

University of Prince Edward Island

Faculty of Veterinary Medicine
Summary of Dissertation

Submitted in Partial Fulfilment
of the Requirements for the

DEGREE OF DOCTOR OF PHILOSOPHY

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Quantifying antimicrobial use and assessment of the resistome on Canadian dairy farms: towards an on-farm benchmarking system Publications

This doctoral work examined scalable infrastructure for benchmarking antimicrobial use (AMU) and antimicrobial resistance (AMR) in Canadian dairy production, focusing on automated dose-based AMU quantification, longitudinal AMU trends, and the potential of bulk tank milk (BTM) resistomic benchmarking.

The first study describes the development and validation of a computer program that converts veterinary dispensing records (VDR) into standardized AMU metrics. The program processed at least one year of sales data from 26 farms across six veterinary practices and was evaluated against manual calculations. Mean AMU across study farms was 6.21 defined daily doses (DDD)/animal-year and 1.46 defined course doses (DCD)/animal-year, values consistent with published expectations. The program generated detailed outputs stratified by antimicrobial class, route of administration, and other metadata, demonstrating suitability for scalable benchmarking.

The second study compared AMU practices on Canadian dairy farms using garbage can audit (GCA) data from studies conducted in 2007–2008 and 2017–2020. Linear and mixed-effects models assessed temporal trends across provinces and antimicrobial classes. A statistically significant decline in AMU was observed. National average parenteral AMU decreased from 14.70 to 8.76 DDD/cow-year and from 4.00 to 2.31 DCD/cow-year. Reductions occurred across all antimicrobial classes except third-generation cephalosporins.

The third study evaluated BTM as a matrix for AMR benchmarking. Duplicate BTM samples from 12 farms underwent target-capture sequencing for antimicrobial resistance genes (ARGs) and 16S rRNA sequencing for microbiota profiling. Eighty unique ARGs were detected, with total ARG reads ranging from 57 to 2854 per sample. Most ARG reads (81%) conferred resistance to aminoglycosides and tetracyclines. Microbial community structure did not differ significantly between cream and pellet fractions.

Together, automated VDR-based AMU metrics, longitudinal GCA analyses, and BTM resistomics form an integrated, scalable framework to support antimicrobial stewardship and targeted intervention strategies in dairy production across diverse regions and production scales nationally overall.

Publications

Warder LMC, Heider LC, Léger DF, Rizzo D, McClure JT, de Jong E, McCubbin KD, Uyama T, Fonseca M, Jaramillo AS, Kelton DF, Renaud D, Barkema HW, Dufour S, Roy JP, Sánchez J. Quantifying antimicrobial use on Canadian dairy farms using garbage can audits. *Front Vet Sci.* 2023 Jun 30;10:1185628. doi: 10.3389/fvets.2023.1185628. PMID: 37456957; PMCID: PMC10347401.

Warder LMC, Doster E, Parker JK, Morley PS, McClure JT, Heider LC, Sánchez J. Characterization of the microbiota and resistome of bulk tank milk samples from Prince Edward Island dairy farms. *J Dairy Sci.* 2021 Oct;104(10):11082-11090. doi: 10.3168/jds.2020-19995. Epub 2021 Jul 30. PMID: 34334208.

Fonseca M, Heider LC, Stryhn H, McClure JT, Léger D, Rizzo D, Warder L, Dufour S, Roy JP, Kelton DF, Renaud D, Barkema HW, Sanchez J. Intramammary and systemic use of antimicrobials and their association with resistance in generic *Escherichia coli* recovered from fecal samples from Canadian dairy herds: A cross-sectional study. *Prev Vet Med.* 2023 Jul;216:105948. doi: 10.1016/j.prevetmed.2023.105948. Epub 2023 May 25. PMID: 37263090.

Fonseca M, Heider LC, Stryhn H, McClure JT, Léger D, Rizzo D, Warder L, Dufour S, Roy JP, Kelton DF, Renaud D, Barkema HW, Sanchez J. Antimicrobial use and its association with the isolation of and antimicrobial resistance in *Campylobacter* spp. recovered from fecal samples from Canadian dairy herds: A cross-sectional study. *Prev Vet Med.* 2023 Jun;215:105925. doi: 10.1016/j.prevetmed.2023.105925. Epub 2023 Apr 23. PMID: 37104967.

Presentations

Landon M.C. Warder, Luke C. Heider, J T. McClure, David Leger, Daniella Rizzo, Jean-Phillipe Roy, Simon Dufour, Herman Barkema, David F. Kelton, David Renaud, Mariana Fonseca, Ana Soffia Jaramillo, Tamaki Uyama, Ellen de Jong, Kayley McCubbin, Javier Sanchez. International Symposium for Veterinary Epidemiologists and Economists, 7-11 August 2022; Changes in antimicrobial use on Canadian dairy farms between 2007-2008 and 2018-2020

Landon M.C. Warder, J McClure, Javier Sánchez, Luke C. Heider. International Symposium for Veterinary Epidemiologists and Economists, 7-11 August 2022; The impact of negative energy balance on the diversity of the enteric microbiome of dairy cattle
Landon M.C. Warder, J McClure, Javier Sánchez, Luke C. Heider. Canadian Emerging Veterinary Scholars Summit, 4-6 November 2021; Relationship between antimicrobial use and ketosis in PEI dairy cows

Landon M.C. Warder, Javier Sánchez, David Léger, Daniella Rizzo, Kaitlyn Ledgerwood, Luke C. Heider. One Health Antimicrobial Stewardship Conference, 10-12 March 2021; Determination of Defined Daily Dose Antimicrobial Drug Usage Rate from a garbage can audit of Canadian dairy farms using Python

Landon M.C. Warder, Javier Sánchez, David Léger, Daniella Rizzo, Kaitlyn Ledgerwood, Luke C. Heider. One Health Antimicrobial Stewardship Conference, 10-12 March 2021; Comparison of dose-based metrics of antimicrobial use on Canadian dairy farms across provinces

Landon M. C. Warder, Enrique Doster, Jennifer K. Parker, Paul S. Morley, J. T. McClure, Luke C. Heider, Javier Sánchez. Conference of Research Workers in Animal Disease, 5-8 December 2020; Characterization of the bulk tank milk microbiome from Prince Edward Island commercial dairy farms

Biographical Data –Born in Owen Sound, Ontario, Canada

Awards

G. Murray & Hazel Hagerman Scholarship 2020

Frederick Banting and Charles Best 2020 Canadian Graduate Scholarship-Master's award

Zoetis investment in innovation 2021