Where are all the Antimicrobials being used? Large Language Models for Monitoring Adherence to Antimicrobial Stewardship Guidelines in Veterinary Practices

Sean Farrell[1] Noura Al Moubayed[1] Alan Radford[2] Gina Pinchbeck[2] Peter-John Mäntylä Noble[2]

[1] Department of Computer Science, Durham University

[2]Institute of Infection, Veterinary and Ecological Sciences, University of Liverpool

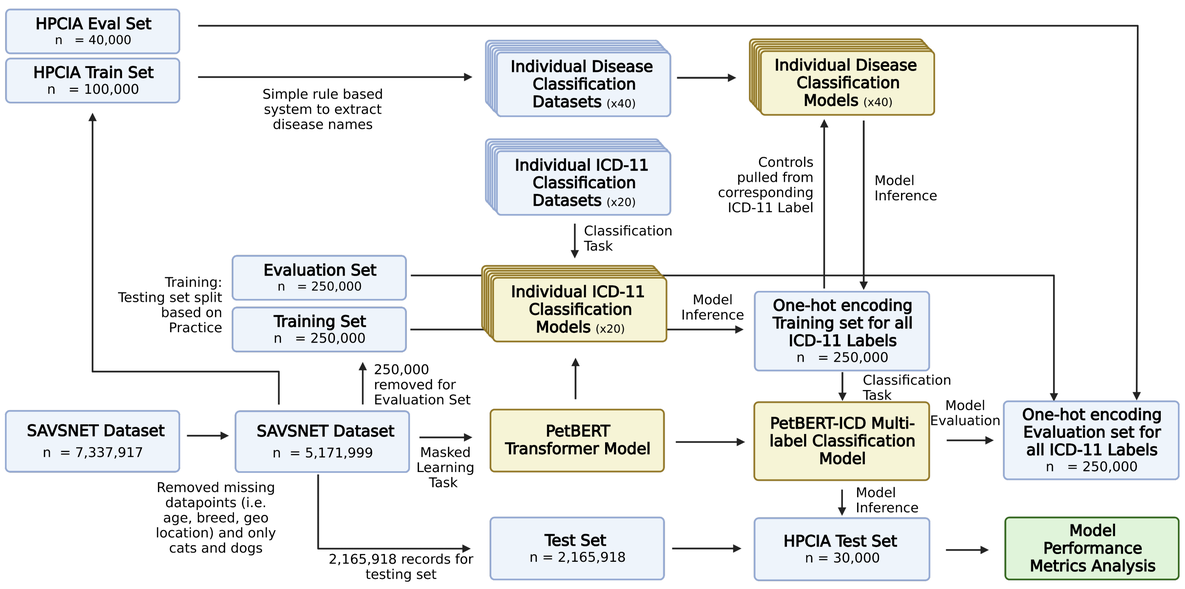
BACKGROUND

- **Importance of Companion Animals**: Recognised as significant contributors to the development and transmission of antimicrobial resistant (AMR) bacteria.
- **Public Health Concern**: AMR poses challenges to effectively treating infectious diseases.
- **Highest Priority Critically Important Antibiotics (HPCIA):** Represents a class of antimicrobials as being permitted within veterinary medicine; however is critically important to be used restrictively given its importance in human medicine
- **Lack of Oversight**: No monitoring for rationale behind HPCIA prescriptions in companion animals in the UK.
- **Antimicrobial Stewardship Guidelines (ASGs)**: Created by organisations to promote responsible use of antimicrobials among veterinarians.
- **Adherence Issues**: No system in place to check adherence to ASGs.
- **UK Reporting Gaps**: Annual reports focus on overall antimicrobial sales data without analysing clinicians' prescription choices.
- **Small Animal Surveillance Network (SAVSNET):** Collects free text Electronic Health records from first opinion veterinary practices found across the UK

In this study, we employ a hierarchical large language model to analyse 195,012 HPCIA and over 1.2 million antimicrobial non-HPCIA prescriptions from more than 500 veterinary practices found acros the UK

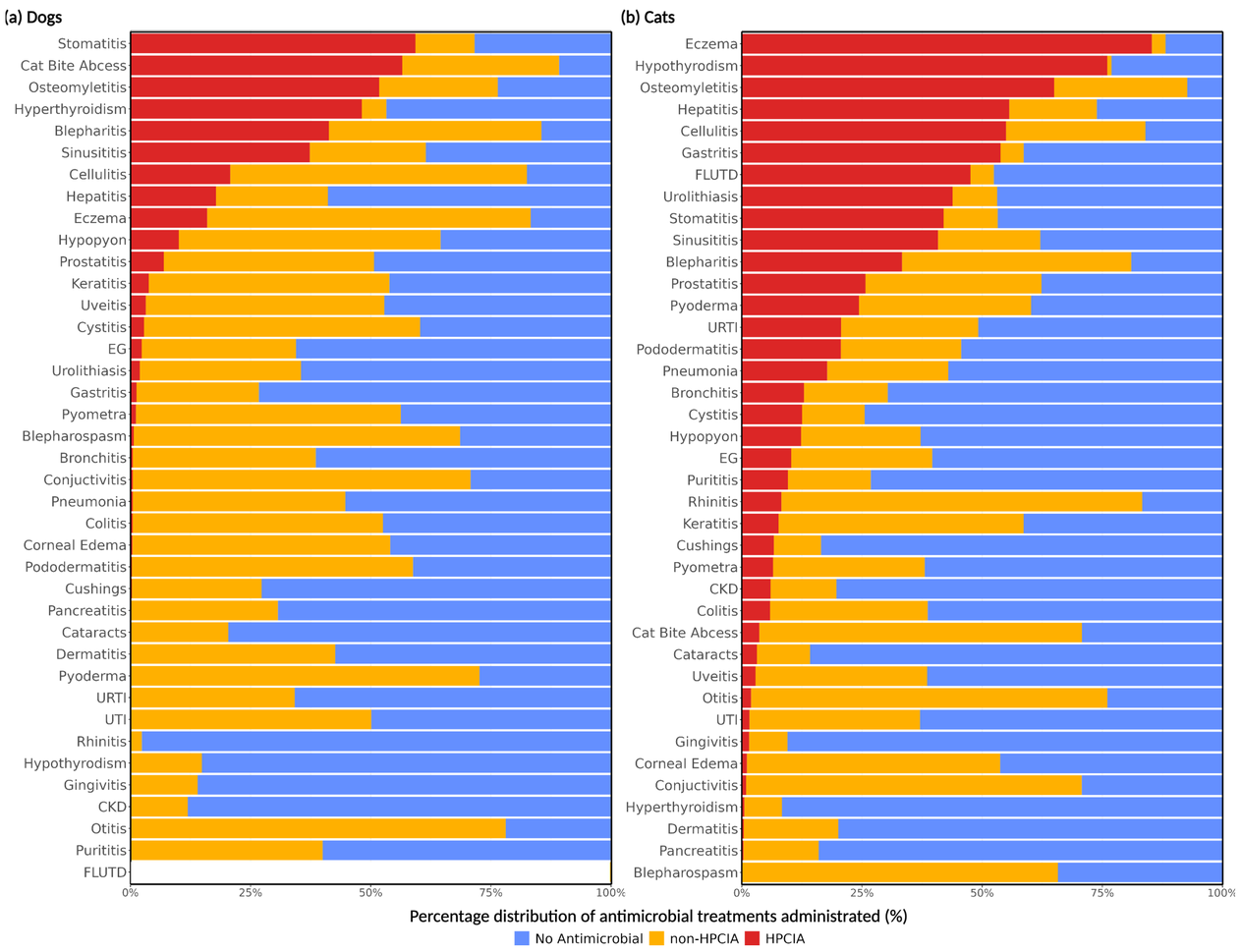
METHODS

1. We create a 5.1 million training and a 2.1 million test divided on a practice level to improve downstream generalisability confidence
2. We additionally pre-trained BERT on some 500 million tokens from first opinion veterinary practices to produced PetBERT [1]
3. We create 40 binary disease classifiers using PetBERT
4. We apply the 40 classifiers to 2 x 250,000 record datasets in a one-hot encoding structure
5. We train a multi-label PetBERT classifier using the produce datasets



RESULTS

We examine the use of antimicrobials, both non-HPCIA and HPCIA, across our 1.4 million antimicrobial prescriptions, using the multi-label disease classifier



▲ Diseases explored for (a) Dogs and (b) Cats. In blue, no antimicrobial has been prescribed to the animal, in yellow a non-HPCIA class antimicrobial has been prescribed and in red a HPCIA class antimicrobial has been prescribed

CASE STUDY: Antimicrobial Stewardship Guidelines Monitoring

- Antimicrobial Stewardship Guidelines (ASGs) aim to encourage effective yet minimal use of antimicrobials
- We identified previously that the PROTECT ME guidelines were the most popular ASG used in the United Kingdom [2]
- There currently exists no system to monitor the uptake and effectiveness of ASGs in clinical practice
- Here we explore the guideline recommended antimicrobial for a given infection relative to the actual prescribing pattern of veterinarian
- We show great variability across different diseases in clinicians adhering to the recommendations of the ASG

▼ Example diseases represented within the PROTECT ME ASG. The recommended antimicrobial guidance is presented with the number and percentage of animals given the correct guideline recommendation

Disease	Guidiance	Cats (% Guidance Agreement)	Dogs (% Guidance Agreement)
Conjunctivitis	Chlortetracycline, Fusidic Acid, Gentamicin	15365 (42%)	36215 (39%)
Cystitis	Amoxicillin Clavulanate	5052 (28%)	10069 (85%)
Gingivitis	Amoxicillin Clavulanate, Clindamycin, Metronidazole	32845 (44%)	39592 (53%)
Hepatitis	Ampicillin, Amoxicillin Clavulanate, Cefalexin, Metronidazole	122 (58%)	262 (56%)
Otitis Externa	Fusidic Acid, Framycetin, Gentamicin, Marbofloxacin, Polymyxin B, Orbifloxacin	2808 (55%)	46146 (78%)
Pneumonia	**Dogs**: Amoxicillin Clavulanate, Fluroquinolnes, Doxycycline, Metronidazole **Cats**: Amoxicillin Clavulanate, Doxycycline	458 (69%)	3191 (96%)
Rhinitis	Amoxicillin Clavulanate	954 (30%)	1174 (59%)
Stomatitis	Metronidazole	4238 (42%)	3934 (60%)
Urinary Tract Infections	Amoxicillin Clavulanate, Trimethoprim/sulfamethoxazole	4477 (47%)	18637 (71%)

CONCLUSION

- We achieve an F1 score of over 88% across our hierarchical LLM classifier
- We can provide a greater granularity of where antimicrobial prescriptions are being utilised
- For the first time, we can reveal the adherence of clinicians in their actual prescribing patterns to the recommended prescription within ASGs
- We will continually monitor adherence rate towards ASGs to all future prescriptions

[1] Farrell, S., et. al **PetBERT: automated ICD-11 syndromic disease coding395for outbreak detection in first opinion veterinary electronic health records.** Sci. Reports 2023 13:1 13, 1–14, DOI:39610.1038/s41598-023-45155-7 (2023)

[2] Farrell, S. et al. **A multinational survey of companion animal veterinary clinicians: How can antimicrobial stewardship guidelines be optimised for the target stakeholder?** The Vet. J. 106045, DOI: 10.1016/J.TVJL.2023.106045 (2023)

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