Review Article

The need of a proof-of-concept in artificial intelligence-based health-related quality of life instruments in veterinary medicine

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ABSTRACT

The current state of the art of health-related quality of life (HRQoL) and quality of life in the animal health industry highlights the limitations of existing methodologies and the potential of artificial intelligence (AI) to overcome these limitations. AI has the potential to revolutionize many aspects of healthcare, including HRQoL assessment, leading to more efficient and accurate measurement and personalized medicine. AI in psychometrics can improve cognitive and behavioral assessments and lead to new insights into animal reactions and perceptions. A proof of concept (POC) study is used to assess the feasibility of an AI-based solution. In the next decade, AI-based HRQoL instruments in veterinary medicine are expected to emerge and become widely distributed, making them easily accessible for practical use in daily practice.

Keywords: artificial intelligence; health-related quality of life; quality of life; animal welfare; natural language processing; machine learning

1. Introduction

The quality of life (QoL) and health-related quality of life (HRQoL) in animals have been an important area of research in the last decades[1–3], as it provides crucial insights into welfare and health[4–7]. The psychometric studies addressing the QoL and HRQoL in animals have been focused on validating instruments to assess behavior[8–10]; pain[11,12]; the impact of cancer[13–15]; heart disease[16,17]; living with spinal cord disease[18]; the impact of osteoarthritis[19,20]; diabetes [21,22]; chronic dermatitis[23,24]; idiopathic epilepsy[25]; chronic kidney disease[26]; enteropathies[27] and obesity[28].

The HRQoL provides a valuable qualitative and semi-quantitative reflection of the impact of any disease or condition on an animal's overall well-being[29]. Indeed, it can be used to assess the effectiveness of potential treatments or interventions. Currently, in veterinary medicine, some clinical trials on novel therapies evaluate the impact of those treatments on HRQoL and report validated instruments along with mortality and morbidity results[30–32]. In humans, the QoL and HRQoL are essential outcome measures in evaluating treatment outcomes and developing health policies, playing a crucial role in recommending novel therapies or interventions in a large population[33,34].

2. Psychometrics in veterinary medicine

Using valid and reliable instruments to measure HRQoL is essential for accurately assessing the impact of a disease or condition

on an individual's overall well-being[6]. Commonly, psychometric evaluation is the starting point to validate these instruments. Psychometrics are used in the study concerned with developing, designing, and using psychological tests and assessments of different aspects of education[35]. It encompasses a wide range of activities, including the development of new tests, the validation of existing tests, and the statistical analysis of test data[36]. The goal of psychometric studies in humans is to measure a variety of constructs, for example, intelligence, personality, and cognitive abilities, as well as to understand the relationship between these constructs and other factors such as behavior, mental health, and educational outcomes[37]. In veterinary medicine, psychometric studies are focused, as mentioned before, on instruments that assess illnesses that influence the HRQoL, focusing on changes in the behavior[38], the reaction to pain[39], the reaction to stress[12], and the impact of the chronic illnesses on the quality of life of the individual affected and sometimes the impact in the owners or proxies[23,27].

Psychometric tests can be used in various settings, such as education, clinical psychology, and personnel selection[40]. They evaluate individual differences in abilities, aptitudes, interests, and personality characteristics. These tests identify strengths and weaknesses, make predictions about future performance, diagnose disorders, and assists professionals planning interventions to improve functioning by combining several disciplines, such as psychology, statistics, and computer science[36,37,41]. Indeed, it involves creating and using mathematical models and statistical techniques to analyze the data collected from the tests and assessments. Particularly, psychometrics in veterinary medicine relies on proxy or owner information providing indirect information about the HRQoL of the animals, typically using a questionnaire in most cases analyzing how the animal behaves or reacts in certain circumstances when affected by an illness and usually these instruments include questions about how the natural behavior or daily routine is altered in the affected animal[32,42].

Behavioral measures are essential for assessing the welfare of animals, as they provide information about the animals' emotional and cognitive states[8,10]. For example, diseases that involve chronic pain can develop an irritable behavior[39]; chemotherapy and radiation therapy can develop enormous impact on appetite or gastrointestinal signs like diarrhea and vomits[43]; the risk of congestive heart failure and pulmonary edema[44]; diabetes mellitus[21,22], and degenerative processes like osteoarthritis can impact the capacity to move freely. In summary, these are among the most critical health issues that require palliatives therapies and definitely a different approach from the point of view of the HRQoL, considering that more animals are facing these conditions in developed countries[19,45].

The use of psychometrics in the study of these chronic diseases in animals provides valuable discernments into the underlying mechanisms of these conditions. It can help to develop a new approach, treatments and interventions or measure the outcomes of therapies tested in clinical trials[31,45,46]. Therefore, it can be stated that, it is a step forward if more investigators test new therapies with quality of life as a complex and multifaceted construct that encompasses physical, emotional, and social well-being, together with traditional outcomes that evaluate the efficacy of any treatment. In the context of health, HRQoL is a widely accepted measure that assesses the physical, emotional, and social functioning of individuals with a specific health condition[2,3]. HRQoL has been particularly relevant in chronic conditions where treatment may not result in a cure but instead aims to improve patients' quality of life.

3. Artificial intelligence & health-related quality of life

The current state of the art in research on QoL and HRQoL is beyond this review; but highlighting key findings and discussing the implications of artificial intelligence (AI) for the animal health industry is a starting point that is needed in this field[47]. Different methodologies are used to measure HRQoL, and the factors that influence it and the relationship between HRQoL and other health outcomes, such as mortality and morbidity,

have some limitations typically associated with qualitative studies complex statistics and the limited capacity to replicate these studies in veterinary medicine. AI can overcome some limitations of these methodologies and can accelerate the acquisition of validated tools, initially by practical solutions in data analysis. For example, machine learning as a part of the tools of AI, can be equipped with models to process data, identify variables, impute missing values, and transform variables in a proper way that would be tedious or time consuming for humans. In addition, with more complex task like regression analysis, hypothesis testing, and Bayesian inference, machine learning algorithms can recognize more intricated patterns and therefore make accurate predictions or evaluate the model itself with new data in other circumstances[48,49]. Big data, for example, can provide important conclusions ensuring that decisions and predictions in medical field are reliable; but due to statistical complexity, AI algorithms will be preferred to learn from data, adapt to new data and modify itself to different settings.

AI is rapidly advancing and has the potential to revolutionize many aspects of our lives, including healthcare[50]. The use of AI in assessing and improving HRQoL is an area of growing interest, as it offers new opportunities for understanding and addressing the complex needs of individuals with chronic health conditions[51]. In the coming years, we expect to see the development of new AI-based tools that can assist in the measurement of HRQoL, such as Deepbehavior or automated analysis of images with deep learning techniques for analyzing animal patient-generated data, more specifically, convolutional neural networks, and machine learning algorithms for predicting HRQoL outcomes[48]. The use of AI in HRQoL research may enable more efficient and accurate measurement of the impact of a disease or condition on an individual's overall well-being, as well as the identification of new treatment targets and interventions[52].

AI could be used to develop personalized medicine, where the treatment plan is tailored to the individual patient's needs and characteristics[53]. This approach could lead to an improvement in the quality of life of patients with chronic conditions. AI-based HRQoL research has an unexplored potential that needs future developments in this field, highlighting the challenges and opportunities that lie ahead, like ethics in AI and the boundaries that need to be applied to AI in the medical field[50]. There are also implications of these developments for animal healthcare that need to be addressed, with a special attention on how AI can be used to improve the quality of life of individuals with chronic health conditions and if the analysis of the results of AI-based HRQoL in ill animals can be used to promote or recommend a modification in the therapy with reliable results. Firstly, harm has to be avoided and hence, it is a challenge to adapt it for everyone[53,54].

The use of AI in psychometrics can lead to the development of more efficient and accurate assessment tools, as well as lead to new insights into the underlying mechanisms of animal behavior and cognition and the fast-track validation of new instruments[55]. As in other aspects of medicine, there has been a growing interest in using AI in psychometrics, particularly in natural language processing, computer vision, and machine learning for extracting valuable patterns and information inferring from complex analysis[56–59]. These techniques have been used to analyze large amounts of data, such as text and images, and to extract information about behavior and cognition. Additionally, AI-based methods have been used to create new test items and to evaluate the quality of existing tests[58].

AI in psychometrics can improve cognitive and behavioral functioning assessment and most probably help to identify new pathways to measure and understand animal reactions and perceptions[60,61]. For example, AI-based tools can create more accurate and efficient assessments of cognitive functioning in animals with stereotypical or compulsive behavior with deep learning implementing convolutional neural networks to behavior imaging analysis, focusing on body posture, facial gesture, or kinematic analysis[60,62].

A proof of concept (POC) is a demonstration of the feasibility or a prototype of a particular method or idea. It is used to assess and validate the concept before it is implemented in the final product. In the context

of AI, a POC is used to demonstrate the potential of a specific AI-based solution or algorithm and to show that it can solve a specific problem or meet certain requirements. For example, a POC for an AI-based image recognition system might involve training a model on a dataset of images and testing its ability to correctly identify changes within new images[63,64]. A POC can also be used to determine the technical and financial feasibility of an AI project and to identify any potential issues that need to be addressed before implementation[53].

4. Conclusion

In conclusion, AI-based HRQoL instruments in veterinary medicine will emerge in the next decade with POC studies that can improve and facilitate the use and distribution of these instruments through different platforms and possibly with easy access to encourage the veterinarians to introduce AI-based tools in daily practice. After diagnostic imaging-assisted diagnosis and clinical pathology-assisted interpretation, the QoL as a measurable outcome using deep learning, machine learning, neuronal networks, and AI-based HRQoL instruments will be extensively distributed with easy practical applications.

Conflict of interest

The author declares no conflict of interest.

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