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Dairy cow disability weights

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ABSTRACT

Over the past 175 years, data related to human disease and death have progressed to a summary measure of population health, the Disability-Adjusted Life Year (DALY). As dairies have intensified there has been no equivalent measure of the impact of disease on the productive life and well-being of animals. The development of a disease-adjusted metric requires a consistent set of disability weights that reflect the relative severity of important diseases. The objective of this study was to use an international survey of dairy authorities to derive disability weights for primary disease categories recorded on dairies. National and international dairy health and management authorities were contacted through professional organizations, dairy industry publications and conferences, and industry contacts. Estimates of minimum, most likely, and maximum disability weights were derived for 12 common dairy cow diseases. Survey participants were asked to estimate the impact of each disease on overall health and milk production. Diseases were classified from 1 (minimal adverse effects) to 10 (death). The data was modelled using BetaPERT distributions to demonstrate the variation in these dynamic disease processes, and to identify the most likely aggregated disability weights for each disease classification. A single disability weight was assigned to each disease using the average of the combined medians for the minimum, most likely, and maximum severity scores. A total of 96 respondents provided estimates of disability weights. The final disability weight values resulted in the following order from least to most severe: retained placenta, diarrhea, ketosis, metritis, mastitis, milk fever, lame (hoof only), calving trauma, left displaced abomasum, pneumonia, musculoskeletal injury (leg, hip, back), and right displaced abomasum. The peaks of the probability density functions indicated that for certain disease states such as retained placenta there was a relatively narrow range of expected impact whereas other diseases elicited a wider breadth of impact. This was particularly apparent with respect to calving trauma, lameness and musculoskeletal injury, all of which could be redefined using gradients of severity or accounting for sequelae. These disability weight distributions serve as an initial step in the development of the disease-adjusted lactation (DALact) metric. They will be used to assess the time lost due to dynamic phases of dairy cow diseases and injuries. Prioritizing health interventions based on time expands the discussion of animal health to view profits and losses in light of the quality and length of life.

1. Introduction

In response to economic constraints, the dairy industry has increasingly mechanized production processes and intensified the management of larger herds (Norgaard et al., 1999; MacDonald et al., 2007; USDA, 2007). This shift in population dynamics is similar to the urbanization of human populations begun during the Industrial Revolution and continuing today on a global scale. These changes have resulted in varying disease and mortality patterns for both humans and dairy cattle (Thomsen and Houe, 2006; Thomsen et al., 2007; WHO, 2015). Over the past 175 years, data related to human disease and death have progressed to a summary measure of population health, the Disability-Adjusted Life Year (DALY), introduced through the first Global Burden of Disease (GBD) study (World.Bank, 1993; Murray, 1996). This measure focuses on the loss of productive life or waste of human potential because of disease.

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As dairies have intensified there has been no equivalent measure of the impact of disease on the productive life and well-being of animals. For the most part disease states are recorded based on treatments, and analyzed through frequency measures independent of their outcomes. Their impact is typically framed in isolation and in terms of the cost of treatments and lost milk production (Van Winden and Kuiper, 2003; Shim et al., 2004; Huxley, 2013). A summary assessment similar to the DALY would help focus efforts to improve animal health management and welfare, key policy recommendations of the U.N. Committee of World Food Security (CFS, 2016).

Summary measures of population health combine information on mortality and non-fatal health outcomes into a single number representing the health of a particular population (Field and Gold, 1998). The DALY quantifies the difference between the actual health of a population and some stated norm or goal for population health (Murray et al., 2000). It measures health gaps and the burden of disease in units of time. A DALY can be thought of as one year of 'healthy' life lost. The subsequent disease burden is measured as the gap between a diseased population and that of a comparative reference population (Prüss-Üstün et al., 2003). This provides an assessment of the effectiveness of health systems that helps health authorities prioritize actions and allocate resources to reduce preventable disease and death. The dairy industry would benefit from a similar measure to the DALY to move beyond simply monetizing health issues by calculating a cost per case, to a more thorough assessment of the implications of time lost due to illness or injury, forced removal, or death. Creating such a measure will account for the burden of disease and consequent opportunity costs of reduced productive life.

Years of life lost due to disability (YLD) and years of life lost due to premature death (YLL) are components of the DALY that measure human morbidity and mortality, respectively. Using time as the common currency for morbidity and mortality requires measuring and numerically valuing time lived in non-fatal health states (WHO/HIS/HSI, 2013). This valuation is accomplished by equating part of the time lived with disease with the time lost due to death. Although morbidity and mortality are complementary aspects of a population's health, there is a rift between conditions that mainly cause morbidity and those that mainly cause mortality (Stouthard et al., 1997). Attempting to combine non-fatal health states and premature death into one assessment must account for differences in health characteristics such as severity and duration.

A key component of variation across summary measures such as the DALY resides in the definition of health states worse than perfect health. In the GBD studies, disability refers to any short-term or long-term loss of health (Salomon et al., 2003). Calculating the contribution of diseases and injuries to summary measures of health gaps requires a classification system. This categorical attribution requires mutually exclusive and collectively exhaustive categories and a set of rules for assigning events to them (Murray et al., 2000). For example, the International Classification of Diseases and Injuries provides a set of unique diseases and injuries that have been developed and refined over nearly 100 years for human cause-of-death tabulations (WHO, 2015).

Human medical epidemiology has historically focused on mortality within health evaluations. Mortality is more easily measured than morbidity and death registration systems are readily available and reliable. Human morbidity is difficult to measure and registration systems tend to be incomplete, unreliable or absent altogether (Stouthard et al., 1997). By contrast, dairy record systems historically have focused (with variable success) on a finite number of specific, treatable diseases with an eye toward monitoring impacts on milk production and drug residues (Kelton et al., 1998; Østerås et al., 2007; Wenz and Giebel, 2012). Information regarding early exit from the herd (forced removal) due to disease, or death is often fragmentary and inconsistent (McConnel et al., 2010). This tendency toward recording non-fatal health consequences provides an appropriate backdrop for the development of a dairy-relevant equivalent measure to the human DALY.

Evaluating the effects of non-fatal health consequences ultimately requires standardized measures of health loss in the form of so-called disability weights (Murray, 1994; Stouthard et al., 1997; Salomon et al., 2012; WHO/HIS/HSI, 2013). Disability weights are an integral component of the DALY calculation that reflect the relative severity of important diseases and provide an extension of epidemiological frequency measures. The disability weight for a specific health state is a number on a scale from zero to one with a value of 0 representing perfect health and 1 representing a state equivalent to death. The disability weight for a given health state within a population is multiplied by the prevalence of that disease or injury without age weighting or discounting to compute the YLD (WHO/HIS/HSI, 2013). With the help of disability weights, part of the time lived with a disease is regarded as not lived and the remainder is regarded as time lived in good health (Stouthard et al., 1997).

There has been extensive debate regarding conceptual and methodological issues related to the definition and measurement of disability weights (Salomon et al., 2012). The latest GBD 2010 disability weights quantify health losses for 220 distinct, non-fatal health states that capture the most salient differences in symptoms and functionality (Murray et al., 2012). These weights were established through a novel, standardized approach utilizing a multi-country household survey and open-access web-based survey. An emphasis was placed on surveying respondents from the general public representing diversity in language, culture, and socioeconomic status. The results demonstrated that it is feasible to elicit consistent assessments about a wide variety of health outcomes from populations with diverse cultural, educational, environmental, or demographic circumstances (Salomon et al., 2012).

Regardless of the species, health decision-making and planning processes can be enhanced through a consistent and comparative description of the burden of disease and injuries, and the risk factors that cause them (WHO/HIS/HSI, 2013). The effects of ill-health on dairy cow milk production are well established (Fourichon et al., 1999; Morrison et al., 2013); however, the effects on cumulative time lost to disease require description to illuminate associated opportunity costs and welfare implications. The development of a dairy disease-adjusted, time-based metric requires a consistent set of disability weights that reflect the relative severity of important diseases. The objective of this study was to use an international survey of dairy authorities to derive disability weights for primary disease categories recorded on dairies.

2. Material and methods

2.1. Colorado state university's dairy cow disease severity survey

A survey was developed to capture information regarding the severity of diseases on dairy cow health and milk production (Fig. 1). Part 1 asked respondents for their title (producer, manager, or veterinarian), primary geographic location, and years in operation or practice. Part 2 queried respondents about the severity of select diseases. This section included 12 common dairy cow diseases and an example of how to score each disease on a scale of 1–10 (least impactful versus euthanasia or death). The health problems encompassed standard terminology for disease and injury events as they are commonly recorded in on-farm databases (Kelton et al., 1998) and included: calving trauma, diarrhea, ketosis, lameness (hoof only), left displaced abomasum (LDA), mastitis, metritis,