.001	
	Working[†]	5,007	64	1.79	1.35-2.37	< 0.001	

	Gundog†	16,943	156	1.29	1.05-1.58	0.017	
	Hound	4,296	37	1.20	0.85-1.71	0.299	
	Terrier	13,597	95	0.98	0.77-1.25	0.850	
	Utility	7,876	44	0.78	0.56-1.08	0.137	
	Toy†	11,623	46	0.55	0.40-0.76	< 0.001	
Adult bodyweight (kg)	< 10.0	20,184	118	Base			< 0.001
	10.0-19.9†	16,598	175	1.80	1.43-2.28	< 0.001	
	20.0-20.9†	14,564	206	2.42	1.93-3.04	< 0.001	
	30.0-30.9†	7,822	149	3.26	2.56-4.15	< 0.001	
	≥ 40.0†	2,686	50	3.18	2.28-4.44	< 0.001	
Breed relative bodyweight	Lower	41,905	404	Base			< 0.001
	Equal/Higher†	19,949	294	1.53	1.31-1.78	< 0.001	
Age (years)	< 3.0	40,489	68	Base			< 0.001
	3.0 - < 6.0†	20,578	127	3.67	2.74-4.94	< 0.001	
	6.0 - < 9.0†	14,850	117	4.69	3.48-6.33	< 0.001	
	9.0 - < 12.0†	10,864	144	8.02	6.01-10.72	< 0.001	
	≥ 12.0†	8,988	298	19.74	15.15-25.72	< 0.001	
Neuter status	Entire	8,618	30	Base			< 0.001
	Neutered†	35,037	594	4.87	3.37-7.03	< 0.001	
Insurance	Non-insured	33,322	309	Base			< 0.001
	Insured†	21,091	330	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. † $P < 0.05$.

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. [†] $P < 0.05$.

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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