The IDEXX Chair in Emerging Technologies and Bond-Centered Animal Healthcare

December 2017

University of Guelph

Improve Life.

TOGETHER, we are forging a future empowered by data.

STRENGTHENING partnership through solutions

Dr. Theresa Bernardo, DVM, MSc
Professor, The IDEXX Chair in Emerging Technologies and Bond-Centered Animal Healthcare, Department of Population Medicine, Ontario Veterinary College

Email: bernardt@uoguelph.ca

The Ontario Veterinary College (OVC) at the University of Guelph wishes to express its gratitude for the generous support of IDEXX for this dynamic research chair in emerging technologies and bond-centered animal healthcare.

One Health serves as the foundation for our research pursuits. Our health and the health of our pets are increasingly affected by the lifestyles we share.

Strengthening our valuable partnership with IDEXX offers the promise of discovery of real solutions through the analysis of big data. We are making important advances, both in relation to specific clinical outcomes that can improve and lengthen the lives of pets, and in how veterinary students and veterinarians understand and use big data to improve animal healthcare.

Trends in Health and Technology

The adoption of health technologies is accelerating (health sensors, electronic health records, point-of-care diagnostic testing, artificial intelligence, big data, etc.). They will have a major impact on how we educate veterinary and graduate students, conduct research, and practice veterinary medicine to strengthen the bonds among the veterinary team, the patients and their human caregivers.

In human healthcare, a recent Deloitte study found that "The convergence of four powerful trends is transforming the traditional U.S. health care market creating opportunities for innovation in four major areas."

- **Everywhere Care:** The shift away from hospitals
- **Wellness and Preventive Care:** From reaction to prevention
- **Personalized Care:** Mass customization and precision
- **Aging, Chronic and End-of-Life Care:** Leveraging big data and personalization to manage chronic conditions

These shifts and opportunities are also apparent in the veterinary market, with new models for delivery of veterinary services, new possibilities for personalization of diagnostic tests, and new insights into health through the combination and analysis of data from multiple sources. **An easy point of entry into data-driven animal wellness is through the use of the weight of pets.** It has the advantage of ease of observation and measurement at home. The importance of monitoring body weight as an indicator of health cannot be overemphasized. In Banfield's State of Pet Health 2017 Report's Spotlight on Obesity, one in every three dogs or cats that walked through their doors was diagnosed as overweight or obese.

In human medicine, a 2017 study from the Harvard T.H. Chan School of Public Health documented the dangers of gaining weight in young adults (18 years of age in women; 21 years in men). Even a moderate amount of weight gain (5 to 22 pounds) was associated with significantly increased risk of major chronic diseases and decreased odds of healthy aging. Thus, weight is an important indicator of health.

We are taking a similar approach and looking at patterns of weight gain and loss over the lifetime of a cat. Once we combine this information with diagnostic test data, we will gain valuable insights into the interactions between weight and health, as well as potential interventions to increase the number of years of healthy life for our pets.

Highlights of Research Results

To maximize our potential impact, we are focusing on chronic disease, which is responsible for the majority of morbidity and mortality in people and animals. We also wanted to look at the whole animal, rather than at a specific disease. In consultation with IDEXX's Chief Medical Officer Dr. Roberta Relford, we decided to focus on "skinny old cats" that suffer from a multitude of chronic conditions including chronic kidney disease and hyperthyroidism. One of the first questions we needed to answer was, "When does a cat start to become a skinny old cat?"

Thanks to our partnership with IDEXX we now know that **cats start to lose weight between 6 and 10 years of age,** depending on their breed, gender and whether they have been neutered.

Through our collaboration with IDEXX, data from over 19 million cats (50 million body weight measurements) was collected from patient records to determine weight trends over the lifespan of a cat. One of the first interesting observations was that for approximately half of the cats, almost 10 million, we only had one body weight measurement, indicating that the cats either were not weighed when they returned to their veterinarian or they did not return to the same veterinarian. It is quite possible that they never returned to any veterinarian because we know that many cats do not visit the veterinarian after they receive their kitten vaccinations and are spayed or neutered. Having early discussions about the importance of monitoring weight and other health parameters may help owners understand the value of bringing their cat for its annual examination.

Even without repeat measures for many cats, the sheer volume of data allowed us to construct the weight of a composite cat over a cat's lifetime. Cleaning over 19 million records in preparation for analysis was a Herculean task. To give a

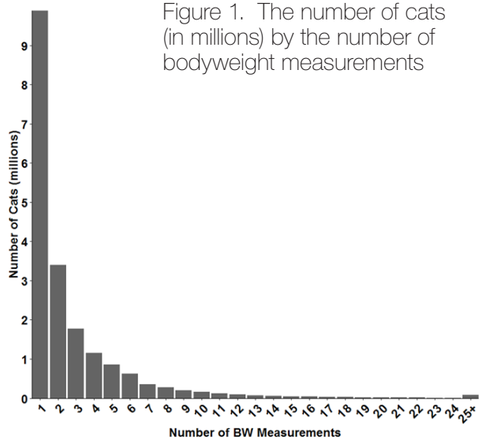


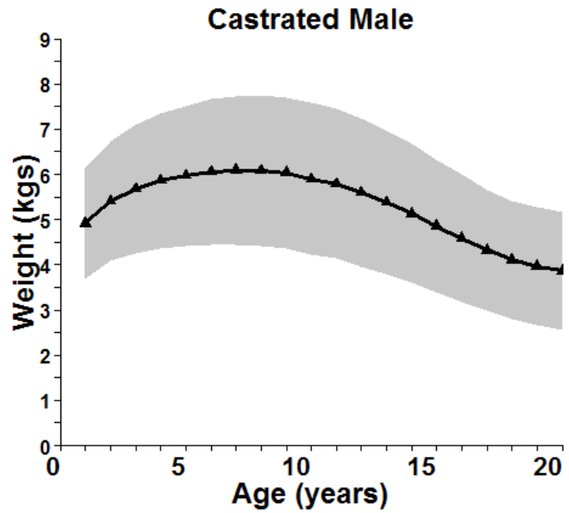
Figure 1. The number of cats (in millions) by the number of bodyweight measurements

sense of the magnitude of the work, there were more than 5,000 distinct values for different breeds listed in the medical records, whereas the International Progressive Cat Breeders Alliance officially recognizes 73 new and old breeds of cats and the Cat Fanciers' Association recognizes 42 pedigreed breeds.

To make sense of the data, we used a combination of computer-assisted translation (fuzzy matching) and human knowledge (manual refinement) to arrive at 123 different breed categories, representing both registered and hybrid breeds. The methodology we developed for cleaning data related to breeds could be useful in the future for the analysis of datasets at IDEXX, or for other datasets, such as the one being developed through the One Health Commission's National Pet Health Survey.

Once the data was prepared, we used machine learning to create a **computerized model that can be used to predict the average weight for a cat at different ages based on its breed and gender.** This model has the potential to be incorporated into a number of IDEXX products.

Figure 2. Estimated average weight in kg (black line) and standard deviation (grey shading).



As a hypothetical example, meet "Noodle," a male, domestic shorthair kitten who visits the veterinarian for the first time. Using our model, we can predict what Noodle is expected to weigh throughout his lifetime (Figure 2.) as a castrated male domestic shorthair cat. Although we do not yet have a way to estimate Noodle's ideal weight at various ages, we can compare his lifetime weight trajectory to other similar cats and note any significant deviations. By 8 years of age, if Noodle reaches a peak weight which exceeds the average weight for cats of his breed and neutered status, then he could benefit from some veterinary guidance.

At 16 years of age, we know, based on statistical data, that Noodle should weigh 10.4 pounds. Noodle weighs 6.2 pounds. Noodle is more than 4 pounds under weight for his age and breed. What happened to Noodle between 8 years of age when he was obese, and 16 years of age when he is a skinny old cat? If the owner doesn't bring Noodle in for examination and diagnostic testing on a regular basis, there is no way to answer this question — and no way to delay his decline.

Discussions about body weight throughout a pet's lifetime could be a useful gateway to engage cat owners in the health of their pets.

Noodle

Healthy Aspirations for 2018

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Big Data Analysis

Next we would like to apply the same methodology to health parameters, looking at how they trend over time and relate to weight and age, for example, measures of chronic kidney disease, such as Blood Urea Nitrogen (BUN), creatinine or SDMA (symmetric dimethylarginine). In addition to weight, this would require having measurements from blood and urine tests that can all be linked to the same animal.

For example, after examining Noodle's medical record, we could compare Noodle's actual weight over time to Noodle's projected weight from our model (Figure 3). Further relationships could be revealed by layering in creatinine levels (Figure 4) and total thyroxine (T4) levels (Figure 5), both of which rise in Noodle's senior years.

Figure 3. Noodle's actual weight over time (red line) versus Noodle's projected weight from our model (black line, +/- one standard deviation in grey)

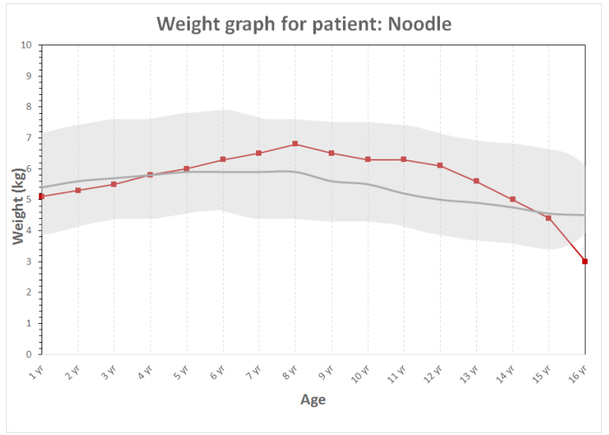


Figure 4. Weight and creatinine levels

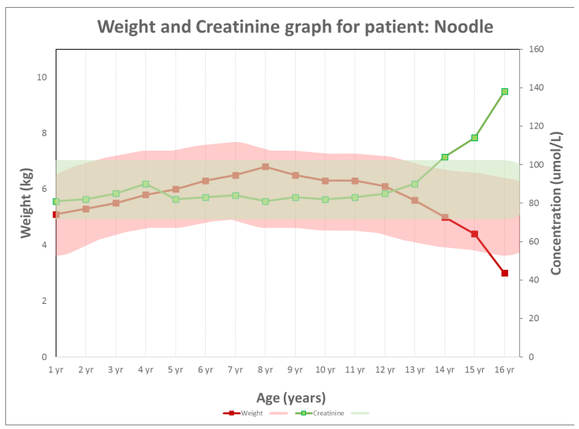
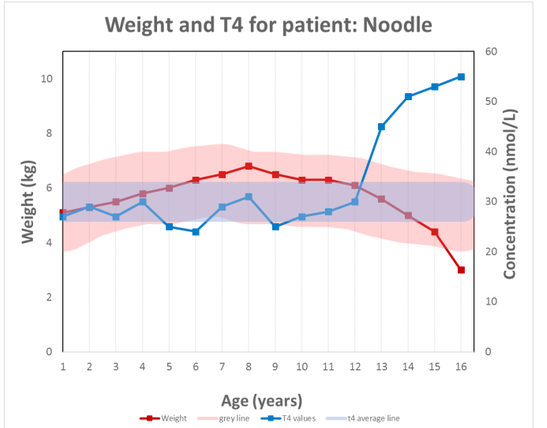


Figure 5. Weight and T4 levels



In our hypothetical example, we can see at age 13 to 14 there are obvious increases in Noodle's creatinine and T4 levels. Could earlier intervention have forestalled Noodle's weight loss or SDMA rise at age eight? Could a veterinarian have lengthened Noodle's life and contributed to his overall health and well-being with a better understanding of data trends? With further research and additional data, we can work towards answering these next-level questions.

Building Health Technology Literacy

Day One Competencies in Animal Health Technology

Critical Day One (first day of work as a veterinarian) competencies for graduating veterinarians have been defined by the Royal College of Veterinary Surgeons of the U.K., the AVMA Council on Education, and the Association of American Veterinary Medical Colleges. However, there has been little focus on the knowledge, skills and experiences necessary to constantly adapt to the rapidly emerging technologies that are changing how veterinarians deliver veterinary services. New technologies, such as telemedicine and point-of-care diagnostics, are making their way into veterinary medicine. Veterinarians need to know how to use them and new graduates will be expected to add value to the practices they join through the introduction of these technologies. Although health informatics is growing more prominent in human medical training, as yet, there is no formal program in veterinary medicine.

As a part of the IDEXX-supported program, we are collaborating with innovative experts to develop competency frameworks for emerging technologies. We seek to determine the skillsets, attitudes and assessment meassures necessary to prepare new veterinarians to successfully integrate these technologies into their practices and businesses. Working with a small group of veterinary practitioners, who are leaders in the use of information technology, we are using a recognized curriculum development process (DACUM: develop a curriculum) to reach a consensus on the Day One competencies in information technology necessary for veterinarians.

Scoping Review of Big Data, Informatics and Bioinformatics

It is rare to go through a day without hearing the words “big data” and “informatics.” But what do these words mean, how are they being used, and how do these fields contribute to animal health? With the guidance of Dr. Jan Sargeant, an OVC professor of epidemiology and an expert in knowledge synthesis, we are conducting a “scoping review” of big data, informatics and bioinformatics in the animal health and veterinary medicine literature. A scoping review is a formal process to rapidly assess the literature in a given policy or clinical area where the aims are to accumulate as much evidence as possible and map the results. Working with our colleagues in library science, over 8,000 journal articles and theses were initially identified and screened for relevance by research students and approximately 1700 of these articles met the defined criteria for inclusion. These articles were then scrutinized in greater depth to provide a better understanding of the type of research done in this emerging field and to develop common definitions and shared language for related educational and research initiatives.

Using Diagnostic Data Trends to Strengthen the Veterinary-Client-Patient Relationship

We are collaborating with Dr. Jason Coe, OVC associate professor of veterinary communications, to explore how veterinarians can use data trends (eg. weight and diagnostic test results over time) to improve the relationship among veterinarians, clients and their animals.

This research will include video recorded observations of real veterinary/client interactions, as well as focus groups and surveys of veterinary clients and veterinarians.

The goals are:

- To determine the nature and frequency of discussions in veterinary practices about diagnostic testing;
- To develop protocols and training materials to help veterinary students and veterinarians become more adept at explaining to their clients the value of diagnostic testing and the use of data trends over time; and
- To use these discussions to improve the relationships between veterinarians and their clients so that they become partners in maintaining and improving the health of the pet.

Team spirit at the summer research student poster presentations: Ben Ouyang (PhD student), Rebecca Ma (BMATH), Adam Campigotto (PhD student), Kate Wycherley (OVC class of 2019), Alison Thomas (OVC class of 2020), Theresa Bernardo (DVM, MSc), Rosa Esmaeilbeigi (OVC class of 2020)

Engaging Students with Health Data and Research

Adam Campigotto and Ben Ouyang.

Adam Campigotto, DVM

Adam completed an undergraduate degree in biomedical computing from Queens University and received his veterinary degree from OVC in 2015. He practiced at an emergency clinic and then started his master's degree in January of 2016. He was awarded an OVC Graduate Fellowship and transferred to the PhD program in the summer of 2017. Adam presented at the 2017 meeting of the Canadian Animal Health Laboratorians Network (CAHLN) and received an award for the best poster presentation at the Campbell Animal Welfare Research Symposium hosted by the Campbell Center for the Study of Animal Welfare in June 2017. His first paper was submitted to the *Journal of the American Veterinary Medical Association* in July 2017 (currently under review), which is circulated to over 80,000 practicing veterinarians. Adam is critical to the success of the feline weight research.

Ben Ouyang, DVM, MS (PhD graduate student)

Ben joined our research team in January 2017 and received the International Graduate Tuition Scholarship. He has an undergraduate and master's degree in applied math and statistics from Johns Hopkins University, a veterinary degree from the University of Pennsylvania and last year, he completed a residency in infection control as well as a Master of Science in clinical sciences with a focus on epidemiology, at Colorado State University. Ben worked two summers as an intern at IDEXX. He is using qualitative research to investigate Day One competencies and how to educate students about the use of emerging technologies in practice. Ben has been instrumental in bridging the gap between veterinary medicine and technology.

Activities with other students

Through our various activities, we have engaged with students from elementary school through graduate school in a number of venues and locations. Director and Country Manager for IDEXX Canada Peter Mosney and Dr. Bernardo served as judges for the FIRST LEGO® League Ontario Innovation Celebration, held at IBM Headquarters in Markham, Ontario. The event was attended by the Minister of Research, Innovation and Science for Ontario, and featured 17 finalist teams of enthusiastic students aged 9 – 14. Student teams pitched their innovative solutions for the 2017 theme of Animal Allies, aimed at improving interactions between humans and animals.

Several student teams contacted OVC experts for input as they were developing their projects, and some of them even impersonated OVC faculty in their presentation.

We co-sponsored The Skinny Cat Challenge at Michigan State University (MSU) with Karl Gude, director of the media sandbox, which was open to students from the College of Communication Arts at MSU. Dr. Bernardo recruited Shelby MacLeod and Jason Carr, from Digital Marketing at IDEXX, to serve as virtual judges. A lot of creative ideas and graphics resulted from the competition to draw cat owners' attention to the weight of their cats.

Dr. Bernardo gave the keynote presentation at the annual meeting of the Society for Veterinary Epidemiology and Preventive Medicine in Scotland, and provided the Douglas D. McGregor Research Lecture at the Biomedical and Biological Sciences Symposium, at Cornell University.

Peter Mosney and Theresa Bernado

LEGO® League Ontario Innovation Celebration

The Skinny Cat Challenge

Douglas D. McGregor Research Lecture

Building Health Technology Literacy

IDEXX was cited as a research partner and collaborator in the following publications and presentations:

Bernardo, T.M. (2016, Sept.). *The Future of Technology in Practice*. Panel presentation and discussion at the College of Veterinarians of Ontario, Guelph, Canada.

Bernardo, T.M. (2016, Dec.). *New Communication Technologies: Connecting People and Data for One Health Emergencies and Resilience.* Presentation at the One Health / Ecohealth International Conference, Melbourne, Australia.

Bernardo, T.M. (2017, March). *TRENDS: Technology, Research, Epidemiology, Networks, Data and Surveillance.* Invited keynote presentation at the meeting of the Society for Veterinary Epidemiology and Preventive Medicine, Inverness, Scotland.

Bernardo, T.M. (2017, May). *One Health Informatics Innovations.* Presentation at the Centre for Public Health and Zoonoses Scientific Symposium, Guelph, Canada.

Bernardo, T.M. (2017, June). *Technological trends: transforming health data into intelligence.* Invited presentation at the 2017 Canadian Animal Health Laboratorians Network Annual Meeting, Guelph, Canada.

Bernardo, T.M. (2017, August). *Technology and health trends: inspire, interact, innovate!* Douglas D. McGregor Research Lecture: Keynote Address presented at the Biomedical and Biological Sciences Symposium, Cornell University, Ithaca, New York.

Campigotto, A., Stone, E.A., Stacey, D., Poljak, Z., Bernardo, T.M. (2017, May). *Using Big Data to Determine Average Cat Weights.* (Awarded Best Student Poster.) Presentation at The Annual Campbell Centre for the Study of Animal Welfare Research Symposium, Guelph, Canada.

Campigotto, A., Bernardo, T.M., Stone, E.A., Poljak, Z., Stacey, D. (2017, June). *Using Machine Learning to Analyze Big Data.* Presentation at the 2017 Canadian Animal Health Laboratorians Network (CAHLN) Annual Meeting, Guelph, Canada.

Campigotto, A., Poljak, Z., Stone, E.A., Stacey, D., Bernardo, T.M. (2017). The Relationship of Body Weight to Age of Over 13 Million Cats, Stratified by Breed and Gender. Manuscript submitted to the *Journal of the American Veterinary Medical Association.*

Esmaeilbeigi, R., Ouyang, B., Ma, R., Thomas, A., Versluis, A., Wycherley, K., Stacey, D., Stone, E., Poljak, Z., Bernardo, T., Sargeant, J. (2017, August). *A scoping review on the use of "big data," "informatics" and "bioinformatics" in veterinary medicine and animal health literature.* Presentation at the Career Opportunities and Research Experience Program, Guelph, Canada.

Thomas, A., Wycherley, K., Esmaeilbeigi, R., Ma, R., Ouyang, B., Sargeant, J., Poljak, Z., Stacey, D., Stone, E.A., Bernardo, T.M. (2017, August). *A comparison of computerized and human-driven relevance screening.* Presentation at the Career Opportunities and Research Experience Program, Guelph, Canada.

We look forward to strengthening our partnership with IDEXX in the service of animal health, as well as veterinary education and practice, providing more years of healthy life for pets with their people.

Sources

Banfield: *State of Pet Health 2017 Report; Focus on Obesity*
https://www.banfield.com/state-of-pet-health/obesity

Cat Fanciers' Association:
http://cfa.org/Breeds.aspx

Deloitte: *The Convergence of Health Care Trends; Innovation Strategies for Emerging Opportunities.* http://www2.deloitte.com/us/en/pages/life-sciences-and-health-care/articles/convergence-health-care-trends.html?id=us:2sm:3tw:convergence:awa:chs:051116:deloitte-health:ftushealth16&linkId=24301399#

Harvard T. H. Chan School of Public Health: *Associations of Weight Gain From Early to Middle Adulthood With Major Health Outcomes Later in Life*
http://jamanetwork.com/journals/jama/fullarticle/2643761

International Cat Breeders Alliance:
http://www.thegreatcat.org/cat-breeds-and-species/

One Health Commission:
https://www.onehealthcommission.org/en/one_health_news/national_pet_health_survey/

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To meet the challenges we face on this planet, the status quo is no longer enough. The future of life as we know it is uncertain. There is no sole solution, no one technology, no single game-changer; what's required instead is collaboration, research that crosses boundaries (natural, artificial and social) and solutions that mirror the complex eco-system of sustainable living. From how we feed the world and preserve its nature to how we live, interact and thrive in our communities and businesses here at home, we must continue to evolve. We must improve.

The University of Guelph, and everyone who studies here, explores here, teaches here and works here is committed to that simple purpose: To Improve Life.

We improve life by focusing on the whole person to shape better citizens of the world. We improve life by passionately engaging in our communities. We improve life through rigorous exploration in the natural sciences. We improve life by finding better ways to nourish all living creatures. We improve life by partnering in and teaching ethical, sustainable business practices. We improve life by teaching the arts and integrating culture into all fields of study. We improve life by engineering solutions that safely connect humankind to this planet and perhaps beyond. We improve life by nurturing positive and respectful social interaction on this campus. We improve life by openly celebrating our capacity to be inclusive.

We improve life by attracting and supporting students, faculty, and staff who share the belief, the passion and the will to do so.

To improve life is our shared challenge. What role will you play? How will you participate locally, nationally and globally? What will you achieve before you leave? What will you achieve after you leave? How will you help us tell the world?

At the University of Guelph, our focus on life has run deep for over 150 years. Today we commit again to improving it for the future.

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Ontario Veterinary College
University of Guelph
50 Stone Road, Guelph, ON Canada N1G 2W1
T. 519.824.4120
www.ovc.uoguelph.ca
@OntVetCollege