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Building a picture: Prioritisation of exotic diseases for the pig industry in Australia using multi-criteria decision analysis

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ABSTRACT

Diseases that are exotic to the pig industry in Australia were prioritised using a multi-criteria decision analysis framework that incorporated weights of importance for a range of criteria important to industry stakeholders. Measurements were collected for each disease for nine criteria that described potential disease impacts. A total score was calculated for each disease using a weighted sum value function that aggregated the nine disease criterion measurements and weights of importance for the criteria that were previously elicited from two groups of industry stakeholders. One stakeholder group placed most value on the impacts of disease on livestock, and one group placed more value on the zoonotic impacts of diseases. Prioritisation lists ordered by disease score were produced for both of these groups. Vesicular diseases were found to have the highest priority for the group valuing disease impacts on livestock, followed by acute forms of African and classical swine fever, then highly pathogenic porcine reproductive and respiratory syndrome. The group who valued zoonotic disease impacts prioritised rabies, followed by Japanese encephalitis, Eastern equine encephalitis and Nipah virus, interspersed with vesicular diseases. The multi-criteria framework used in this study systematically prioritised diseases using a multi-attribute theory based technique that provided transparency and repeatability in the process. Flexibility of the framework was demonstrated by aggregating the criterion weights from more than one stakeholder group with the disease measurements for the criteria. This technique allowed industry stakeholders to be active in resource allocation for their industry without the need to be disease experts. We believe it is the first prioritisation of livestock diseases using values provided by industry stakeholders. The prioritisation lists will be used by industry stakeholders to identify diseases for further risk analysis and disease spread modelling to understand biosecurity risks to this industry.

1. Introduction

Freedom from many diseases affecting pig production in the rest of the world gives welfare, management and production advantages to the pig industry in Australia, supporting its economic viability in a competitive market. However, the incursion of equine influenza into Australia in 2007 (Kirkland et al., 2011) highlighted that geographic isolation, trade restrictions and biosecurity do not guarantee protection from exotic disease incursions. Following the equine influenza incursion and the recommendations of the report "One health: a working partnership" (Beale et al., 2008), a project was initiated to investigate and prioritise exotic disease risks to the pig industry. The overall aim of the project is to enhance the industry's preparedness

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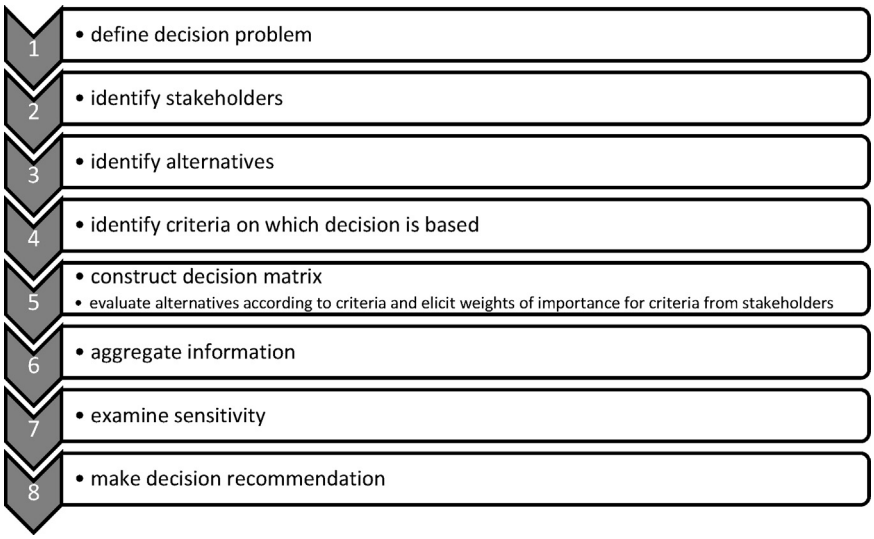

Fig. 1. Flowchart of steps for multi-criteria decision analysis (MCDA) using a multi-attribute decision making (MADM) structure.

and response to an incursion of the highest priority diseases in order to minimise impact on trade.

A variety of methods have been used to prioritise diseases. These include rapid risk analysis (McKenzie et al., 2007), qualitative decision trees (Palmer et al., 2005), consensus techniques (Weinberg et al., 1999) and semi-quantitative scoring techniques based on levels of severity of disease criteria that may or may not be weighted to contribute to disease importance (Carter, 1992; Rushdy and O'Mahony, 1998; Valenciano and Working Grp, 2001; Doherty, 2006; Krause and Prioritization Working Grp, 2008; Balabanova et al., 2011). All of these methods take into account the complex decision problem that is disease prioritisation; there is more than one criterion by which to rank the importance of a disease. However, the transparency of these prioritisations is affected by subjectivity when scoring diseases; particularly when using qualitative criteria that have been assigned arbitrary numerical levels of severity which are difficult to define.

More recently, multi-criteria decision analysis (MCDA) has been used for prioritisation of diseases or disease control options (Havelaar et al., 2010; Mourits et al., 2010; Humblet et al., 2012; Mintiens and Vose, 2012; Del Rio Vilas et al., 2013). MCDA is a group of established methodologies for decision analysis, used extensively in other disciplines such as information technology, engineering and environmental sciences (Bragge et al., 2010). The decision analysts in these projects aim to improve transparency and repeatability by using a structured MCDA approach.

The aim of this study was to combine disease information with pig producer values to prioritise exotic diseases for the pig industry in Australia, as a decision-aid to direct further research. To achieve this aim we used MCDA, applying a modified multi-attribute value theory (MAVT) based multi-attribute decision making (MADM) technique which used several approaches not widely used in previously in disease prioritisation. These novel approaches included using a set of quantifiable disease attributes as indicators of disease impact, deriving and validating weights of importance from a stakeholder group (pig producers) not considered to be experts in diseases via an online survey (Brookes et al., in preparation), and presenting the results as series of prioritisation lists that build up impacts to aid communication with stakeholders. We evaluated this technique in the context of disease prioritisation in the Australian pig industry.

2. Materials and methods

2.1. Overview

MCDA is a family of decision-making methodologies that can be divided into two categories: multi-attribute decision making (MADM) and multi-objective decision making (MODM) methods (Triantaphyllou, 2000). MADM methods are designed to rank or group the best alternatives from a set of discrete choices by following a standard series of steps (Fig. 1), and can be used in disease prioritisation because there is choice over discrete alternatives (diseases or disease control methods). MADM methods can again be subdivided into elementary methods (pros and cons analysis, maximax and maximin methods, conjunctive and disjunctive methods, lexicographic methods), multi-attribute utility theory (MAUT) or multi-attribute value theory (MAVT) based methods, and outranking methods.

This study used a modified MAVT based method following the steps in Fig. 1.The decision problem was defined as ranking diseases exotic to the pig industry in Australia by potential impact and importance of those impacts to the stakeholders. The stakeholders were defined as pig producers in Australia. Diseases exotic to the pig industry in Australia were identified as the decision alternatives and criteria describing disease impacts were selected. Impacts included the potential effects of disease on the pig industry (described by on-farm effects of attack rate, length of clinical disease and case fatality rate in pigs, and industry wide effects of market loss and government cost sharing