Proceedings of the 2016 Winter Simulation Conference
T. M. K. Roeder, P. I. Frazier, R. Szechtman, E. Zhou, T. Huschka, and S. E. Chick, eds.

USING HYBRID SIMULATION MODELING TO ASSESS THE DYNAMICS OF COMPASSION FATIGUE IN VETERINARIAN GENERAL PRACTITIONERS

Andrew J. Tekippe
Caroline C. Krejci

Department of Industrial and Manufacturing
Systems Engineering
Iowa State University
3004 Black Engineering Bldg.
Ames, IA 50011, USA

ABSTRACT

Veterinarians have experienced disturbing trends related to workplace-induced stress. This is partly attributed to high levels of compassion fatigue, the emotional strain of unalleviated stress from interactions with those suffering from traumatic events. This paper presents a three-stage hybrid model designed to study the dynamics of compassion fatigue in veterinarians. A discrete event simulation that represents the work environment is used to generate client and patient attributes, and the veterinarian's utilization throughout the day. These values become inputs to a system dynamics model that simulates the veterinarian's interpretation of the work environment to produce quantifiable emotional responses in terms of eight emotions. The emotional responses are mapped to the Professional Quality of Life Scale, which enables the calculation of compassion satisfaction, burnout, and secondary traumatic stress measures. A pilot study using the hybrid model was conducted to assess the viability of the proposed approach, which yielded statistically significant results.

1 INTRODUCTION

For many people, work-related stress is a fact of life. Deadlines, difficult customers or coworkers, and technology breakdowns induce detrimental changes in an employee's mental state that ultimately affects their work and personal lives. The field of veterinary medicine in particular has experienced disturbing trends related to workplace-induced stress. A recent mental health survey by the Centers for Disease Control and Prevention showed that approximately 6.8% of male and 10.9% of female veterinarians experiences serious psychological distress (Nett 2015). This means that veterinarians are up to three times more likely to be impacted by work-related stress than the general public (Reeves 2011).

This increased susceptibility to psychological distress is believed to be a result of factors that are unique to the field of veterinary medicine. However, it also coincides with overall growing concern with the professional quality of life for healthcare providers. According to Stamm (2010), people who are exposed to traumatic situations are susceptible to developing symptoms associated with burnout, depression, and posttraumatic stress. Additionally, healthcare providers are also subject to altruism, which can lead to increases in personal satisfaction through the act of helping others. Therefore, while the professional quality of life of healthcare providers, including veterinarians, can be enhanced through compassion satisfaction, it can also be diminished by compassion fatigue.

This paper describes a hybrid simulation-based approach to proactively assessing the Professional Quality of Life (ProQOL) for veterinarian general practitioners as they are placed in various workplace scenarios. The model consists of three stages. The first is the Work Environment Model, which is a discrete-event simulation that represents the working conditions of a mid-sized veterinary clinic. The second is the Emotional Model, which uses system dynamics to simulate a veterinarian's cognition of various stimuli from the Work Environment Model and interpretation into basic primary emotions. The final component is the Professional Quality of Life (ProQOL) computational model, which translates the quantified emotions to the ProQOL Scale to produce an indication of an individual's compassion satisfaction, burnout, and secondary traumatic stress levels (Stamm 2010). Assessing these measures will provide a greater understanding of factors and situations that should be promoted or avoided to support veterinarian mental health and wellbeing.

2 BACKGROUND

This section reviews the literature on compassion fatigue in veterinarians and describes a fundamental theory of human emotion. Applications of simulation modeling to healthcare systems and human emotions are also reviewed.

2.1 Compassion Fatigue in Veterinarian General Practitioners

A veterinarian's empathetic nature is one of their most venerable strengths. However, it exposes them to uncompromising dilemmas regarding those they serve: the animal patients and the human clients (de Graff 2005). Bernard Rollin (2011) identified that veterinary medicine and other animal work-related professions face a unique form of moral stress. Specifically, he recognized that most veterinarians enter the field to treat disease, alleviate pain and suffering, and provide a high quality of life for all they tend to. Unfortunately, due to a variety of economic and societal reasons, they are often prevented from pursuing these objectives, causing a substantial internal conflict that cannot be alleviated by normal approaches (Rollin 2011).

One major source of moral stress for veterinarians involves the use of euthanasia. Euthanasia is one of the most powerful tools in medicine for ending pain and suffering by humanely ending the patient's life. In most cases, veterinarians provide this service without issue. However, veterinarians are repeatedly faced with clients who wish to euthanize unwanted pets that are in relatively good health, purely for convenience. Conversely, clients are sometimes unwilling to euthanize in dire circumstances because of their attachment to the animal. In these types of instances, the doctor is put into a helpless position of knowing the right thing to do, yet being unable to act because U.S. law dictates that an animal is the property of the owner, thereby giving the owner full authority (Rollin 2011).

Veterinarians are also constantly subjected to an "emotional rollercoaster" (Tekippe 2016). This term refers to the psychological impacts of dealing with extreme variability in the types and severity of illnesses seen in a given day. For example, a veterinarian might be required to euthanize a senior pet with cancer, whose owners are in mourning, followed immediately by an appointment to provide vaccinations to a new puppy, whose owners are elated. Additionally, details of the worst cases may remain vivid in a veterinarian's mind long after the experience is over, and often they are unable to take the time to fully process their emotions because of how busy they are. They may be unable to discuss these experiences openly, because of the statutory and regulatory provisions that protect their clients. The eventual degradation of physical and mental well-being as a result of such long-term unalleviated stress is referred to as compassion fatigue.

2.2 Understanding Human Emotion

In order to begin to understand the mechanics of compassion fatigue, it is necessary to understand its emotional constituents. By all accounts, the human psyche is infinitely vast and complex. Moreover, it is entirely individual and subjective. However, significant effort has been put towards the study of behavior and the mind in the field of psychology, and general theories have been produced that make it possible for researchers to come to some level of understanding. One such theory is Plutchik's (1980) general psychoevolutionary theory of emotion. Plutchik's theory states that "an emotion is an inferred complex sequence of reactions to a stimulus and includes cognitive evaluations, subjective changes, autonomic and neural arousal, impulses to action, and behavior designed to have an effect upon the stimulus that initiated the complex sequence." This suggests that human emotion can be thought of as a system with a definable sequence of events. In addition, the theory stipulates that there are a small number of basic, primary emotions that can be conceptualized in terms of pairs of polar opposites. These are joy and sadness, trust and disgust, anger and fear, and anticipation and surprise.

2.3 Modeling Techniques

The three major simulation modeling paradigms are discrete event simulation, agent-based modeling, and systems dynamics, each of which has its own distinct advantages. Discrete event simulation is well-suited for modeling systems that can be represented as a sequence of discrete events over time at a low-medium level of abstraction. Agent-based models employ autonomous agents with individualized behavior logic that interact and communicate with one another over time, yielding emergent global system behavior. Agent-based models can handle a wide range of abstraction. Systems dynamics is a modeling approach that represents system behavior at a high level of abstraction, in terms of stocks that change states at a rate that is defined by causal relationships, which are represented by interacting feedback loops (Borshchev and Filippov 2004).

Agent-based modeling could be used to model certain aspects of a veterinary clinic system. In particular, the veterinarian, nurses, clients, and patients could be represented as computational social agents that interact and emotionally adapt to their environment over time. However, agent-based modeling does not provide a convenient means of representing the flow of discrete entities (i.e., clients and patients) through a system with capacity-constrained resources (i.e., veterinarians and nurses) and queues – these modeling constructs are typically unavailable. By contrast, discrete event simulation is a natural choice for representing resource allocation and client and patient movements through the veterinary clinic system. The veterinarian can be modeled as a resource with an embedded model of human emotion that is triggered by the attributes of the entities that it processes. This embedded model is best abstracted by the stocks and flows of systems dynamics. Based on Plutchik's theory of emotion, the veterinarian's mental state can be represented as a stock moving from one state (e.g., happy) to its opposite (e.g. sad) at a rate that is determined by interactions between external stimuli and internal coping mechanisms.

The following sections describe how discrete event simulation and system dynamics have been applied in related research.

2.3.1 Discrete Event Simulation

Discrete event simulation has been used extensively to study human healthcare systems. Jacobson, Hall, and Swisher (2006) provide a survey of existing literature, including research on outpatient scheduling, inpatient scheduling and admissions, emergency room simulations, specialist clinics, physician and health care staff scheduling, bed sizing and planning, room sizing and planning, and staff sizing and planning. Their review clearly articulates that discrete event simulation is well suited to investigate the problems in healthcare systems.

The use of discrete event simulation in veterinary medicine appears to be focused in epidemiology (Cohen, Artois, and Pontier 2000; Viet, Fourchon, and Seegers 2004). However, Steward and Standridge (1995) describe a model that integrates a rule-based expert system approach with process world view modeling capabilities to produce a veterinary practice simulator. This simulator provides decision support for patient scheduling as well as decision making capabilities for veterinarian and staff behavior to more accurately represent the staff assignment and prioritizations that occur in a real system. The simulator input includes patient demand for service, the time required for procedures and related activities, physical resources, and operating policies, and it produces estimates for patient waiting times, service times, number of patients concurrently served, and resource utilization.

2.3.2 System Dynamics

System dynamics has also been used to evaluate human healthcare systems. For instance, Townshend and Turner (2000) developed a system dynamics model of a system for chlamydia screening in the UK. Their research was focused on assessing the impacts of different screening interventions. This required a quantitative assessment, and systems dynamics was chosen because it allowed them to account for re-infection of treated people and the reduction in prevalence after the screening, and modeling the large population would have been impractical with discrete event simulation, (Brailsford and Hilton 2001).

While system dynamics models are often used for policy analysis and design, they can be used to simulate any dynamic system characterized by interdependence, mutual interaction, information feedback, and circular causality (System Dynamics Society 2016). With this in mind, Morris, Ross, and Ulieru (2010) used systems dynamics to model the human response "stress" in an effort to make computer systems more human aware and human-like in order to improve human-system interaction. They first developed an influence diagram, in which a total of seventeen feedback loops impacting stress were identified with a mixture of reinforcing and balancing effects. In addition, delays were added to include the effects of time. The influence diagram was then converted to a stock and flow diagram with six stocks (Demand, Resource, Stress, Positive Emotion, Cortisol, and Heart Rate), with associated inflows and outflows. The remaining factors were used to define flow rates between these stocks. Through their research, Morris, Ross and Ulieru illustrated that it is possible to simulate fuzzy human factors through the use of system dynamics and produce quantifiable and explainable results.

3 MODELING APPROACH

This section provides an overview of the hybrid model that was developed for this study, as well as a detailed description for each component of the model.

3.1 Model Overview

A three-stage hybrid model has been developed to study the dynamics of compassion fatigue in veterinary doctors in response to workplace stress. The first stage is the Work Environment Model, which is a discrete event simulation of the daily operations in a medium-size veterinary clinic. This model represents the process by which clients (i.e., humans) and patients (i.e., animals) arrive at the clinic, wait for service, receive an examination and possibly treatment from the doctor and nurses, and are discharged from the clinic. The Work Environment Model is used to generate client and patient attributes, as well as the veterinarian's utilization over time, which are used as inputs to the second stage of the model, which is the Veterinarian Emotional Model. This is a system dynamics model that simulates a veterinarian's interpretation of client characteristics, patient characteristics, and their own utilization throughout the day to produce a quantifiable emotional response, in terms of eight different emotions: joy, sadness, trust, disgust, anger, fear, surprise, and anticipation. Finally, the third part of the model is the ProQOL Computational Model, which maps these eight emotions to the assessment questions from the Professional Quality of Life Scale. This enables the calculation of the compassion satisfaction, burnout, and secondary traumatic stress measures. To facilitate the development of the hybrid discrete event-system dynamics simulation model, AnyLogic (version 7.3) was chosen as the modeling environment, as it allowed for easy integration of the various model elements.

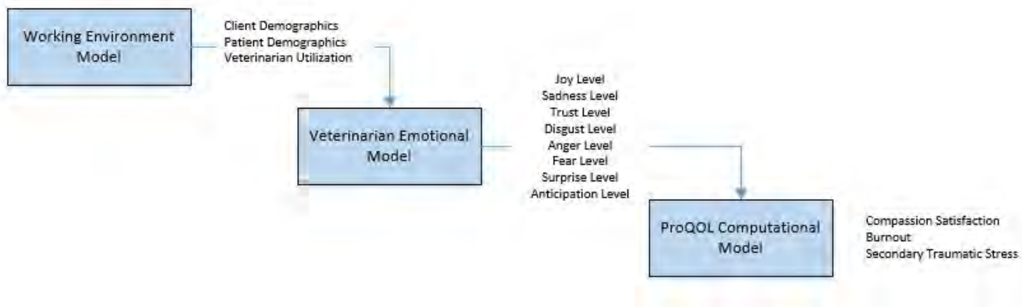

Figure 1: Hybrid model overview.

3.2 Work Environment Model

A discrete event simulation (DES) was developed that closely represents a veterinarian's typical working environment. DES was chosen because it is well-suited to representing real-world healthcare systems, which are characterized by a flow of entities (i.e., clients and patients) through a clinic or hospital to receive evaluation and treatment from finite-capacity servers (e.g., doctors) with queues (i.e., waiting rooms) in which the entities wait for service. A medium-sized veterinary clinic was chosen as the representative working environment. This type of clinic typically has a diverse client and patient population and may employ one or more doctors. A physical representation of the clinic is illustrated in Figure 2, which is based on the layout of a real-world clinic. Client and patient movement is restricted to the waiting area, the exam rooms, and the treatment area, since these are the only areas that are typically used during appointments. The treatment tables and exam rooms were defined as static resources, and the doctors and nurses were defined as mobile agents. Controls were provided to allow the user to vary the number of doctors and nurses.

A flowchart of the process that each client-patient (i.e., human owner-companion animal) pair follows upon arrival at the clinic is also illustrated in Figure 2. This process sequence was developed using input from a veterinary medicine expert and represents a typical appointment without any significant complications. First, a client and patient arrive at the clinic and immediately go to the reception desk to get checked in. They then proceed to the waiting area and wait there until the doctor, a nurse, and an exam room are available. When everyone is ready, they proceed to the exam room, where the examination of the patient is conducted. The client is then required to make a choice, based on the information they receive from the healthcare staff. The client can either choose not to have the patient treated or leave the system immediately, or they can choose to accept the recommended treatment, in which case the patient is taken into the treatment area, given the treatment, and then released to exit the system with the client.

Because most veterinary clinics accept walk-in appointments along with their scheduled appointments, the actual client arrival rate is uncertain. Therefore, the arrival rate of clients and patients entering the system was approximated using a Poisson distribution with $\lambda = 3$ arrivals per hour. When clients and patients enter the system, binary values are randomly assigned to each of three key entity attributes: client demeanor (hostile or friendly), patient demeanor (hostile or friendly), and presented ailment (healthy or sick). These attributes are encoded as static parameters (client/patient demeanor) and a dynamic variable (ailment), and they are used to inform the veterinarian's emotional model, which will be described in the following section. The randomness of these attribute values represents the variability in the types of clients, patients, and ailments that a veterinarian can face on any given appointment.

The registration process also has some uncertainty associated with it, because clients sometimes need to complete additional actions when they register, such as completing paperwork or updating contact information. Therefore, the registration service time was represented by a triangular distribution with minimum, most likely, and maximum times set to 0.5, 2.0, and 5.0 minutes, respectively. Since medium-sized clinics typically have only one staff member at the front desk, registration capacity was limited to one client, with a finite-capacity queue (limited to 20 client-patient pairs) to accommodate waiting patrons.

The exam services also involve uncertainty. Some exams are simple wellness checks to fill a prescription, whilst others involve lengthy consultations. Therefore, the exam service time was represented by a triangular distribution with minimum, most likely, and maximum times set to 3, 8, and 20 minutes, respectively. After the examination is completed, the client is required to make a decision on whether to have the patient treated or not. Based on the opinion of a subject matter expert, it was assumed that a client will choose to have the patient treated 60% of the time. The treatment service time is also stochastic, for a variety of reasons. For example, the treatments could be as simple as providing a vaccination or as complicated as conducting emergency surgery. Therefore, the treatment service time was represented by a triangular distribution with minimum, most likely, and maximum times set to 1, 15, and 25 minutes, respectively.

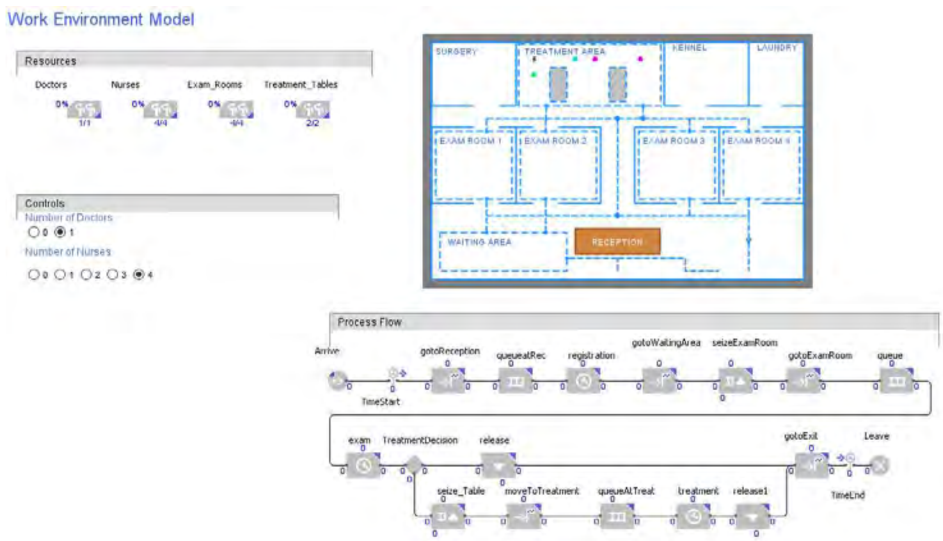

Figure 2: Work Environment Model.

3.3 Veterinarian Emotional Model

Plutchik's general psychoevolutionary theory of emotion states that emotion is a complex set of reactions to a stimulus, which involves cognitive evaluation, subjective changes, autonomic and neural arousal, impulse to action, and behaviors to have an effect upon the stimulus (Plutchik 1980). This section describes the Veterinarian Emotional Model, which accounts for the first three steps of this process: the veterinarian's cognitive evaluation of client demeanor, patient demeanor, and patient ailment, and the translation of this evaluation to the neural arousal of two of the eight primary emotions, joy and sadness. Because the dynamics of human emotion are highly abstract, system dynamics was chosen to simulate these emotional responses over time. System dynamics focuses primarily on high-level causal relationships, rather than the specific details of an agent. The associated causal loop diagram and stocks and flows diagram are described in the following sections.

3.3.1 Causal Loop Diagram of Joy and Sadness

Figure 3 is the causal loop diagram for the joy and sadness emotions in the Veterinarian Emotional Model. This diagram illustrates that the external factors (i.e., presented ailment, patient demeanor, client demeanor and current doctor utilization) are interpreted into two internal concepts, perceived patient wellness and demand. These internal concepts were developed using information obtained from interviews with a subject matter expert in veterinary medicine (Tekippe 2016). In this model, perceived patient wellness represents the physician's assessment of the overall health of the animal, which includes both physical and mental considerations, and demand represents the doctor's feeling of being required to respond to a negative or positive stimulus. Perceived patient wellness has been determined to have an effect on demand, as well as joy and sadness. This is because a veterinarian will often empathize with clients and is expected to have an emotional response, based on the animal's current condition and the services to be administered.

These two internal concepts are then processed into the neural responses: joy and sadness. These two emotions have a balancing effect on one another (i.e., when one increases or decreases the other does the opposite). This is consistent with Pluchik's theory that primary emotions can be conceptualized in terms of pairs of polar opposites. Emotional coping is also included to serve as a regulatory mechanism for the each of the emotions in this model. According to Lazarus (2013), people actively select the environments they respond to and shape their response. Two ways in which they can shape their responses are through problem-focused coping and emotion-focused coping. Problem-focused coping relates to the changing of relationships between person and environment, whereas emotion-focused coping relates to the regulation of emotional distress produced by the environment. An example of emotion-focused coping is positive reappraisal, which is the process through which people focus on the positive aspects of a situation (Folkman and Moskowitz 2000).

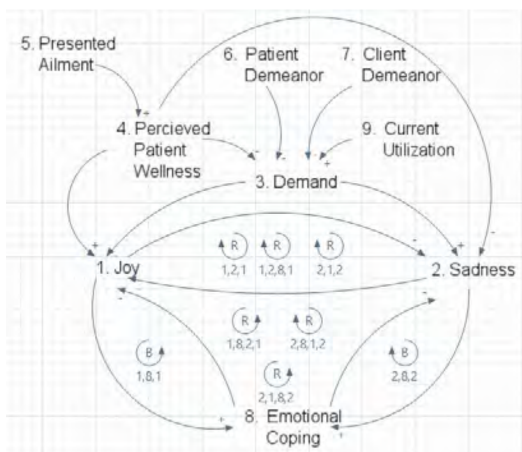

Figure 3: Causal loop diagram of Joy and Sadness.

Figure 3 identifies four separate feedback loops that affect joy and sadness. These loops are described in Table 1 and Table 2. Three of the feedback loops for each emotion were determined to be reinforcing, or positively correlated (i.e., when one increases or decreases so does the other) to the emotion in which they are associated. Only the emotional coping feedback loops are defined as balancing.

Table 1: Feedback loops in Veterinarian Emotion Model (from Joy).

Loop	Description	Effect on Joy
1,2,1	As joy increases sadness decreases which in turn further increases joy	Reinforcing
1,2,8,1	As joy increases sadness decreases, which reduces emotional coping, which increases joy	Reinforcing
1,8,1	As joy increases emotional coping increases which reduces joy	Balancing
1,8,2,1	As joy increases emotional coping increases, which reduces sadness, which increases joy	Reinforcing

Table 2: Feedback loops in Veterinarian Emotion Model (from Sadness).

Loop	Description	Effect on Sadness
2,1,2	As sadness increases joy decreases which further increases sadness	Reinforcing
2,1,8,2	As sadness increases joy decreases which reduces emotional coping which increases sadness	Reinforcing
2,8,2	As sadness increases emotional coping increases which reduces sadness	Balancing
2,8,1,2	As sadness increases emotional coping increases which reduces joy which increases sadness	Reinforcing

3.3.2 Stocks and Flows Diagram

In order to quantify the effects of the causal relationships and to enable the simulation, a stocks and flows diagram (Figure 4) was constructed using the relationships defined in the causal loop diagram. Eight stocks were defined for each of the primary emotions (joy, sadness, trust, disgust, anger, fear, surprise, anticipation), with associated inflows and outflows between each pair of emotions. Although the outputs of the Work Environment Model only affect joy and sadness, all eight primary emotion stocks were included in the stock and flow diagram to enable computation of the compassion satisfaction, burnout, and secondary traumatic stress measures discussed in the ProQOL Computation Model.

Recall, the three key entity attributes (client demeanor, patient demeanor, and presented ailment) and the doctor's utilization from the Work Environment Model were encoded through the use of static parameters and a dynamic variable, respectively. Perceived patient wellness is a dynamic variable that represents the complex process of evaluating the patient's current ailments, history, and diagnostic information (Tekippe 2016). For simplicity, it is assumed that the doctor's perception of patient wellness is equivalent to the presented ailment. Additional static parameters (ECJoytoSad, ECSadtoHappy) were defined to incorporate the emotional coping factors. Because emotional coping is considered to be an inherent trait that the doctor has acquired through training and experience, each of these values has been defined as a constant probability of resistance to emotional shift. For example, a veterinarian with twenty years of experience is less likely to experience an emotional shift than a new graduate. Therefore, the experienced veterinarian might have an emotional coping probability of 0.2, whereas a new graduate may have an emotional coping probability of 0.6. For the purposes of this study, the doctor is assumed to be an experienced veterinarian, and therefore the emotional coping factors have both been set to 0.2.

The three key entity attributes, the doctor's utilization, and the emotional coping parameter are combined to inform the emotional flows between the joy and sadness stocks. This was accomplished through the summation of each element multiplied by the relative influence each has on the emotional shift.

$$JoyProb = Emotional\ Coping\ Factor + W_1(Perceived\ Wellness) + W_2(Client\ Demeanor) + W_3(Patient\ Demeanor) + W_4(Utilization)$$

$$SadProb = Emotional\ Coping\ Factor + W_1(1 - Perceived\ Wellness) + W_2(1 - Client\ Demeanor) + W_3(1 - Patient\ Demeanor) + W_4(Utilization)$$

The relative influence of each parameter on the flow of emotion between joy and sadness was generated through the use of the swing weight method. First, a veterinarian was asked to rank order the four parameters based on their emotional influence. One hundred points were assigned to the highest-ranked element, and then the veterinarian assigned point values to the remaining parameters relative to the highest-ranked parameter. The relative weight for each parameter was then calculated by dividing its assigned points by the total number of points for all parameters. These values were then scaled to 0.8 to accommodate the addition of the emotional coping factor, such that the sum of all five parameters never exceeds 1.0. A tabulation of the weight calculation is provided in Table 3.

Table 3: Relative influence on emotional shift calculation.

	Rank Order	Points	Relative Weight	Scaled Weight
Perceived Wellness (W_1)	2	90	0.30	0.24
Client Demeanor (W_2)	1	100	0.33	0.27
Patient Demeanor (W_3)	4	50	0.17	0.13
Utilization (W_4)	3	60	0.20	0.16

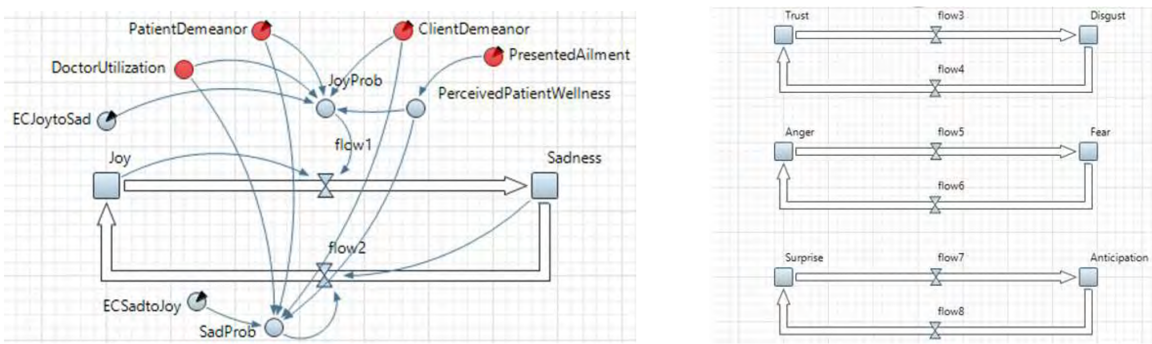

Figure 4: Stocks and flows diagram for Veterinarian Emotion Model (inputs from Work Environment Model highlighted in red).

3.4 ProQOL Computational Model

The Professional Quality of Life Scale, known as ProQOL (Stamm 2010), is a tool currently being promoted by the American Veterinary Medical Association to help practitioners establish a baseline reading of their current mental health ("Work and Compassion Fatigue" 2016). This self-administered tool is designed to assess both personal and work-related stressors through a series of questions that focus on compassion satisfaction and compassion fatigue, two areas that have been identified as critical to the mental wellness of healthcare professionals. Examples of questions included in the ProQOL assessment are "I feel invigorated after working with those I provide care for" and "I think that I might have been affected by the traumatic stress of those I provide care for." Individuals respond to each of these questions on a 1-5 Likert scale to describe how frequently they have experienced each of the questions within the last 30 days. Because of its wide use, the familiarity veterinary health care professionals have with it, and its extensive validation (Stamm 2010), this tool was used as a basis for calculating values for compassion satisfaction, burnout, and secondary traumatic stress.

Using the ProQOL tool requires that each emotion produced in the Veterinary Emotional Model be mapped to the questions in the ProQOL tool. With the assistance of a veterinary medicine subject matter expert, the each question was mapped to one of the eight emotions. Although in reality each question may map to multiple emotions, and the mapping may change based on contextual factors, it was assumed that each question mapped to a single emotion for simplification. The compassion satisfaction (CS), burnout (BO), and secondary traumatic stress (STS) measures were then calculated using the ProQOL algorithm (Stamm 2010).

4 RESULTS

A pilot study using the hybrid model described in the previous section was conducted to verify the model and to assess the viability of the proposed approach to studying compassion fatigue in veterinarians. This study focused on the effect of the client's attitude (hostile or friendly) on the doctor's emotional wellbeing over the course of a ten-hour day with no breaks, which is typical in this type of clinic. The likelihood that an arriving client would be hostile was incrementally increased in five experimental scenarios (0.0, 0.3, 0.5, 0.7, 1.0) while the probability the patient will be hostile and the probability the patient will be sick were held constant at 0.5. The number of doctors and nurses in the system was also held constant at one and four, respectively. Because the Work Environment Model includes stochastic components, each scenario was replicated thirty times.

Figure 5 provides charts of the compassion satisfaction, burnout, and secondary traumatic stress measures, as well as doctor utilization, as a function of time for a representative run. These charts clearly illustrate the dynamic nature of the key metrics over time which is consistent with the "emotional roller coaster" that veterinarians experience throughout the course of a workday.

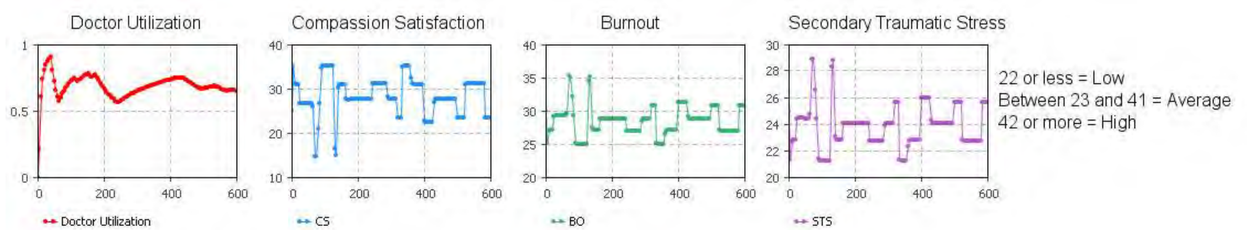

Figure 5: Doctor utilization, compassion satisfaction, burnout, and secondary traumatic stress over time for a representative run.

Data from each experiment was compiled and analyzed to determine the statistical significance of the results. The mean value for compassion satisfaction, burnout, secondary traumatic stress are provided in Figure 6. The expected response from the model was observed. As the probability of encountering a hostile clientincreased, the average ProQOL score for compassion satisfaction decreased from 30.0 to 22.0. Correspondingly, an increase in average burnout (27.5 to 31.5) and in secondary traumatic stress (23.1 to 26.1) was observed.

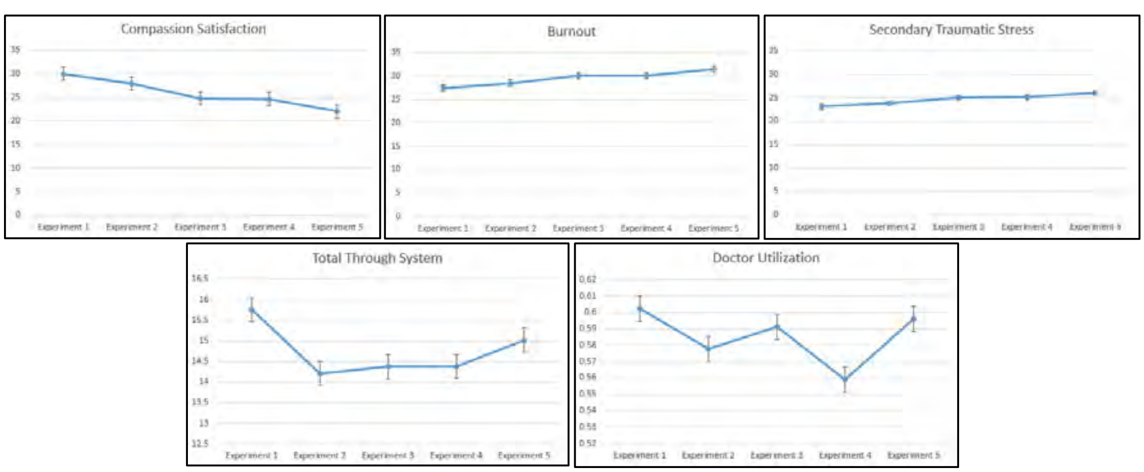

Figure 6: Plots of mean values for measures (bars represent standard deviation).

Additionally, an analysis of variance (ANOVA) was conducted to test the differences among the means for each metric. The resulting computations are provided in Table 6 and Table 7. It was determined that there was a statistically significant difference between the experiment measures as determined by one-way ANOVA ($F(4,20) = 244.789, p = 1.152E - 16$).

5 CONCLUSION

This paper introduced a framework for a hybrid discrete event simulation and systems dynamics model capable of representing an individual human's cognition of work environment stimuli, interpretation of that stimuli into primary emotions, and ultimately translation of those emotions into the familiar compassion satisfaction, burnout, and secondary traumatic stress measures. Specifically, this study showed that a discrete event simulation representing the veterinary clinic can be used to generate client and patient attributes, and the veterinarian's utilization which can be used as inputs to a system dynamics model that simulates the veterinarian's interpretation of the work environment to produce quantifiable emotional responses for Joy and Sadness. These responses were based on relative influences of each parameter as defined by a veterinarian and were converted into compassion satisfaction, burnout, and secondary traumatic stress measures that gauge how that individual feels in relation to their work. The pilot study focused on the effect of the client's attitude (hostile or friendly) on the doctor's emotional wellbeing showed that the model can produce statistically significant differences between the experimental measures.

Future work will focus on further development of the Veterinarian Emotional Model to incorporate the causal relationships between client and patient attributes, and the veterinarian's utilization for the remaining emotion doublets. Additionally, the Work Environment Model will be updated to include additional client and patient characteristics that are associated with specific agents, additional procedure types, such as surgical and emergency, as well as incorporating decision logic for the doctor and nurse agents to prioritize clients/patients based on their characteristics. Finally, a more in-depth assessment of the relationships between the veterinarian's emotional state and client/patient characteristics will be performed, with the intent of coming to an understanding of what a healthy workplace looks like for veterinarians.

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AUTHOR BIOGRAPHIES

ANDREW J. TEKIPPE is a graduate student of Industrial and Manufacturing Systems Engineering at Iowa State University. He holds a B.S. in Aerospace Engineering from Iowa State University. His research interests include developing hybrid quantitative methodologies for the analysis of human emotion in operational environments. His email address is atekippe@iastate.edu.

CAROLINE C. KREJCI is an Assistant Professor of Industrial and Manufacturing Systems Engineering at Iowa State University. She holds a Ph.D. in Industrial Engineering from the University of Washington. Her research is focused on the development of quantitative methodologies for the analysis and sustainable management of sociotechnical systems. Her email address is ckrejci@iastate.edu.