Animal Disease Investigations: Comparison of Methods for Information Collection and Identification of Attributes for Information Management Systems

A Thesis Submitted to the College of

Graduate Studies and Research

In Partial Fulfillment of the Requirements

For the Degree of Master of Science

In the Department of Large Animal Clinical Sciences

University of Saskatchewan

Saskatoon

By

Bobbie Lynn Lundquist, D.V.M.

PERMISSION TO USE

In presenting this thesis/dissertation in partial fulfillment of the requirements for a Postgraduate degree from the University of Saskatchewan, I agree that the Libraries of this University may make it freely available for inspection. I further agree that permission for copying of this thesis/dissertation in any manner, in whole or in part, for scholarly purposes may be granted by the professor or professors who supervised my thesis/dissertation work or, in their absence, by the Head of the Department or the Dean of the College in which my thesis work was done. It is understood that any copying or publication or use of this thesis/dissertation or parts thereof for financial gain shall not be allowed without my written permission. It is also understood that due recognition shall be given to me and to the University of Saskatchewan in any scholarly use which may be made of any material in my thesis/dissertation.

Requests for permission to copy or to make other uses of materials in this thesis/dissertation in whole or part should be addressed to:

Head of the Department of Large Animal Clinical Sciences

University of Saskatchewan

Saskatoon, Saskatchewan, S7N 5B4

Canada

ABSTRACT

In an infectious animal disease outbreak, effective management of the event requires timely and accurate information collection, processing, storage and distribution. This thesis focuses on the tools to assist information collection and management. The first study describes the comparison of questionnaire methodology for the information collection in the initial epidemiologic investigation of a Canadian federally reportable disease. The second study defines attributes of an animal disease outbreak information management system (IMS). The studies were performed within a one-year period (July 2013-July 2014).

The first study performed two comparisons to determine differences in the information quality (completeness and accuracy) between differing questionnaire methodology and modes of completion (hard copy and electronic). The study was conducted with 24 Canadian Food Inspection Agency (CFIA) inspectors and veterinarians using a fictitious Canadian reportable disease scenario. The first comparison used a hard copy of a Canadian Food Inspection Agency (CFIA) questionnaire designed to be applicable (or generic) for all highly infectious reportable disease investigations with a supplementary disease specific section compared to an electronic disease specific reportable disease questionnaire. There was no significant difference in the information quality (N = 22; $P = 0.09$). The mean difference in completeness and accuracy scores was 3.5% (95% CI -0.6, 7.6). The second comparison focused on the hard copy disease questionnaire and assessed differences in information quality between using only the generic sections of the questionnaire compared to the supplementation of a disease specific section. A difference in information quality was determined (N = 24; $P < 0.0001$). The mean completeness and accuracy score for the generic only sections was 50.2% (95% CI 43.6, 57.2) compared to 80.2% (95% CI 76.2, 84.5) with the inclusion of the disease-specific section. The greatest

difference in information quality occurred in the tracing specific information categories ($P < 0.0001$) with a mean difference of completeness and accuracy scores of 67.7% (95% CI 52.0, 83.4) for the trace-in (exposure history) category and 38.3% (95% CI 28.3, 48.3) for the trace-out (potential spread of disease) category. The absence of disease-specific questions were determined to be the primary factor in the difference in information quality.

The second study determined a comprehensive list of user-defined attributes of an animal disease outbreak IMS and further identified the most important (key) attributes. A list of 34 attributes and associated definitions were determined through a series of focus group sessions and two surveys of Canadian animal health stakeholders. The animal health stakeholders included federal and provincial governments, veterinary academia and animal production industry representatives. The key attributes of an animal disease outbreak IMS identified were: 'user friendly', 'effectiveness', 'accessibility', 'data accuracy', 'reliability' and 'timeliness'. 'User friendly' received the highest frequency of ranking as the most important attribute, followed by 'effectiveness'. Information management was identified as the main purpose of an animal disease outbreak IMS with a median rating of 10 (rating scale of 0-10 with 10 = strongly agree).

The occurrence of a federally reportable disease or a large-scale animal disease outbreak can have a great impact on the animal agriculture sector, regulatory government agencies and the economy. Information collection and management are essential to assist with the epidemiologic investigation and disease control measures. The study provided a novel opportunity to study information management for an animal disease outbreak from a Canadian perspective. The knowledge obtained will add value to the future development of tools and systems designed for information collection and management involving an animal disease outbreak.

ACKNOWLEDGEMENTS

It came to my attention very early in graduate studies in epidemiology that a grad student's final completion is truly an amazing example of causality. The following acknowledgements and dedication are arguably all the 'necessary' components to lead to this miraculous causal event of my completion of graduate studies. Without the support of those recognized in my acknowledgements and dedication, this would not have been possible.

To my supervisor, Dr. Tasha Epp, I want to thank you for your patience and guidance. You always maintained a positive outlook on all aspects of research and graduate studies. To my committee members, Dr. Margaret Morrison, Dr. Harold Kloeze and Dr. Cheryl Waldner, thank you for your dedication, support, wealth of knowledge and guidance. Thank you to Dr. Keith Lehman for taking a leap of faith to support me in this endeavor and to Andrea Dropko, Dr. Harpreet Kochar and Stephen Baker for granting both education leave and the ability to do research with a strong CFIA focus. I would also like to give special mention to Dr. Shamir Nizar-Mukhi for your early contributions to the project.

There are several individuals to thank for their direct involvement with the project. First, thank you to Dr. Mel Hoffer, for the countless hours spent as the actor for the questionnaire comparison and numerous hours on the road together. Thank you to my summer students, Dr. Maria Fuchs and Rianna Wagner and to study contracts Colleen Fitzpatrick and Dr. Odette Blankvoort. Also, a special mention goes to Dr. Heather Brown for your assistance with the scenario development and review of the scrapie-specific sections of the questionnaires. Special mention goes to Dr. Dennis Will and Dr. Sandra Stephens for the many hours of participating in the pilot trials of the questionnaire.

To my fellow grad students, grad studies would not have been quite so enriched without you. I would like to especially thank Colleen Fitzpatrick for your never-ending wealth of help and Dr. Chad Paetsch for the many hours of collaborative studying and conversation.

I would especially like to thank the research project funding support provided by the Saskatchewan Ministry of Agriculture through the Agriculture Development Fund, the Saskatchewan Sheep Development Board and Canadian Food Inspection Agency. Also, thank you to the Canadian Food Inspection Agency for the in-kind contribution of the two summer students. And finally, thank you to the Western College of Veterinary Medicine and University of Saskatchewan for the provision of the Interprovincial Graduate Student Fellowship. Without these contributions, this project would not have been possible.

DEDICATION

I dedicate this thesis to my family: Your patience, support and encouragement have been inspiring. To my husband, Jean, thank you, I would have not even thought to start this demanding life event without your unyielding support and confidence in me. You are my core, without you I am but a shell. To my four incredible girls, Brett, Drew, Casey and Sydney, you are my inspiration and joy. I hope with this accomplishment I can serve as a role model and prove that a woman can be a mom, a wife, a friend, a professional and pursue a life goal all in one brave stroke (as long as family is always at the top of list of priorities). I also hope to have shown you to never be afraid to try something new (this was pretty scary and I did it!). To both sets of parents, you are a wonderful example of a supportive and loving family. I always believed I could do grad studies as a working professional of four because I saw my father pursue graduate studies at the same life stage. Life events are nothing if not based in solid faith and shared with those you love. Thank you for sharing this life achievement with me!

ORIGINAL CONTRIBUTION

I created the original concept of this study in consultation with Canadian Food Inspection Agency (CFIA) disease control veterinarians and Dr. Tasha Epp. I was responsible for developing the study design and writing funding proposals.

For the questionnaire comparison study, I arranged, observed and collected the data for all 24 participants. Dr. Heather Brown, a CFIA veterinarian, assisted with the scenario development and reviewed the scrapie-specific questions of both questionnaires to ensure relevancy to a scrapie disease investigation. Dr. Mel Hoffer, a study contract, performed actor duties for all of the participant interviews. Dr. Maria Fuchs, a CFIA summer student, converted the scrapie disease-specific questionnaire to electronic format in FluidSurveys™. Ms. Colleen Fitzpatrick, a study contract, completed the assignment of randomized participant numbers and removal of personal identifiers in the questionnaire data. Dr. Odette Blankvoort, a study contract, performed the blinded assessment of questionnaire responses for completeness and accuracy and entered the results into a database.

For the animal disease outbreak information management system study, I conducted both focus group sessions. I developed both surveys with the guidance of Dr. Tasha Epp. Ms. Rianna Wagner, a CFIA summer student, converted the first survey into electronic format in FluidSurveys™ and I converted the second survey. Dr. Harold Kloeze and Dr. Maggie Morrison assisted with the modified Consensus technique for determination of the top three attributes responses. Dr. Cheryl Waldner and Dr. Tasha Epp assisted with the final determination and definition of the top three attributes.

I performed all of the data processing and statistical analysis under the guidance and supervision of Dr. Tasha Epp.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1: INTRODUCTION AND LITERATURE REVIEW

1.1 Introduction

In an epidemiologic investigation of an infectious or highly contagious animal disease outbreak the primary goal of the initial investigation is to collect information. The investigator will typically collect information and intelligence to describe the affected animals, clinical presentation, timing of cases, identify the disease agent, determine the source, and trace the potential for disease spread. Information collected is used for a variety of purposes including: determination of the cause of the outbreak, initiation of disease control actions to prevent spread of disease, implementation of prevention and preparedness measures to mitigate risk of future outbreaks, assistance in making policy decisions and communication of information related to the event (Dwyer et al., 2014; Levings, 2012; MacDonald, 2012; Mukhi et al., 2007; Putt et al., 1987).

This literature review was conducted with two purposes in mind. The first objective was to provide a general overview of the processes involved in the field collection of information in an infectious animal disease outbreak with specific focus on the use of an interviewer-delivered questionnaire. The second objective was to provide an overview of the principles of information management and an information management system (IMS) with specific focus on an IMS for an animal disease outbreak event.

1.2 Disease Outbreak Investigation

1.2.1 Information Collection In a Disease Outbreak Investigation

The World Organization for Animal Health (OIE) (2014) defines an outbreak investigation as “a systematic procedure to identify the source of cases of infection with a view to control and prevent possible future occurrence.” The goal of a disease investigation in the early stages is to determine its nature and cause, assess the significance and identify prevention methods and control strategies to reduce the impact of the disease on the population or economy (Dwyer et al., 2014; Wobeser, 2007). An epidemiologic investigation of any disease investigation examines the overall disease event in the population rather than at a case or individual level (Bartlett and Judge, 1997). However, in order to get a population based view of the event, information at the individual or case level is required to establish the foundational information (World Organisation for Animal Health (OIE), 2014).

A simplistic approach to disease investigation is the classic investigative process of the 5 W's: Who? What? Where? When? Why? The population characteristics (i.e. species affected, age, gender) are the 'who'. The 'what' is the clinical or pathological presentation and the disease agent involved. The 'where' is the location of the event and the environmental factors associated with the event. The temporal distribution of the disease is the 'when' and the 'why' is origin of the disease event (MacDonald, 2012; Schwabe et al., 1977; Waldner and Campbell, 2006; Wobeser, 2007).

A stepwise approach to performing disease investigation and addressing the 5 W's is recommended. The steps to the investigation include verifying the diagnosis, confirming the outbreak, defining a case, conducting case finding, tabulating and orienting the data to time, place and person, implementing control measures, formulating and testing hypothesis, executing additional studies, and communicating the findings. While some steps may occur in conjunction with other steps, the overall process can be applied to any disease outbreak investigation (Centers for Disease Control and Prevention (CDC), 2014; Dwyer et al., 2014; MacDonald, 2012; Spickler et al., 2010; Waldner and Campbell, 2006; Wobeser, 2007; World Organisation for Animal Health (OIE), 2014).

1.2.2 Information Collection Specific to Infectious Animal Disease Outbreak Investigations

Information collected in the epidemiologic investigation becomes the basis of all further actions and decisions made about the disease outbreak. Therefore, it is important the information is accurate and precise to ensure it is a true representation of the disease event (Bartlett and Judge, 1997; World Organisation for Animal Health (OIE), 2014). While the requirement to collect information and investigation principles are the same for human and animal disease outbreaks, there are several unique information collection requirements for animal disease outbreaks that differ. These differences are apparent in each of the 5 W's previously described (Who? What? Where? When? Why?).

First, in considering the description of the 'who' of the disease outbreak, it must be identified what species are affected, as there may be more than one (Perry et al., 2001). For each case, information must be collected regarding the premises, number of each species affected per premises, animal owner, operator and employee specific information (Animal and Plant Health Inspection Service (APHIS), 2003; Waldner and Campbell, 2006). The type of identification of animals can vary per species. For many countries, domestic livestock require a formal identification that is unique to the animal and/or animal operator or operation. In the absence of formal identification, the animal(s) involved must be identified as specifically as possible with physical description (i.e. coat colour, markings), breed, species, visual tags, tattoos or microchips (Spickler et al., 2010; Waldner and Campbell, 2006).

The collection of information in regards to the clinical presentation and disease agent involved (the 'what') must include consideration of the potential of different clinical and pathological presentations in each species involved. As a result, distinct differences in morbidity and mortality may occur in each species involved (Perry et al., 2001). For example, in foot and mouth disease (FMD), the clinical presentation in ovine species can be mild or asymptomatic, whereas, porcine and bovine species present with apparent production limiting lesions, particularly in naïve populations (Radostits and Done, 2007).

In collecting information on the 'where' of the disease outbreak, there can be unique features of defining geographic residence of the animal(s). For example, the location of domestic animals can vary through production practices such as pasture rotation or multi-site multi-stage production. In some cases, the geographic range can be quite large (i.e. several square kilometers) and can have seasonal differences (i.e. summer grazing practices over a large geographic range but winter feeding in a single location). As a result, careful geographic information about the affected and any unaffected animal(s) must be collected and may require temporal associations. Often, the most appropriate means to collect this information is via the collection or drawing of a farm or site diagram. The diagram should include temporally specific or unique information such as water source and manure disposal site (Waldner and Campbell, 2006).

The 'when' or information on the temporal distribution of the disease can be unique due to the animal production practices. For example, high production animal facilities can have a large number of animals on one site. Infectious disease introduction may spread more rapidly in more secular animal populations or have the opportunity to exist for an extended period of time at subclinical level before it is recognized or detected (Spickler et al., 2010). Animal production parameters records are unique features of an animal disease outbreak investigation. Review of these records are important for determining the onset of clinical signs into a herd or flock. Production parameters can be animal production specific (i.e. dairy production will look at individual animal milk production versus beef cow-calf operations may look at number of animals infertile as a production measure) but may include common factors such as feed and water intake (Kelton, 2006; Ruegg, 2006; Waldner and Campbell, 2006).

The ‘why’ or origin of the disease event presents some of the most unique information requirements of an animal disease outbreak investigation. While human disease outbreak investigations will focus on the term ‘exposure’ it is common in animal populations to see the additional use of the word ‘incursion’ or ‘introduction’ of disease. This is due to the secular nature of some domestic animal production. In particular, intensively raised livestock will often have a ‘disease free’ status where additional management measures (i.e. biosecurity) are placed in the operation to prevent, reduce or eliminate the introduction of disease. In these types of operations, the biosecurity practices become an avenue of investigation where investigators must collect information on the efficacy of these measures to assess for source of disease introduction (Spickler et al., 2010).

The tracing of animal movements and animals introduced to or removed from the herd or animal group is an essential component of investigating the disease exposure. Movement tracing must consider the animal movements (i.e. pasture to pasture or escaping contained housing) and human conducted animal movements (i.e. transport to a livestock show or sale). Animal disease outbreaks often require the need to investigate potential exposures due to the movements of fomites, animal products or by-products, wildlife, vectors, feed, water, air and other unique environmental factors such as flooding conditions (Levings, 2012). Spatial mapping information also becomes an important consideration for the disease exposure (Corbin and Griffin, 2006). Mapping can include geo-referenced positions of animal disease outbreaks, affected farms and associated animal agricultural businesses or epidemiologically linked premises (Kroschewski et al., 2006).

Animal disease outbreaks are often a complex relationship between the environment, disease agent and host. The collection of information must include specific information related to the disease, species, animal production type and geography. As a result, the collection of information is complex and extensive. In some cases, a single explanation of ‘exposure’ or ‘introduction’ cannot be identified but rather involves a set of risk factors for the animal or animal populations affected (Dohoo et al., 2009; Gay, 2009; Kelton, 2006). Additionally, animal production often follows a seasonal or production cycle variation requiring interpretation of production parameters unique to the various cycles (Dohoo, 1993). Investigations involving animal production units need to consider both individual and herd level risk factors. The information collected must allow for exploration of risk factors at both individual animal and herd level (Corbin and Griffin, 2006; Waldner and Campbell, 2006). In the case of unavailable information at the individual animal level, investigators must then collect the next smallest group level information (Waldner and Campbell, 2006).

Because of the heterogeneity of each animal disease outbreak event, a defined ‘list’ of information to be collected must be adapted to the event, species involved, animal production and management practices. The result can be an extensive amount of information to be collected in the disease investigation process. (Dohoo et al., 2009; Gay, 2009; Kroschewski et al., 2006; Levings, 2012; Spickler et al., 2010; United States Animal Health Association, 1998; Waldner and Campbell, 2006).

1.2.3 Methods for Obtaining Information in a Disease Investigation

Interviews and questionnaires are commonly used for obtaining additional information not available through laboratory reports. The questionnaire or interview process may be used independently or combined together for a standardized interview where the interviewer progresses through the questionnaire in a structured or semi-structured approach (Harris and Brown, 2010; Oppenheim, 1992; Putt et al., 1987). The use of an interviewer-delivered questionnaire is a commonly used method for disease outbreak investigations requiring extensive information or multiple interviews (Centers for Disease Control and Prevention (CDC), 2014; Dwyer et al., 2014; MacDonald, 2012; Stehr-Green et al., 2012; World Health Organization (WHO), 2008). Regardless of specific method, the general process involves a series of questions to be asked of the case, case proxy or in the case of animal disease, the animal operator or owner to collect information specific to the disease event. The primary function of all the methods is to act as an instrument of information collection (Oppenheim, 1992). The use of the questionnaire and interview will be discussed individually in further detail.

1.2.4 Questionnaire as an Information Collection Tool

Oppenheim (1992) describes a questionnaire as "an important instrument of research and a tool for data collection." Questionnaires have a primary function of measurement (Fink, 2003; Oppenheim, 1992). They are considered to be an objective research tool producing generalizable results. Questionnaires provide the advantage of simplicity in design and delivery, consistency, versatility and cost effectiveness (Richardson, 2005). In a disease investigation, a properly designed and validated questionnaire can provide quality data useful for hypothesis testing and assisting in policy decisions. Hypothesis generating questionnaires pose exploratory type questions to the audience. The use of a questionnaire for hypothesis generating provides an indication of how common certain responses are to a standardized question (Breakwell et al., 2006). The questionnaire used in the initial investigation often contains extensive questions regarding the case's potential pathogen exposure for the purposes of tracing and hypothesis generation. Once investigators have an indication of exposure source, hypothesis testing may be performed with a subsequent questionnaire to further trace source(s) of exposure. The overall goal is to provide proof of evidence for the source of the disease event and to assist regulators and health officials in preventative and control measures (Centers for Disease Control and Prevention, 2013).

1.2.5 The Interview as an Information Collection Tool

An interview is a method of data collection "in which one person, an interviewer, asks questions of another person, a respondent" (Appleton, 2006). There are three types of interviews including: structured, unstructured and semi-structured. The unstructured informal interview is where the interviewer conducts free-flow questioning that may be guided by a pre-defined list of information required. In contrast, the structured standardized interview is where the interviewer conducts the interview in a consistent approach with a specific questionnaire. In this type of interview, the intended result is quantitative information while the unstructured interview results in qualitative information (Food and Agriculture Organization of the United Nations, 1997). The use of a structured interview provides a greater degree of reliability but if too restrictive, can eliminate the opportunity for interviewers to further inquire on points of interest (Harris and Brown, 2010). The semi-structured interview is a combination of both unstructured and structured interviewing (i.e. interviewer may start the interview with open questions followed by a structured interview via use of a questionnaire). In semi-structured interviews, the interviewer may have a guideline of themes, categories or questions to ask but the order in which they are delivered is left to the discretion of the interviewer. Typically, the data of a semi-structured interview are weighted towards data that are qualitative (Kajornboon, 2005).

Alwin (2011) argues the use of an interview offers a qualitative advantage of being able to provide an understanding of the meaning behind the number produced by a quantitative survey question, and subsequently providing insight into construct validity. The interview offers the ability for the interviewer to explain complex questions. Interviewers may also choose appropriate use of aids to enhance respondent recall (i.e. visual prompts) and probe for additional information. As a result, higher response rates are often achieved (Phellas et al., 2011). In contrast, the use of an interviewer introduces several limitations to the information collection process. A major consideration is the interviewer can introduce bias and affect the reliability of responses. Also, the time taken to conduct the interview can be lengthy with increased cost due to travel and interviewer wages. Finally, the time required to transcribe the information collected, and the quality of the information collected are heavily dependent on the skills and expertise of the interviewer (Appleton, 2006; Phellas et al., 2011).

In a disease investigation based interview, while the main objective is to collect disease event related data, the interview provides an important function in the establishment of a rapport between the interviewer and respondent, provision of information to the respondent and discussion of future actions to be taken in regards to the disease event (Baumal and Benbassat, 2008). Interviews provide a forum in which respondents are able to ask for clarification and elaborate on details, while the interviewer is allowed opportunity to explore certain fields of information more closely and provide insight to question intent or meaning (Harris and Brown, 2010).

1.2.6 Assessing Information Quality of an Interviewer-Delivered Questionnaire

Obtaining optimal information quality is the primary goal of the disease investigation information collection process (Naumann and Rolker, 2000). Often the process of evaluating a questionnaire's validity and reliability is the main method to assess information quality (Wiseman-Orr et al., 2006). In simplistic terms, the validation process evaluates how well a questionnaire will yield accurate and consistent information regardless of the variability in respondents, time to completion and to whom the respondents respond to (Alwin, 2011; Dohoo et al., 2009; IEA European Questionnaire Group et al., 1998; Marshall, 2005; McDonald et al., 2003; Meadows, 2003).

One method to assess information quality is to define key criteria by which a subjective and/or objective evaluation can be made (Lee et al., 2002; Naumann and Rolker, 2000; Pipino et al., 2002; Vaziri and Mohsenzadeh, 2012). The key criteria are often described as dimensions, information quality (IQ) criteria or sub-characteristics of information quality (Knight and Burn, 2005). Commonly listed dimensions of information quality include: completeness, accuracy, timeliness, accessibility, relevancy, objectiveness, free-of-error, understandability and interpretability (Knight and Burn, 2005; Vaziri and Mohsenzadeh, 2012). Pipino et al. (2002) describe the practice of using both a subjective and objective assessment of data quality. In the objective assessment, pre-determined metrics are utilized to assign quantitative values to the information. Objective assessment can be completed on the dimensions of free-of-error, completeness and consistency. In the subjective assessment, a qualitative assessment is performed to determine if the information meets the intended purpose. The dimensions of understandability and interpretability are commonly assessed subjectively (Pipino et al., 2002).

1.2.7 Bias in Information Collection Methods Affecting Information Quality

1.2.7.1 Questionnaire Bias

Bias in questionnaires is inherent (IEA European Questionnaire Group et al., 1998).While it is beyond the scope of this review to describe all forms of questionnaire introduced bias, a focus discussion of the bias introduced by the design of the questionnaire and mode of completion will be reviewed.

1.2.7.1.1 Bias Due to the Design of the Questionnaire

One of the major flaws of questionnaire design is the use of questions that are too difficult to ask, comprehend or answer (Meadows, 2003). Each element of the questionnaire design can affect the information acquired. For example, an open-ended question asks for a narrative or non-numerical answer from the respondent producing qualitative data. In contrast, a closed question requires the respondent to select a predetermined option (i.e. multiple choice) for the answer resulting in a quantitative response. The open ended question might obtain a more detailed answer from the respondent to increase the depth of knowledge on the subject matter, but may result in missing information and highly variable responses between respondents creating difficulty in converting answers into quantitative values for analysis. The closed question structure facilitates a rapid analysis of responses but offers the disadvantage of forcing the respondent to choose the most appropriate answer which may not offer the same depth or understanding to the respondent's answer as an open-ended question (Dillman et al., 2009; Murray, 1999; Oppenheim, 1992).

The questionnaire should be designed to minimize respondent and interviewer errors in the understanding of the questions and recording of the answers while maintaining both party's interest and cooperation (Marshall, 2005). Many studies have investigated the effects of certain components of questionnaire design on the response rate and quality of data collected. However, few studies are health specific and even fewer explore effects of questionnaire design on the quality of information collected in an animal disease outbreak investigation (Jacoby et al., 2001).

1.2.7.1.2 Bias Due to the Mode of Completion of the Questionnaire

The mode of completion (i.e. handwritten or electronically completed) can have an impact on the quality of data generated (Jacoby et al., 2001; Murray, 1999). This discussion is not an exhaustive list of bias associated with the two modes of completion but rather examples of areas of potential error or bias unique to each method.

Electronically completed questionnaires have unique potential for error and bias introduction. Issues with Internet accessibility, Internet connection speeds, computer configurations, computer and typing skills and familiarity with computer technologically are all unique to this mode of completion. Also, due to the horizontal nature of a computer screen, design effect can be introduced if visual representation of the questions is not considered (Dillman and Smyth, 2007). In the case of an interviewer-delivered electronic questionnaire, interviewers are forced to simultaneously perform two interactions, one with the respondent and one with the computer potentially causing interviewer distraction and disengagement of the respondent (Presser et al., 2004). Electronically completed questionnaires allow questions to be asked one screen at a time, whereas paper-based handwritten questionnaires are often presented in a booklet style to navigate between pages. The electronic presentation can cause limitations on the ability of the interviewer or respondent to easily navigate between pages (Dillman et al., 2009).

Paper-based handwritten questionnaires require manual data entry and subsequent transcription and coding of the responses into electronic format allowing for increased opportunity of measurement error. The legibility of the handwriting and ability to write outside of the response area can lead to difficulty of transcribers and other readers to understand the response. The hard copy questionnaire does not allow automated features such as branching (skipping areas not applicable) and drill down (ability to automatically prompt more specific questions) unless the interviewer or respondent has specific directions to guide them (Dillman et al., 2009).

1.2.7.2 Interview Bias

The interview is fundamentally a social interaction that occurs between at least two people (Maynard and Schaeffer, 2006). In the interviewer-delivered questionnaire, the three components of interviewer, respondent and questionnaire create a complex interaction (Figure 1.1). Subsequently, interaction between each may introduce bias to the interview.

Situational effects such as the gender, ethnicity and age of the interviewer can influence the validity of data, particularly depending on the subject matter of the interview (IEA European Questionnaire Group et al., 1998). Language differences between the interviewer and respondent can create cognitive issues in the comprehension of the question or response leading to measurement error. Interviewer techniques such as courtesy, eye contact, and demeanor can affect the respondent's willingness to provide answers. For example, an interviewer that is too authoritative or has too little eye contact may reduce the respondent's willingness to answer (Meuleman and Caranasos, 1989).

Interviewers failing to follow the structure of the questionnaire can introduce measurement error or the omission of available information. Interviewers who use paraphrasing of questions in a structured interview can bias the respondent's understanding and response due to altered wording changing the original question intent. The interviewer's reactions to responses (i.e. surprise at a response) may bias the respondent's subsequent answers (Food and Agriculture Organization of the United Nations, 1997). In cases where the respondent is articulate and well informed, the issue of 'elite bias' is reported; this is where data may be overvalued due to the increase in cognitive understanding by the respondent and/or increased detail in the answers provided. Another bias to consider in the use of interview is 'holistic fallacy' where the interviewer introduces their bias into the responses recorded due to their own deductive reasoning (Appleton, 2006). Overall, interviews are important means to collect information in a disease outbreak investigation, but it must be recognized the information collected may be subject to distortion and misrepresentation (Harris and Brown, 2010).

1.3 Information Management

1.3.1 Overview of Information Management

Information management is the process of managing the planning, organization, training, maintenance and budgeting of organizational information (Jordan and de Stricker, 2013). Components of information management include the process of knowledge management, data management, records management, security, content management and information archiving. The common element amongst all the components is the holding of information assets (Government of Alberta, 2003). The Treasury Board of Canada Secretariat's *Policy on Information Management* (2008) defines information management as: "A discipline that directs and supports effective and efficient management of information in an organization, from planning and systems development to disposal or long-term preservation".

Information management can be considered as having a formal information life cycle (Figure 1.2). General stages within the lifecycle start with the planning of the information required, followed by the acquisition or capture of information. Once information is collected it must be organized and managed in a retrievable format for analysis, situational awareness, decision-making and event reporting. The final stage of the cycle involves the evaluation of information for the determination of the final disposition and impact of the knowledge obtained in the process (Bent, 1995; Fu et al., 2014; Government of Canada, 2008; Jordan and de Stricker, 2013).

1.3.2 The Importance of Information Management

The need for information management within organizations is increasing in importance. There is an expectation both within organizations and from the public to provide complex information in a timely manner while adhering to the protection of privacy. Added to this pressure is the explosion of technology allowing for large amounts of data and information to be collected. To meet these demands, more defined information management practices are required. Careful consideration must be taken for the content management of the information to ensure it is readily available, current, correct and useful. The use of an electronic service delivery system for information management requires consistent information management practices and an expanded community of information professionals (Government of Alberta, 2003; Jordan and de Stricker, 2013; Lumpkin and Magnuson, 2014).

1.3.3 Differences between Information Management and Data Management

The difference between terms such as data, information, and knowledge appear semantic in nature; however, different organization or professions will look upon each term differently. First, we will look at the difference between information and data. The Merriam Webster dictionary (2014) defines information as “knowledge that you get about someone or something; facts or details about a subject” and “knowledge obtained from investigation, study, or instruction.” Gordon (2007) defines data as “a re-interpretable representation of information in a formalized manner suitable for communication, interpretation or processing”.

Data are concrete pieces of evidence such as a number, but it does not necessarily infer the meaning behind the datum. For example, Gordon (2007) describes the number 08052014 which may be considered a datum, whereas, information is datum with meaning attributed to it. In this example, the same number sequence of 08052014 presented as the day/month/year has meaning attributed to it and is therefore considered information (Gordon, 2007). Data are converted into information through analysis (Lumpkin and Magnuson, 2014; Yasnoff et al., 2000). The difference between data management and information management follow the same line of rationale. Data management is the function of managing specific recorded data in a structured manner, whereas information management has a broader incorporation of information that includes structured and unstructured data such as premises drawings or maps (Gordon, 2007).

1.3.4 Challenges in Managing Information in a Disease Outbreak

Disease outbreak investigations involve the gathering of large amounts of information from varying sources through formal and sometimes, informal processes. The volume and disparate types of information can pose a significant challenge from an information management perspective, particularly in large outbreaks or multi-jurisdictional responses (Hopkins and Magnuson, 2014). In the case of emergency disease outbreak management, there are additional challenges presented to regulators in regards to the timeliness of information, the ability to interact amongst stakeholders and provision or lack of data sharing agreements (Mukhi et al., 2011). In this situation, information management may include not only information on the disease outbreak but on the emergency management of the disease outbreak event as well (Office of the Auditor General of Canada, 2010).

1.4 Information Management Systems - The Tool to Managing Information

1.4.1 Overview of an Information Management System

An information management system (IMS) is the specific software technology designed to facilitate the storage, organization and retrieval of data and information (Bent, 1995; Technopedia, 2014). The purpose of an IMS is to provide interactive and adaptive data and information management of the various stages of the information lifecycle (Figure 1.2) through the available technology (Fu et al., 2014; Mukhi et al., 2011). The end result of an effective IMS is information is available to users as a valuable source of intelligence or knowledge transfer (Aspevig, 2014; Lumpkin and Magnuson, 2014). The differentiation between information management and an IMS is that the latter is the functional tool in which to implement the former, information management (Bent, 1995).

1.4.2 Format of Information Management Systems: Databases and Dataspaces

The term 'database' is the IMS format familiar to many. A database is a general repository for the storage and querying of data. It assumes complete control of all information within the system. It is important to also understand the concept of 'dataspace' as an alternate form of an IMS. This is the idea of providing a platform allowing all data to be within the control of a single administrative domain. The dataspace may provide an integration or co-existence of multiple data sources or databases. A dataspace allows the information to be managed by the participant systems and provides an additional set of 'umbrella' services to all data sources within the dataspace (Franklin et al., 2005).

1.4.3 Importance of Information Management Systems Specific to Disease Outbreak Investigations

Electronic systems are increasingly used for the collection, query and storage of information related to health events (Mukhi et al., 2007). An estimated 96% of health care workers have full time access to a personal work site computer (Turner et al., 2009). A reported 77% of health department staff use internet services for queries related to health information at least one to two times a day (Mukhi et al., 2011; Turner et al., 2009). In Canada, it is expected that within the next decade, most to all human health records will be available on-line; thus, wireless technology will continue to increase in use in both individuals and health providers (Mukhi et al., 2007). Magnusson et al. (2014) describe developing standards in public health information management and informatics as “one of the most efficient ways to prevent data silos, achieve system interoperability and promote the value of the data.” The Naylor report on the 2003 SARS outbreak in Canada describes the need for “uniform adoption of highly flexible and interoperable data platforms, that allow sharing of public health information, capture of clinical information from hospitals, and integration into an outbreak management database platform” as a key step in disease outbreak management (Health Canada, 2003; Mukhi et al., 2011).

The use of an IMS provides an important tool for disease outbreak information management (Health Canada, 2003; Mukhi et al., 2007, 2011; Office of the Auditor General of Canada, 2010; Yasnoff et al., 2000). Information systems initiated only upon emergency response are described as reactive and chronically ‘behind the curve’ leading to time lags in information and questionable accuracy. To prevent this issue, information management preparedness measures implemented prior to response enable the IMS to effectively provide assistance upon deployment. The preparedness through availability of a complete IMS improves the response and impact of the event (United Nations Office for the Coordination of Humanitarian Affairs, 2002). The system should allow for effective disease recognition and response by the utilizing timely, accurate and official information from a wide variety of sources (Yasnoff et al., 2000).

1.4.4 Importance of Information Management Systems for Infectious Animal Disease Outbreak Investigations

A response to a significant infectious animal disease event requires specific systems and tools, including a functional IMS as a key component of an effective response (Levings, 2012). Powerful software tools are required to effectively accomplish animal disease outbreak control, response and outbreak management. The IMS needs to be able to handle diverse amounts of information such as contact between farms, animal movements, farms within the affected region, laboratory results, outbreak management progress and outbreak-specific information (Kroschewski et al., 2006).

In Canada, the Canadian Food Inspection Agency has faced a number of federally reportable disease events (i.e. Avian Influenza) requiring a large scaled disease response. The importance of availability of an IMS for an animal disease outbreak is highlighted in the Report of the Auditor General of Canada (2010) to the House of Commons where it was recommended the CFIA "set priorities for future development of emergency information systems for animal diseases in relation to other information priorities" and "improve information management and information technology capabilities." This recommendation for improved information management and technology resulted from a review of multiple Canadian disease outbreak events of notifiable avian influenza in 2004, 2007 and 2009 (Office of the Auditor General of Canada, 2010).

1.4.5 Identifying Attributes of an Animal Disease Outbreak Information Management System

To ensure an IMS meets its intended purpose, it is recommended to identify a set of qualities (attributes) of the system (Drewe et al., 2012; German et al., 2001; Health Canada and Health Surveillance Coordinating Committee (HSCC) Population and Public Health Branch, 2004; Hoinville et al., 2013; Thacker et al., 1988). An attribute is defined as the "qualitative characteristic of an individual or item" (Health Canada and Health Surveillance Coordinating Committee (HSCC) Population and Public Health Branch, 2004). The defining of attributes provides a set of standard measures or objectives to be used as a guideline for system development, evaluation and refinement (Drewe et al., 2015; German et al., 2001; Hendrikx et al., 2011). Drewe et al (2013) suggest defining a large number of attributes to evaluators to provide an extensive choice of key attributes (suggested between 5 and 10) to evaluate against the system's objectives. The attributes specific to an animal disease outbreak IMS are not well documented in the literature.

In the absence of animal disease outbreak IMS attributes, existing exemplars can be identified. The attributes described for human and animal surveillance system evaluation could provide a proxy example for evaluating an IMS (Drewe et al., 2015, 2012; German et al., 2001; Health Canada and Health Surveillance Coordinating Committee (HSCC) Population and Public Health Branch, 2004; Hendrikx et al., 2011; Hoinville et al., 2013; Thacker et al., 1988; World Health Organization (WHO), 1997). The current Centers for Disease Control and Prevention's (CDC) Updated Guidelines for Evaluating Public Health Surveillance Systems (2001) and Thacker et al. (1988) provide accepted definitions of attributes of human health surveillance systems. The key attributes identified by the CDC guideline are 'simplicity', 'flexibility', 'data quality', 'acceptability', 'sensitivity', 'positive predictive value', 'representativeness', 'timeliness', 'stability' and 'usefulness'.

In the defining of the attributes of an animal disease outbreak IMS it is important to consider the pre-existing critiques for surveillance systems, one of which being current attribute definitions lack standardization and overall agreement on similarly named attributes. As suggested by Drewe et al (2012), there is a need for "clear definitions and agreement on what each attribute, indicator or criterion actually measure…if surveillance evaluations are to be comparable and universally understood." It is also important to consider that several of the attributes described in human and animal surveillance systems are not necessarily applicable to an animal disease outbreak IMS. For example, attributes such as sensitivity, specificity and positive predictive value are attributes appropriate to the overall purpose of a surveillance system but may not translate to the primary purposes of an animal disease outbreak IMS. A system designed for information management of an animal disease outbreak must also consider attributes related to project management, outbreak management and electronic system management (Centers for Disease Control and Prevention (CDC), 2004; Hopkins and Magnuson, 2014; Mukhi et al., 2011; Transport for London, 2007).

1.5 Conclusions and Rationale for this Study

The first part of this literature review described an overview of information collection in an animal disease outbreak investigation with specific focus on the use of an interviewer-delivered questionnaire as the main information collection tool. The availability of complete and accurate information related to the disease investigation of infectious animal disease outbreaks is important for implementing control and prevention measures (Dwyer et al., 2014; MacDonald, 2012). Despite the importance of the information collection, available literature comparing differences in questionnaire methodology for effects to information quality is limited.

The second part of the review described a general overview of information management, information management systems and the importance of defining attributes of an animal disease outbreak IMS. Despite the increasing importance and use of technology for the management of information collected in an infectious animal disease outbreak investigation, there is no defined comprehensive list of key attributes of an animal disease outbreak based IMS (Mukhi et al., 2007).

Based on the identified knowledge gaps, this study was designed to address the following research objectives:

- To compare questionnaire methodologies for differences in information quality.
- To develop a comprehensive list with clear definitions of attributes of an animal disease outbreak IMS.
- To identify key attributes of an animal disease outbreak IMS.

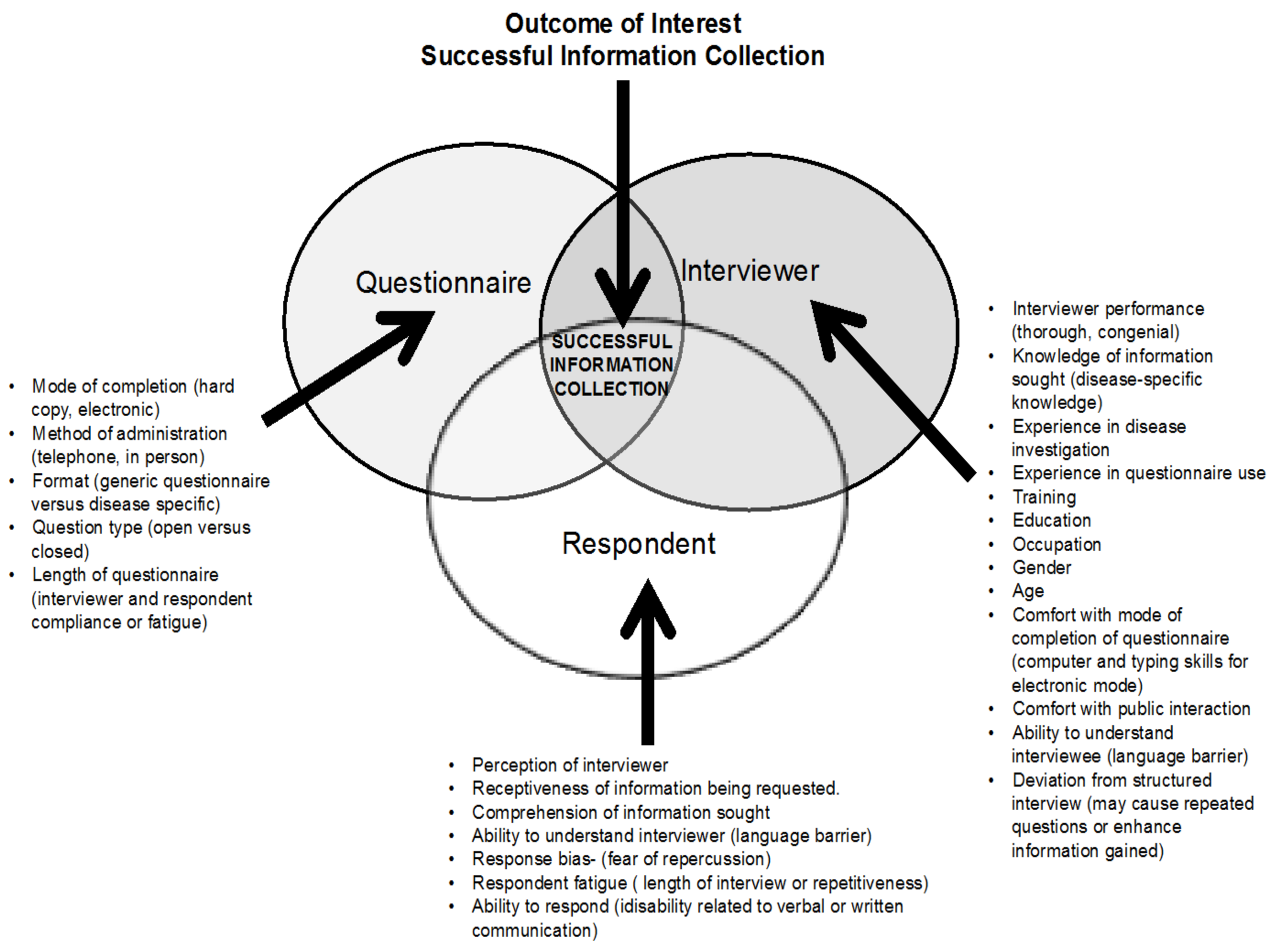

Figure 1.1. Causal diagram of successful information collection in an animal disease investigation using an interviewer-delivered questionnaire.

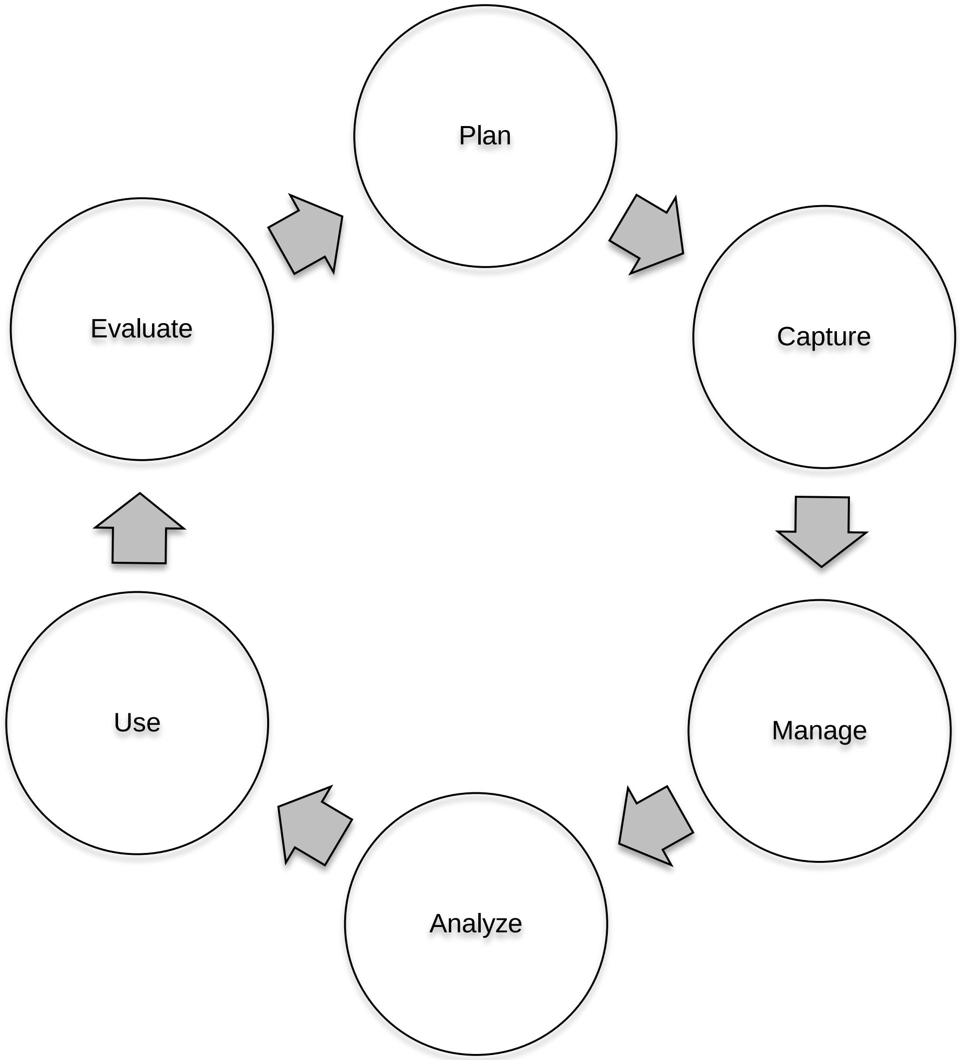

Figure 1.2. The Information Value Cycle (Fu et al., 2014).

CHAPTER 2: COMPARISON OF QUESTIONNAIRE METHODOLOGY FOR ANIMAL DISEASE INVESTIGATIONS AND ASSOCIATED DIFFERENCES IN INFORMATION QUALITY

The collection of complete and accurate information in the initial investigation of an animal disease outbreak is essential for the immediate tracing of the source of introduction, case finding and all further decisions made for disease control measures. This chapter outlines the comparison of different interviewer-delivered questionnaire methodologies for use in a Canadian reportable animal disease investigation. The main purpose of the chapter is to describe the differences in overall information quality, specifically the completeness and accuracy, for each questionnaire method. In instances of significant differences, the critical information categories of owner and premises information, positive animal and flock information and epidemiological tracing (trace-in and trace-out) were compared for impact on information quality.

2.1 Introduction

In the initial investigation of an infectious disease outbreak, detailed collection of information from the index case is required. (MacDonald, 2012; Stehr-Green et al., 2012). The overarching goal of the disease investigation is to collect accurate and reliable information to be able to take action, mitigate risk and communicate facts related to the disease event. The ability to perform a successful and timely investigation becomes particularly important when the investigation involves a foreign, emerging and/or highly infectious disease or outbreak event from a natural or bioterrorist event (Spickler et al., 2010; The Federal Bureau of Investigation (FBI), n.d.; Wobeser, 2007).

Disease investigations should answer the 5W's of the situation: 'who', 'what', 'where', 'when' and 'why' (MacDonald, 2012; Waldner and Campbell, 2006; Wobeser, 2007). The initial aim is to obtain all available information and characterize the disease event (Wobeser, 2007;

World Health Organization (WHO), 2008). Of particular importance in infectious disease outbreaks is the tracing of the index case movements and epidemiologically significant contacts to identify the source of infection and spread of disease (Levings, 2012).

A common approach to the information collection process is to use an interviewer-delivered questionnaire (Centers for Disease Control and Prevention (CDC), 2014, n.d.; Dwyer et al., 2014; MacDonald, 2012; Stehr-Green et al., 2012; World Health Organization (WHO), 2008). The use of a questionnaire in structured or standardized format improves information quality by ensuring the interviewer uses a standard suite of essential questions (Fraga et al., 2013). In animal disease outbreak investigations, the use of an interviewer is essential to query the animal owner of details on the population of concern that may not be answered by diagnostic testing alone such as husbandry practices, health history and animal movements (Putt et al., 1987).

In Canada, the diagnosis or suspicion of a federally reportable domestic animal disease can trigger a disease investigation by the Canadian Food Inspection Agency (CFIA). For all highly infectious reportable diseases, the information collection process involves a local CFIA veterinarian conducting an interview with the affected owner or operator of the animal(s) using a structured questionnaire (Canadian Food Inspection Agency, 2012a, 2012b, 2013). The CFIA has employed two different methods of structured questionnaires for disease investigation of federally reportable diseases. The first method is to use an interviewer-delivered paper-based questionnaire titled the “Premises Investigation Questionnaire” or PIQ. The questionnaire contains generic and disease-specific components. The generic sections are applicable to all federally reportable diseases and should be completed during the initial disease investigation. This questionnaire was primarily developed to facilitate the use of CFIA’s animal disease information management system known as the Canadian Emergency Management Response System or CEMRS (Office of the Auditor General of Canada, 2010). Information collected includes: reason for disease investigation, disease presentation, animal owner or operator contact information, premises and animal production specific information, clinical history of the animal(s) on the premises and tracing the potential source and spread of disease if the disease is confirmed or determined as high risk. The final adjunct of the generic paper based questionnaire is an extended disease-specific questionnaire. This part augments the epidemiological investigation upon confirmation of the specific disease. It is to be administered by a CFIA veterinarian, with expertise in the specific disease. However, the disease-specific component of the questionnaire is not routinely available or completed. Therefore, the disease investigation information is primarily dependent on information collected by use of the hard copy generic questionnaire.

A second method for disease investigation within the CFIA is to use a single disease-specific questionnaire. This questionnaire method is generally delivered in a structured interview during an on-premises visit. The questionnaire is designed specifically for the disease under investigation and animal production type involved, but also includes general information about the owner and premises-specific information. (Canadian Food Inspection Agency, 2013a, 2012b, 2012c).

Within the CFIA, progress towards development of information collection tools for disease investigation has been made since the onset of multiple disease outbreaks starting with the 2004 avian influenza outbreak in British Columbia (Office of the Auditor General of Canada, 2010). The hard copy generic questionnaire described is one of the formally implemented steps towards preparedness and having the correct tools available in the event of a highly infectious disease outbreak. The goal of this questionnaire was to provide a tool to facilitate consistent information collection by field staff and to simplify data capture in CEMRS; however, there has been no systematic assessment to determine whether the use of a general questionnaire is more effective than a disease-specific questionnaire. Similarly, there is no evidence on whether a handwritten or electronically completed questionnaire is more effective under field conditions. Finally, there has been no systematic assessment of the CFIA's PIQ to quantify the difference of the completeness and accuracy of information obtained during the initial investigation using only generic components compared to that of the full investigation with the adjunct of disease-specific questions.

The objectives of this study were to: 1) assess differences in the information quality (completeness and accuracy) between an interviewer-delivered electronic disease-specific questionnaire and a hard copy generic and disease-specific questionnaire, and 2) compare differences in completeness and accuracy of initial investigation information collected using a generically designed questionnaire (hard copy generic questionnaire) compared to the supplementation with a disease-specific component (hard copy generic and disease-specific questionnaire).

2.2 Materials and Methods

The study proposal underwent University of Saskatchewan behavioural ethics approval. The University of Saskatchewan Behavioural Research Ethics Board concluded the study was considered exempt as per Article 2.1 of the Tri-Council Policy Statement (TCPS): Ethical Conduct for Research Involving Humans (December, 2010) and issued BEH 13-113 as approval of research methodology.

2.2.1 Participant Selection

The target population was CFIA veterinarians (VM) and animal health inspectors (EG). A convenience sample for this study included animal health branch veterinarians and inspectors in the CFIA western area including the provinces of Alberta, Saskatchewan and Manitoba. A total of 36 participants were nominated for participation by CFIA management. Each participant was sent a formal request to participate as per University of Saskatchewan Behavioural Research Ethics Board Article 2.1 of the Tri-Council Policy Statement (TCPS): Ethical Conduct for Research Involving Humans (December, 2010) and BEH 13-113 approval of research methodology. All participants provided written consent before beginning the study.

2.2.2 Sample Size Calculation

Based on preliminary sample size calculations, 24 participants would allow investigators to differentiate a completeness and accuracy score of 90% for one questionnaire delivery method from a 60% success in the other questionnaire method, using a 95% confidence level and 80% power, assuming a within participant correlation of as high as 0.5 (Hintze, 2013).

2.2.3 Defining a Fictitious Disease Scenario and Interview Process

A fictitious disease scenario was created for the purpose of the research. The scenario involved a scrapie test-positive result of a four year-old ewe found during routine slaughter surveillance. The farm under investigation was a sheep breeding flock operation with false farm and owner name(s), land location and flock-specific details. Fictitious farm records including movement records of sheep on and off the farm for the previous five years, mortality records, genotype records, site diagram, laboratory report and initial presenting scenario were also created for use in the research. A defined script was created with responses to each question for both questionnaires. The actor's scripted answers for both questionnaires were piloted with two separate individuals. Corrections to script inconsistencies and the scenario were made following the pilot sessions.

The interview process involved the use of an actor playing the role of the fictitious sheep producer. The actor had scripted responses available to reference during the interview process to ensure standardized answers were provided to the interviewer. The actor had sufficient background knowledge to answer interviewer questions outside of the scripted responses due to previous experience in both veterinary medicine and sheep production.

2.2.4 Questionnaires Selected for Use

Two types of pre-existing CFIA questionnaires were used for the research project, a hard copy generic and disease-specific questionnaire and an electronic disease-specific questionnaire. Both questionnaires were capable of collecting the same critical information. The questionnaires differed in mode of completion (hard copy versus electronic), construct and chronology.

For the hard copy generic and disease-specific questionnaire, the generic sections were based on the pre-existing PIQ used by CFIA in an initial disease investigation. The disease-specific section for scrapie was developed from a pre-existing template for an extended epidemiologic investigation. It was evaluated for relevance and applicability by CFIA's scrapie veterinary program specialist prior to use. The electronic disease-specific questionnaire was based on a pre-existing CFIA scrapie-specific questionnaire. The questionnaire was updated in consultation with the CFIA national scrapie disease program veterinarian to ensure the questionnaire reflected current scrapie disease control policy and converted into electronic format in a FluidSurveys™ software program.

To ensure each participant could complete both questionnaires in a 7.5-hour time frame, sections of the generic questionnaire were removed to allow for completion of the questionnaire in a 2-hour time period. Section removal was determined on either the basis of lack of relevancy to the scenario and disease presented (i.e. risk assessment not relevant due to the laboratory confirmation of the disease) or time required to complete the section (i.e. drawing of the site diagram). Portions of the scrapie-specific questionnaire not included in the FluidSurveys™ electronic version included: flock veterinarian information, reason for investigation and laboratory specific information (i.e. sample collector, tracking number and results).

2.2.5 Participant Preparation

Each participant was sent correspondence via e-mail detailing the research objectives and the participant's respective role. Information sessions were provided to participants to ensure a standardized amount of material was available to each participant before their interview date but did not exceed training available in the current CFIA workplace. The training materials available to staff included subject matter expert provided web-based live presentations on scrapie, the use of the CFIA PIQ and the use of the electronic disease-specific questionnaire. Attendance at the informational sessions and review of reference materials was voluntary. Electronic copies of relevant CFIA training and reference materials were made available to the participants at least two weeks before their scheduled interview date. Participants were not instructed or required to review or prepare in advance of the investigation date to avoid over preparing and potentially misrepresenting readiness for an actual disease investigation. A copy of the disease scenario and a fictitious laboratory report related to the scenario was provided to participants 48 hours in advance of their scheduled interview. This was intended to model an actual scrapie investigation where investigators are supplied with case information before contacting the affected flock owner.

2.2.6 Data Collection and Trial Methodology

The study design was a crossover clinical trial. Participants performed two separate interviews with the same actor and disease scenario using the two different questionnaires. The first participant performed a coin toss to determine the questionnaire starting method and each subsequent participant alternated with the questionnaire type they started with. The participant and sheep producer actor were placed at a table at a comfortable distance. The researcher was situated at a further distance and not directly across from the participant to allow for a less conspicuous observation of the interaction between participant and sheep producer. The researcher began each participant session by reading a letter from the research team and reviewing the purpose of the research, the participant's unique identification and the interview process. This was followed by an opportunity for open questions. The researcher read the disease scenario to the participant and provided the participant with copy of the scenario and fictitious laboratory report. The researcher offered no further comment unless the participant encountered technical difficulty with the electronic questionnaire or had other process specific questions.

All materials required for the questionnaire method were provided to the participant. A hard copy (paper) version of the generic and disease-specific questionnaire was provided for use in this portion of the trial and a laptop computer connected to a projector for viewing by both participant and producer was provided for the completion of electronic disease-specific questionnaire. Participants were provided with additional materials including: blank paper, clipboard, pencil, pen and highlighters. Production and premises-specific records were available for the actor to provide upon interviewer request. These materials included: copies of the record of movement, genotype and mortality records, site diagram and aerial photographs. The actor was provided with a script of standardized responses for each questionnaire method.

The participant was allowed a maximum of two hours to complete each questionnaire method. A rest period of 30 to 60 minutes was provided between methods. At the beginning of the second session, the participant was instructed to restart the interview process as if they were meeting the producer for the first time. They were allowed to ask any further questions of the researcher before beginning the process described for the first method. At the conclusion of the second questionnaire method, an informal debrief of the participant's overall experience was conducted. All materials from each method (including any scrap paper written on) were collected and contained in a folder labeled with the participant's individual identification. Following each trial, the participants were sent an electronic invitation to complete an online survey created in FluidSurveys™. The survey collected information on the participants' demographics, individual training and experience in animal health and disease investigation. The responses from the survey were downloaded from FluidSurveys™ and exported into a Microsoft Excel spreadsheet (Microsoft Corporation, Redmond, WA, US).

2.2.7 Questionnaire Completeness and Accuracy Assessment

For the information quality assessment, four categories of critical information were determined based on information important to collect in an animal disease outbreak investigation (MacDonald, 2012; Spickler et al., 2010; Waldner and Campbell, 2006; Wobeser, 2007). The four critical information categories included: owner and premises information, disease-positive animal and flock (cohort) information, epidemiologically significant trace-in animal movements (trace-ins) and epidemiologically significant trace-out animal movements (trace-outs). Scripted responses in each category considered as critical information for the fictitious disease scenario were identified for each category (Table 2.1).

The electronically completed questionnaires were downloaded from FluidSurveys™ and critical responses exported into a Microsoft Excel spreadsheet (Microsoft Corporation, Redmond, WA, US). The handwritten paper completed questionnaires were scanned and responses for the identified critical information (listed in Table 2.1) were transcribed into a Microsoft Excel spreadsheet (Microsoft Corporation, Redmond, WA, US).

The participant’s responses were compared to the scripted expected answer and assessed for information quality (completeness and accuracy) using a double-blinded assessor. First, a research assistant not previously engaged in the project assigned a random identifier to all participants. Other information that could be used to identify the participant was also removed from the records. Second, a research assistant not previously engaged with the respondents or research project assessed each completed questionnaire for information quality.

To evaluate information quality, the observed answers for each questionnaire method were compared to the scripted answer and assigned a quantitative data quality metric for completeness and accuracy (Pipino et al., 2002). The valuation consisted of ‘0’ for incomplete or inaccurate information, ‘0.5’ for partially complete or accurate and “1” for fully complete or accurate. Each observed answer was assessed and assigned a score for completeness and accuracy separately. The cumulative accuracy and completeness score for critical information categories 1-4 (Table 2.1) were 10, 10, 6 and 8 respectively. Each category’s raw score was weighted to have equal value (denominator 25) for a total completeness and accuracy score denominator of 100. Scores were captured in a Microsoft Excel worksheet (Microsoft Corporation, Redmond, WA, US). Descriptive statistics for the cumulative completeness and accuracy for each questionnaire were performed using SPSS commercial statistical software package (SPSS Inc., Chicago, IL, US).

2.2.8 Questionnaire Completeness and Accuracy Comparisons

The questionnaire methods were compared in two separate analyses. In the first analysis, the cumulative completeness and accuracy scores of the hard copy generic and disease-specific questionnaire were compared to the electronic disease-specific questionnaire. The second analysis focused on the differences within the hard copy generic and disease-specific questionnaire method. In this comparison, the cumulative completeness and accuracy scores of the generic only sections were compared to the supplementation of the disease-specific section.

The statistical analysis for each questionnaire comparison was approached in a stepwise process. First, assumptions of normality of differences between populations were performed using the Shapiro-Wilk Test statistic. If the differences were normally distributed, the analysis continued using the parametric matched pair t-test. If the differences were not normally distributed, the pairwise comparison continued using the non-parametric Wilcoxon Matched-Pairs Signed Rank Test.

If the pairwise comparison of the cumulative scores was significant ($P < 0.05$), the descriptive statistics and comparison of individual critical information categories were performed as described for the cumulative scores. All calculations were completed with the commercial statistical package (SPSS Inc., Chicago, IL, US). The level of significance set for all statistical analysis was $\alpha = 0.05$.

2.2.9 Defining a Cut Point of Acceptable Information Completeness and Accuracy

The determination of an acceptable level of information quality was completed to assess each questionnaire method's ability to meet a defined cut point of completeness and accuracy. Expert opinion was elicited to define the cut point due to no available literature recommendation.

The frequency of participants achieving the cut point for each questionnaire method was completed in Microsoft Excel (Microsoft Corporation, Redmond, WA, US).

2.3 Results

2.3.1 Participant Demographics

Participants originated from 11 different CFIA district offices in the Saskatchewan, Alberta North and Alberta South CFIA regions. Of the 36 manager nominated staff, 24 participants were processed between September 2013 and March 2014. Of the 12 nominated staff that did not participate, 1 did not consent to participate, 2 participants withdrew for personal reasons, 1 withdrew due to operational requirements and 1 participant moved out of the research determined travel region. The remaining 7 participants in Manitoba and Southern Alberta were not processed due to time constraints.

Study participants included 17 (71%) veterinarians and 7 (29%) animal health inspectors. Gender and age of the participants were approximately equally represented with 11 (42%) female and 13 (58%) male participants and 11 (46%) in the age category of 26 to 45 years of age and 13 (58%) in the age category of 46 years or older. Fourteen (58%) had six years or greater experience in animal health in CFIA compared to 10 (42%) with up to five (0 - 5) years of experience. Thirteen (54%) participants had conducted six or greater reportable disease investigations compared to 11 (46%) with up to five (0-5) disease investigations. The participants' experience in completing a disease investigation questionnaire was roughly equally represented with 12 of 22 (55%) reporting experience in completing a questionnaire and 10 (45%) with no experience.

2.3.2 Questionnaire Completeness and Accuracy Results

Completeness and accuracy scores (%) for the 24 participants for each questionnaire method are displayed in Table 2.2. Participants 15 and 18 were unable to complete the critical information category 1 questions due to a technical error associated with the electronic questionnaire and were removed from all further analyses including the electronic disease-specific questionnaire.

The descriptive statistics of the completeness and accuracy scores (%) for each questionnaire method is summarized in Table 2.3. The mean completeness and accuracy scores for the hard copy generic and disease-specific questionnaire was 80.2% (95% CI 79.7, 88.1) and 83.9% for the electronic disease-specific questionnaire (95% CI 76.2, 84.5). The method with the lowest information quality score was the hard copy generic questionnaire with a mean completeness and accuracy score of 50.2% (95% CI 43.6, 57.2). The range of scores within each questionnaire method was relatively large with the smallest range in the electronic disease-specific questionnaire (32.6%) and largest with the hard copy generic questionnaire (54.2%).

Figure 2.1 demonstrates the scores for each questionnaire method per participant when sorted in ascending order of scores for the hard copy generic only section. Both the hard copy generic and disease-specific and the electronic disease-specific questionnaires had an overall increased accuracy and completeness score compared to the hard copy generic only questionnaire. Those individuals with the highest completeness and accuracy scores in the hard copy generic questionnaire method were also the individuals that demonstrated consistency in scores across all questionnaire methods. However, very few individuals performed equally across all three methods.

2.3.3 Results of Defining a Cut Point of Acceptable Information Completeness and Accuracy

For the determination of an acceptable level of information quality, expert opinion ranged from a completeness and accuracy score of 30% to 90% with 80% being reported at the highest frequency. Therefore, the cut point of 80% or greater was considered as acceptable information quality. The percentage (%) of participants achieving 80% or greater was 73% with the electronic disease-specific questionnaire, 54% with the hard copy generic and disease-specific questionnaire and 8% with the generic only section of the hard copy questionnaire (Figure 2.2).

2.3.4 Comparison of Questionnaire Methods for Differences in Accuracy and Completeness Scores

The first comparison of the electronic disease-specific questionnaire to the hard copy generic and disease-specific questionnaire demonstrated no significant difference (P = 0.09) in the completeness and accuracy scores (N = 22). The mean difference in scores was 3.5% (95% CI -0.6, 7.6). The second comparison of the supplementation of the disease specific section to the generic sections for the within questionnaire comparison of the hard copy generic and disease-specific questionnaire demonstrated a significant difference (P < 0.0001; N = 24). The mean difference in completeness and accuracy scores was 29.9% higher (95% CI 23.1, 36.8). In other words, the supplementation of the disease specific section resulted in scores for completeness and accuracy that were 29.9% higher than those obtained with the use of the generic only sections.

Due to the determination of a significant difference between the supplementation of the disease specific section to the generic sections of the hard copy questionnaire, the descriptive statistics and pairwise comparisons of the critical information categories were performed. The descriptive statistics of the critical information categories for the hard copy generic and disease-specific and generic only questionnaire are summarized in Table 2.4. The pairwise comparison of the completeness and accuracy scores in the critical information categories of positive animal and flock information, trace-in and trace-out demonstrated significant differences ($P < 0.0001$; Table 2.5). The critical information category of owner and premises information had no difference in scores due to no supplemental questions for this category in the disease-specific section. The largest difference of completeness and accuracy scores was found in the trace-in information category, followed by the trace-out information category with a mean difference in completeness and accuracy scores of 67.7% (95% CI 52.0, 83.4). On average, the hard copy generic and disease-specific questionnaire generated 67.7% higher completeness and accuracy scores for trace-in information and 38.3% (95% CI 28.3, 48.3) higher for trace-out information compared to the hard copy generic only questionnaire.

2.4 Discussion

The ability to collect complete and accurate information in the investigation of a disease outbreak is a foundational component to provide a true representation of the disease event. The ability to perform disease control actions, tracing of the source or exposure to disease and case finding rely upon the information collected in the initial investigation (Bartlett and Judge, 1997; MacDonald, 2012; Stehr-Green et al., 2012; World Organisation for Animal Health (OIE), 2014). This is the first identified study to compare the information quality between differing questionnaire methodologies for an animal based infectious disease investigation. The study also was the first to compare the information quality difference between initial investigation information collected using a generically designed questionnaire compared to the supplementation of a disease-specific component.

The study demonstrated there was no significant difference in completeness and accuracy scores of the electronic disease-specific questionnaire compared to the hard copy generic and disease-specific questionnaire. The lack of difference between mode of completion (handwritten versus electronically completed) is in agreement with Dillman et al. (2009) who reported the quality of information obtained is affected more by the question and questionnaire construct than mode of completion.

In the second comparison of the hard copy generic only questionnaire compared to the supplementation of a disease-specific component a difference in the information quality was demonstrated. This difference in information quality was visible in the descriptive statistics and the low frequency of the participants achieving the information quality cut point of least 80% or greater completeness and accuracy. Rationale for the difference may be that generic questions do not elicit the information from the interviewee unless the interviewer has the intuition, knowledge or experience to probe for the response, whereas, the disease-specific questionnaire ensures the interviewer asks questions regardless of the interviewer’s characteristics or experience.

The compilation of the two comparisons, suggests that the difference in information quality gathered between questionnaires is attributable more to the presence (or absence of) disease-specific questions than mode of questionnaire completion. This supports the recommendation by Stehr-Green et al. (2012) for initial investigations to focus on disease-specific aspects if a specific pathogen has been identified or suspected.

The further comparison of the critical information categories revealed higher information quality was achieved in the disease positive animal and flock information, trace-in and trace-out categories with the supplementation of the disease-specific section. The large difference in information quality scores found in both of the tracing critical information categories, suggested the exclusion of disease-specific questions would compromise information essential to determine source of exposure and potential spread of disease. Levings (2012) reported the issue of traceability gaps in infectious animal disease investigations. This research suggests the use of questionnaires with disease-specific questions would mitigate the issues identified by Levings.

When considering the ability of each questionnaire method to produce complete and accurate scores, the large range of completeness and accuracy scores for each suggested inconsistent information quality existed across all methods. The low reliability may be attributable to bias introduced by both the questionnaire construct and the use of an interviewer to complete the questionnaire. Questionnaire construct such as lack of mandatory field completion allowed for failure to inquire or record information critical to the disease investigation. The interviewer further introduced variability with discretionary use of skipping question, paraphrasing, change to question chronology and additional questions. This finding supports Oppenheim's (1992) suggestion that use of an interviewer-delivered questionnaire introduces variability to the information obtained. The ability of a few participants able to achieve high scores greater than 80% completeness and accuracy across all questionnaire methods suggested certain interviewers could perform well with any mode of questionnaire construct or mode of completion. Interviewer features such as experience, training, aptitude for thoroughness may have accounted for this finding.

This is first identified study to provide an objective methodology for the assessment of information quality of an animal disease outbreak based questionnaire. This methodology has applicability for the piloting of questionnaires prior to use in field situations. The objective metric to assess information quality and the blinded information quality assessment minimized subjectivity issues inherent in qualitative data assessment (Bryman, 2008; Harris and Brown, 2010; Pipino et al., 2002). The result was a quantitative assessment of information quality for each questionnaire method based on a completeness and accuracy score with a range of 0-100 percent. The repeated use of the questionnaires also provided a simplified means to assess a questionnaire's validity and reliability. The scores allowed evaluation of the questionnaire's utility for obtaining accurate information providing an indicator of the questionnaire's validity, and the range of completeness and accuracy scores provided an indicator of the questionnaire's overall reliability.

The study limitations included the introduction of bias due to the interviewer, questionnaire and respondent. The use of an interviewer introduces a form of bias to the investigation process referred to as the 'interviewer effect' (Harris and Brown, 2010; Meadows, 2003). Examples of interviewer effects include interviewer's use of question paraphrasing, interpretation of the respondent's response, skipping of questions and lack of experience in disease investigation and questionnaire completion. The questionnaire construct introduced this bias to some degree due to the lack of scripted questions. The presence of complex question matrices (tables) also forced interviewers to determine the most appropriate method to both query and complete the information fields. The slightest change to a question can change the intended meaning and compromise previous questionnaire validation. In all the questionnaire methods, the interviewer had the ability to skip asking or recording an answer, leading to a reduction of information collected despite the question being present in the questionnaire. As such, interviewer and questionnaire introduced bias presented a challenge to questionnaire validation (Davis, Couper, Janz, Caldwell, & Resnicow, 2010; de Vaus, 1991; Hammal & Bell, 2002; Johannes, Crawford, & McKinlay, 1997; Kreuter, 2008).

The respondent bias to the information quality was limited in this research project with the use of scripted responses and a consistent actor. However, respondent bias was possible, particularly in cases where the respondent was required to interpret the meaning of the interviewer’s question (i.e. paraphrased questions). Respondent bias was also possible due to negative reaction to the interviewer’s demeanor (i.e. aggressive behavior).

The limitations highlight some important considerations in the design of questionnaires and training of interviewers. For questionnaire design, it is recommended to script questions to avoid the need for paraphrasing or interpretation of question intent and to include mandatory completion fields for critical information. Training of interviewers should include specific instructions regarding the intent of each question, how to complete the questionnaire and conduct an interview.

Overall, this research provided valuable insight to differences in information quality between questionnaires. In all of the questionnaire methods, similar completeness and accuracy scores were obtained for the animal owner and premises information. Therefore, considering the earlier stated 5 W’s of a disease investigation, the ‘who’ and ‘where’, specifically information related to the affected animal’s most recent residence, appeared to be sufficiently addressed by all questionnaires. The ‘what’ and ‘when’ including clinical information such as the disease-positive animal’s clinical history and flock history, were found to be answered more accurately with the presence of disease-specific questions. The largest impact of the difference between the information quality was with answering the ‘where’ the disease may have spread and ‘why’ it entered the flock (Dwyer et al., 2014; Wobeser, 2007). Therefore, it is recommended when designing a questionnaire for disease investigation, particularly for tracing, that questions are specific as possible to the disease or event. Future studies with alterations to the questionnaire construct to reduce or avoid interviewer effects such as skipping of data entry and use of paraphrasing would allow for more consistent information gathering and reduced variability.

This research also provided methodology to pilot and assess information quality of questionnaires for infectious animal disease investigation. It is recommended that all questionnaires be subjected to a similar evaluation of accuracy and reliability prior to use in a field application with a method similar to the one used in this study (Dillman et al., 2009; IEA European Questionnaire Group et al., 1998; Meadows, 2003; Murray, 1999; Olsen and IEA European Questionnaire Group, 1998).

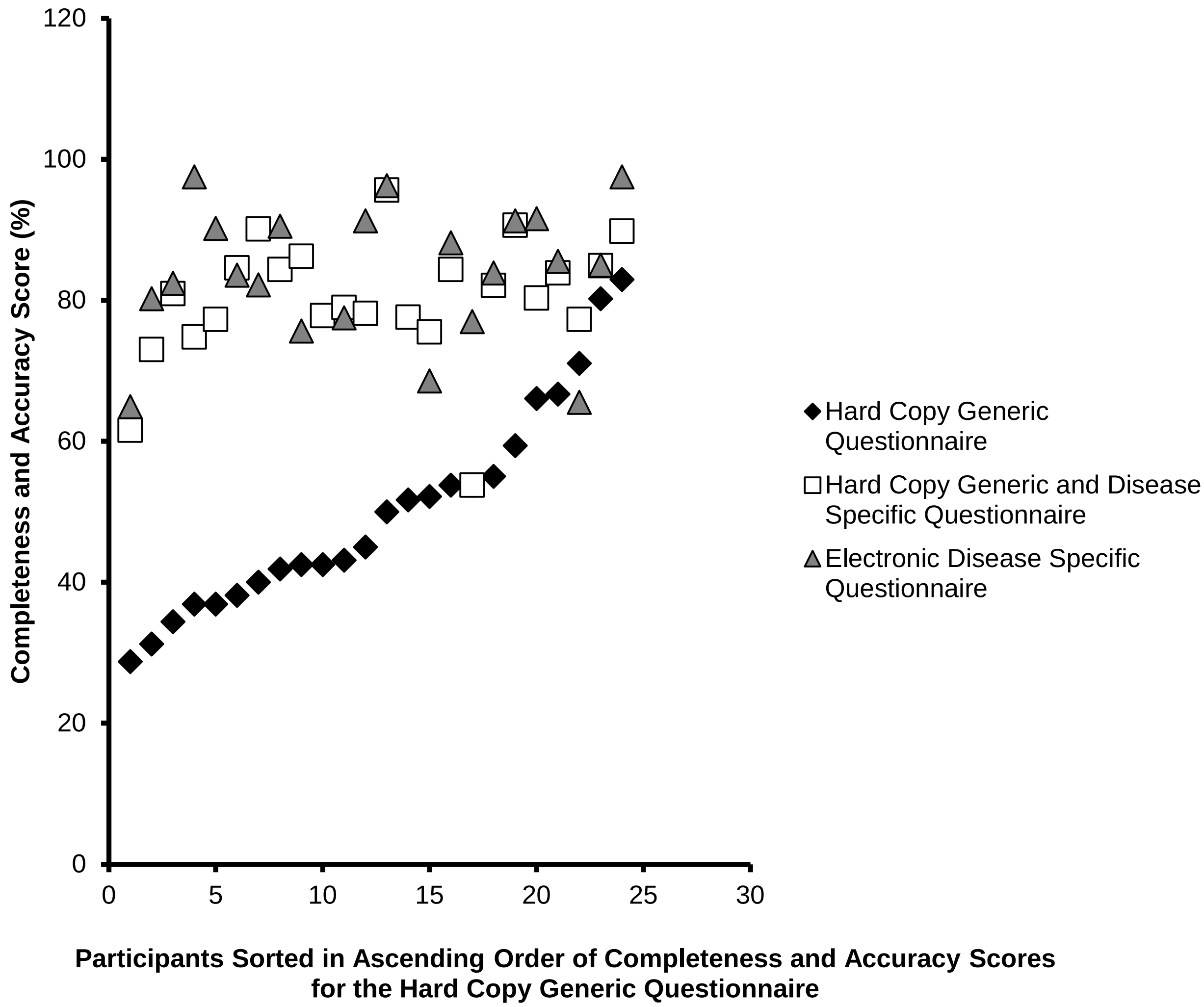

Figure 2.1 Participant mean completeness and accuracy score (%) observed per disease investigation questionnaire method when sorted in ascending order of completeness and accuracy scores (%) for the hard copy generic questionnaire method (n=24).

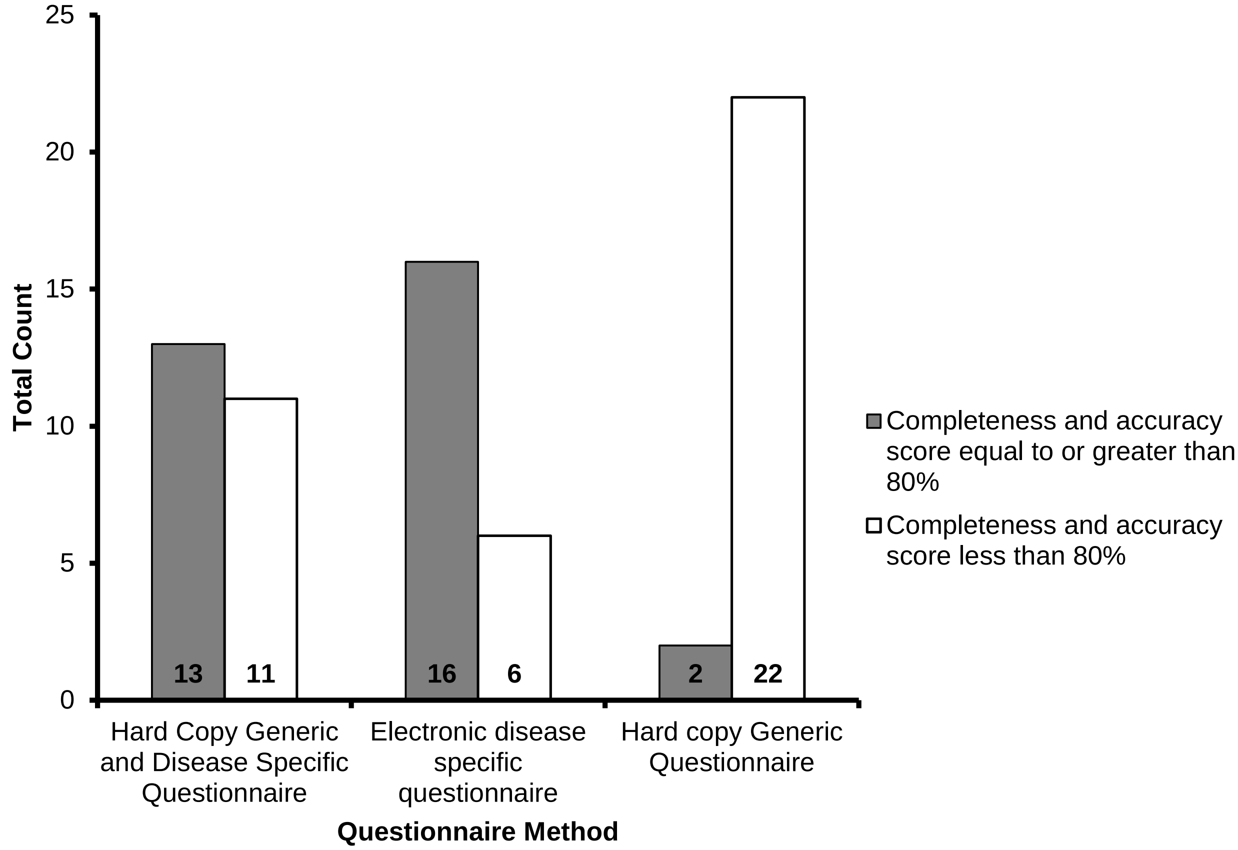

Figure 2.2. Frequency of achieving ≥80% and <80% disease investigation information completeness and accuracy for the hard copy generic and disease-specific questionnaire (n=24), the electronic disease-specific questionnaire (n=22) and the hard copy generic questionnaire (n=24).

Table 2.1. Critical information categories and disease investigation specific information used to assess questionnaire information quality.

Category 1: Owner & Premises Information	Category 2: Animal & Flock Information	Category 3: Trace-In Information	Category 4: Trace-Out Information
Farm name	Animal production type	Identification of origin of scrapie-positive animal	Scrapie-positive animal lambing information
Operation address	Number of animals on farm	Contact information for premises of origin	Disposition of scrapie-positive animal's lambs
Land location	Scrapie-positive animal's identification	Date of entry of scrapie-positive animal	Contact information for destination of scrapie-positive animal's lambs
Owner phone number	Scrapie-positive animal's clinical history	-	Contact information for significant epidemiologic links
Owner name	-	-	

Table 2.2. Observed participant information quality completeness and accuracy score (%) for the hard copy generic and disease-specific questionnaire (n=24), the electronic disease-specific questionnaire (n=22) and the hard copy generic questionnaire (n=24).

Participant	Hard Copy Generic and Disease-specific Questionnaire	Electronic Disease-specific Questionnaire	Hard Copy Generic Questionnaire
	Completeness and Accuracy Score (%)	Completeness and Accuracy Score (%)	Completeness and Accuracy Score (%)
1	90.1	82.2	40.0
2	75.5	68.5	52.2
3	86.3	75.6	42.5
4	61.6	64.9	28.8
5	84.4	88.1	53.8
6	74.8	97.5	36.9
7	84.9	85.0	80.2
8	95.6	96.3	50.0
9	77.3	90.2	36.9
10	89.8	97.5	82.9
11	84.6	83.5	38.1
12	53.8	77.0	53.8
13	78.1	91.3	45.0
14	79.0	77.5	43.1
15 [a]	77.6	- [a]	51.7
16	84.4	90.5	41.9
17	77.3	65.5	71.0
18 [a]	77.8	- [a]	42.5
19	83.9	85.5	66.7
20	80.9	82.4	34.4
21	80.3	91.6	66.0
22	90.6	91.3	59.4
23	73.0	80.2	31.3
24	82.1	83.9	55.0

[a] Case removal of participant 15 and 18 due to missing data in dimension 1 of the electronic questionnaire.

Table 2.3. Descriptive statistics of information completeness and accuracy scores (%) for the hard copy generic and disease-specific questionnaire (n=24), the electronic disease-specific questionnaire (n=22) and the hard copy generic questionnaire (n=24).

	Hard Copy Generic and Disease-specific Questionnaire	Electronic Disease-specific Questionnaire	Hard Copy Generic Questionnaire
N	24	22	24
Mean	80.2	83.9	50.2
Median	80.6	84.4	47.5
Minimum	53.8	64.9	28.8
Maximum	95.6	97.5	82.9
Range	41.9	32.6	54.2
Standard Deviation	9.0	9.5	14.8
75^{th} quartile	84.8	91.3	58.3

Table 2.4. Descriptive statistics of information completeness and accuracy score (%) for the critical information categories for the hard copy generic and disease-specific questionnaire and the hard copy generic questionnaire (n=24).

	Hard Copy Generic and Disease-specific Questionnaire Completeness and Accuracy Score (%)	Hard Copy Generic Questionnaire Completeness and Accuracy Score (%)
Category 1: Owner & Premises Information		
Mean	84.6	84.6
Median	80.0	80.0
Minimum	60.0	60.0
Maximum	100.0	100.0
Range	40.0	40.0
Standard Deviation	13.6	13.6
Category 2: Animal & Flock Information		
Mean	83.8	69.8
Median	85.0	72.5
Minimum	55.0	25.0
Maximum	100.0	100.0
Range	45.0	75.0
Standard Deviation	11.7	19.1
Category 3: Trace-In Information		
Mean	87.2	19.4
Median	91.7	0.0
Minimum	0.0	0.0
Maximum	100.0	91.7
Range	100.0	91.7
Standard Deviation	21.1	33.6
Category 4: Trace-Out Information		
Mean	65.1	26.8
Median	62.5	25.0
Minimum	25.0	0.0
Maximum	100.0	75.0
Range	75.0	75.0
Standard Deviation	19.4	17.2

Table 2.5. Pairwise comparison of information completeness and accuracy scores (%), mean difference and 95% confidence intervals (CI) for the critical information categories of the hard copy generic and disease-specific questionnaire to the hard copy generic questionnaire (n=24).

	Category 1: Owner & Premises Information	Category 2: Animal & Flock Information	Category 3: Trace-In Information	Category 4: Trace-Out Information
Method of analysis	No difference in scores	Matched Pair T-Test	Wilcoxon Matched-Pairs Signed Rank Test	Matched Pair T-Test
P Value	-	<0.0001	<0.0001	<0.0001
Mean difference of completeness and accuracy scores (%)	-	14.0	67.7	38.3
95% CI of the difference (%)	-	8.3, 19.6	52.0, 83.4	28.3, 48.3

CHAPTER 3: DEFINING KEY ATTRIBUTES OF AN ANIMAL DISEASE OUTBREAK INFORMATION MANAGEMENT SYSTEM

In a large-scale animal disease outbreak, an information management system is required to handle the complex and extensive information collected in the initial investigation and the subsequent disease control measures. The following chapter investigates the characteristics (attributes) of an information management system designed for use in animal disease outbreak events. The purpose of the study was to survey Canadian stakeholders involved in animal disease outbreaks to identify a comprehensive list of attributes and to further determine the most important (key) attributes of an animal disease outbreak information management system.

3.1 Introduction

A critical component of disease outbreak investigation and response is the management of information. Information systems are becoming increasingly important for supporting the outbreak epidemiologic investigation, epidemiologic analysis, disease response, prevention measures, and in managing and summarizing information associated with the outbreak (Hopkins and Magnuson, 2014). The general term for such a system is information management system (IMS). The function of an IMS is to acquire, sort, manage, store and make information available to the system users (Hopkins and Magnuson, 2014; Mukhi et al., 2007). Electronic databases or dataspaces are commonly used platforms for IMS's (Franklin et al., 2005).

Systems specific to infectious animal disease response have been developed around the world in response to outbreaks of animal diseases with high economic impact such as bovine spongiform encephalopathy (BSE), foot and mouth disease (FMD), classical swine fever (CSF) and avian influenza (Levings, 2012). For example, in Canada, a disease control IMS was developed following response to outbreaks of avian influenza, a federally reportable disease (Canadian Food Inspection Agency, 2012d; Office of the Auditor General of Canada, 2010).

Despite their known presence and use, the definition of an animal disease outbreak IMS was not available in the literature at the time of this investigation. The suggested working definition of an animal disease outbreak IMS is "the software technology and/or system designed with the purpose of facilitating storage, organization and retrieval of information related to the response to, surveillance of, intelligence gathering, policy and decision making associated with an animal disease event."

In a well-designed IMS, the users of the IMS and information technology professionals collaborate to ensure the system meets the intended goals (Mukhi et al., 2007). In order to evaluate a system for effectiveness, the first step is to define a set of attributes of the system (Drewe et al., 2012; German et al., 2001; Health Canada and Health Surveillance Coordinating Committee (HSCC) Population and Public Health Branch, 2004; Hoinville et al., 2013; Thacker et al., 1988). Attributes are the qualitative characteristics of the system design and operation which can be converted into specific measurable criteria for evaluation (Centers for Disease Control and Prevention (CDC), 2004; Health Canada and Health Surveillance Coordinating Committee (HSCC) Population and Public Health Branch, 2004; Thacker et al., 1988). The defined attributes can then be converted into measurable criteria for use in system evaluation (Drewe et al., 2015; German et al., 2001; Hendrikx et al., 2011).

Currently, there are no universally defined attributes of an animal disease outbreak IMS. For health surveillance systems, Drewe et al (2012) stated "Clear definitions and agreement on what each attribute, indicator or criterion actually measures is essential if surveillance evaluations are to be comparable and universally understood." The same need can be said about attributes of an animal disease outbreak IMS.

The objectives of this study were 1) to identify a comprehensive list of user-defined attributes of an animal disease outbreak IMS, and 2) to further identify from the above comprehensive list, the attributes of greatest importance to stakeholders (i.e. key attributes).

3.2 Materials and Methods

The study proposal underwent University of Saskatchewan behavioural ethics approval. The University of Saskatchewan Behavioural Research Ethics Board concluded the study was considered exempt as per Article 2.1 of the Tri-Council Policy Statement (TCPS): Ethical Conduct for Research Involving Humans (December, 2010) and issued BEH 13-112 as approval of research methodology.

3.2.1 Building the Initial List of Attributes: Focus Group and Literature Sourced

A series of two focus group sessions were conducted using the Consensus Workshop technique to collect stakeholder beliefs and attitudes regarding features of an animal disease outbreak IMS ("Facilitator Tool Kit," n.d.; Gibbs, 1997). One group consisted of 12 Canadian Food Inspection Agency (CFIA) western area disease control veterinarians. The other group consisted of 10 Western College of Veterinary Medicine, University of Saskatchewan, epidemiologists, staff and graduate students. Both groups were requested to identify attributes of an animal disease outbreak IMS and sort the identified attributes into 'like' themes.

A literature review was performed to identify animal disease outbreak IMS applicable attributes. The main themes of literature sourced included: health surveillance system evaluation, outbreak or emergency management, project management and public health informatics. The list of attributes was cross-referenced to those identified in the focus group sessions. Unique attributes identified in the focus group session were combined with the literature sourced (Table 3.1).

3.2.2 Survey 1: Identifying a Comprehensive List of Attributes of an Animal Disease Outbreak Information Management System

3.2.2.1 Survey 1 Purpose

The first survey's main objective was to identify stakeholder perception regarding the purpose of an animal disease outbreak IMS and to develop a single comprehensive list of user defined attributes. To develop this, the new attributes identified by the open responses, focus group sessions and literature review were combined into a single user-defined list. An additional objective of this survey was to collect stakeholder perception of the importance of the focus group and literature sourced attributes to determine relevancy of these attributes for an animal disease outbreak IMS.

3.2.2.2 Survey 1 Study Group

The four main stakeholders identified for receiving the survey included federal government, provincial government, animal industry groups and veterinary academia. The federal government organizations included the CFIA, Public Health Agency of Canada (PHAC) and Health Canada. Provincial government stakeholders included agriculture or animal livestock departments. Animal industry groups included provincial and regional domestic livestock organizations. The veterinary colleges included the Western College of Veterinary Medicine, the University of Calgary Veterinary Medicine College, Atlantic Veterinary College, and Ontario Veterinary College.

3.2.2.3 Survey 1 Content

The survey consisted of an introduction to the research, intent of the survey and statement of the study approval from the University of Saskatchewan Behavioral Research Ethics Board, followed by three main sections consisting of 57 questions. Section I contained 14 questions. Six questions related to respondent demographics. Four questions related to respondents' familiarity with IMS's and experience in disease control activities. One of the four questions was an open response requesting a description of experience with animal (or human) disease events or outbreaks and three were closed response requesting respondents to choose the appropriate frequency of use of surveillance based database/IMS and involvement in regulatory disease prevention or control. One open response question requested a description of any IMS the respondent had experience with. Two open response questions requested the respondent's likes and dislikes of the IMS(s) they were familiar with. One open response question was dedicated to asking respondents to list and describe optimal attributes of an animal disease outbreak IMS. This question was followed by a request for respondents to rank the three most important attributes from their previously described list.

Section II had five questions dedicated to defining the respondent's beliefs on system use and purpose based upon a list of options. A scale of 0 to 10 was provided to respondents to grade each option with 0 being strong disagreement and 10 indicating strong agreement. Multiple literature sourced animal disease outbreak IMS purposes were presented including: information management (i.e. capture of data, diagnostic results, premises specific information and other information related to the disease event), knowledge management (i.e. capacity to capture new science learned, new diagnostic capacity, lessons learned, best practices), surveillance capacity (i.e. able to detect new disease occurrence or emerging disease events), outbreak or project management (i.e. human resources, financial tracking, communication, risk identification and mitigation, progress planning and tracking of event activities), and finally, all of the previously described purposes (Aspevig, 2014; del Rocio Amezcua et al., 2010; Gerami, 2010; Gordon, 2007; Morris et al., 1996; World Organisation for Animal Health (OIE), 2014).

Section III had 38 questions in total. There were 35 questions relating to each of the literature surveillance system or focus group sourced IMS attributes and subcomponents (Table 3.1). Respondents were asked to rate the importance of each attribute on a scale of 0 to 10 (0 as strongly disagree and 10 as strongly agree). The survey closed with two open-ended responses for capturing any missed attributes and one question to determine the value of defining animal disease outbreak IMS attributes.

3.2.2.4 Data Collection and Analysis

The survey was created using University of Saskatchewan available FluidSurveys™ online survey software. The survey URL was activated August 13, 2013 and closed October 1, 2013. The survey URL link was distributed through electronic mail by two different methods. In the first method, key contacts within the CFIA and PHAC received an electronic mail notice with a request for further distribution amongst the key contacts' network or associated groups. In the second method, individual electronic mail invitations were issued to members of Health Canada, members of livestock industry associations and to members of four of the five Canadian veterinary colleges' epidemiology or other applicable faculty members. A reminder for completion of the survey was sent mid-September. Completed surveys were collected within the FluidSurveys™ software platform and exported to Microsoft Excel (Microsoft Office, v.15, Microsoft Corporation, Redmond, WA, USA) for further data coding.

Descriptive statistics of closed responses were calculated using Microsoft Excel (Microsoft Office, v.15, Microsoft Corporation, Redmond, WA, USA). Analysis of the open response question for the top three attributes was performed using a modified Consensus Workshop technique (“Facilitator Tool Kit,” n.d.; Gibbs, 1997). Modifications to the cited technique involved a two-stage process. First, three research team members independently sorted the open responses into common theme. The themes identified by each member were cross-referenced for commonality and condensed into a single final list of newly identified attributes. Definitions were assigned to each attribute either using existing literature if available or agreement amongst research team members. Open responses were sorted into the most appropriate attribute description. The frequency of categorization of each open response was calculated using Microsoft Excel (Microsoft Office, v.15, Microsoft Corporation, Redmond, WA, USA).

The final comprehensive list of animal disease outbreak IMS attributes for use in the second survey was created by combining the focus group and literature sourced attributes with the newly identified attributes from the open responses of the respondent’s top three attributes. Attributes with multiple subcomponents in the focus group and literature sourced list were collapsed into a single definition. Any individual attributes with significant overlap in definitions were combined into a single attribute and description for both the focus group and literature sourced list and newly identified open response list. The original attributes were condensed into a more concise attribute title and single description.

3.2.3 Survey 2: Determining Key Attributes of an Animal Disease Outbreak Information Management System

3.2.3.1 Survey 2 Purpose

A subsequent survey was created May 2014 with the objective to further determine the stakeholder perception of the most important ('key') attributes of an animal disease outbreak IMS based on the comprehensive list identified in the first survey.

3.2.3.2 Survey 2 Study Group

The study group for the second survey consisted of the same four main animal health stakeholders identified in the first survey (section 3.2.2.2).

3.2.3.3 Survey 2 Content

The survey contained a total of 14 questions. The first section contained eight questions. Three questions related to respondent demographics. Three questions related to respondents' familiarity with IMS's and experience in disease control activities and included: frequency of dealing with animal (or human) disease events or outbreaks, use of surveillance based database/IMS and involvement in regulatory disease prevention or control. One question asked respondents to identify the type(s) of IMS users they were or currently are. The final question in this section requested respondents to describe (if applicable) any IMS the respondent had working knowledge of.

The second section divided the final list of animal disease outbreak IMS attributes from Survey 1 into three groupings of randomly presented attributes with the request to rank the three most important attributes from the presented list. Branching syntax was built into the survey to present the attributes ranked as most important and those not ranked to appear in the third section's ranking questions. The definition of each attribute was available via a software help tool.

The third section of the survey presented two final ranking exercises. First, those attributes ranked as important in section II were randomly presented for a final ranking into the five most important attributes (rank #1 = most important). The second question randomly presented all attributes not ranked as important in section II for a final ranking of the five least important attributes (rank #1 = least important).

The final section of the survey asked respondents to identify any attributes not represented in the original list and to rank the level of importance of any missing attribute(s).

The survey was piloted by the committee members of the research project and epidemiology graduate students within the department of Large Animal Clinical Sciences, Western College of Veterinary Medicine, University of Saskatchewan. Changes to the survey addressed issues with question structure, esthetics, clarification issues and grammatical errors.

3.2.3.4 Survey 2 Data Collection and Analysis

The survey was created using University of Saskatchewan available FluidSurveys™ online survey software. The survey was deployed and distributed in the same manner as the first survey described in 3.2.2.4. Additionally, participation was promoted during the annual Canadian Association of Veterinary Epidemiology and Preventative Medicine Conference, June 9-10th, 2014, at Charlottetown, PEI. The survey URL was deployed June 1, 2014 and closed July 2, 2014. A reminder for completion of the survey was sent mid-June. Completed surveys were collected within the FluidSurveys™ software platform and exported into a Microsoft Excel spreadsheet for further data coding. The descriptive statistics of responses were performed using Microsoft Excel (Microsoft Office, v.15, Microsoft Corporation, Redmond, WA, USA).

The frequency of the attribute ranking responses were sorted into four 'top ten' lists of the 10 attributes with the highest frequency of ranked as the five most important (rank #1-5), most important (rank #1), five least important (rank #1-5) and least important (rank #1). The identification of key attributes and determination of a hierarchical tier of importance for all attributes was accomplished by use of an algorithm to sort the attributes into five tiers of importance (Figure 3.1). The hierarchy was based upon an attribute's presence (or absence) in the top 10 lists for the most important (ranks #1-5 and rank #1) and least important (ranks #1-5 and rank #1). Attributes within each tier were listed in descending order of importance by determining the cumulative frequency of most important (ranks #1-5 and rank #1) scores for tiers 1-3 and frequency of least important (ranks #1-5 and rank #1) for tiers 4 and 5. The key attributes were determined to be those attributes in tier 1. This tier contained those attributes common to both lists of the top 10 most important lists (ranks #1-5 and rank #1).

3.3 Results

3.3.1 Findings of Building the Initial List of attributes: Focus Group and Literature Sourced

The combination of focus group and literature sourced attributes are presented in Table 3.1. A total of 35 attributes and associated subcomponents were defined. The two focus group sessions additionally identified main themes of attributes. The CFIA focus group identified three main themes of attributes: 'use', 'outbreak management' and 'system design'. The 'use' theme identified qualities of an IMS required for the ease of use and accessibility of the system. Attributes within the theme of 'system design' contained examples such as robustness, ability to expand and linkage to other systems. Attributes contained in 'outbreak management' related to features of the system to support the disease control activities and investigation (i.e. the system has disease investigation tracing capacity). In the WCVM focus group, the themes identified were: 'what you are collecting' (i.e. data required for an animal disease outbreak investigation), ‘user interface and access’ (i.e. the system is easy to use and build), ‘how’ (i.e. how to collect the data and information), ‘data quality and security’, ‘rapid reporting to facilitate communication’, ‘resources’ (i.e. disease control measures, communication templates) and ‘liaison and linkage to stakeholders’.

3.3.2 Survey 1: Identification of a Comprehensive List of Attributes of an Animal Disease Outbreak Information Management System

Sixty completed responses were received and another 59 incomplete surveys were logged within the survey response report in FluidSurveys™. The survey URL was sent to an estimated 150 persons with an estimated response rate of 40%.

The respondents included 37 (62%) from federal government. The CFIA represented all of the federal government respondents. Nine (15%) respondents were from academia, 9 (15%) from provincial or territorial government, and 5 (8%) from animal industry organizations. No responses were received from other federal government agencies including PHAC and Health Canada. Twenty respondents (33%) were from Ontario, 11 (19%) from Saskatchewan, 8 (13%) from Alberta, 7 (12%) from Manitoba, 5 (8%) from Quebec, 4 (7%) from British Columbia, 2 (3%) from New Brunswick, 1 (2%) from Newfoundland and Labrador, 1 (2%) from Prince Edward Island and 1 (2%) did not report their province.

Respondent frequency of use of surveillance based IMS and involvement in regulatory disease prevention is summarized in Table 3.2. The open response experience with animal (or human) disease events indicated broad and extensive experience with only one respondent indicating no previous experience. The description of the IMS the respondents were familiar with resulted in the reporting of 25 different systems. The most common (24 respondents) was the Canadian Emergency Management Response System (CEMRS), a system utilized exclusively by the CFIA, with a total of 24 respondents (41% of respondents) indicating familiarity (Canadian

Food Inspection Agency, 2013b). Five respondents (9%) indicated familiarity with the Canadian Animal Health Surveillance Network (Kloeze et al., 2010). Further classification was limited by the respondents' heavy use of acronyms and the inability to distinguish the reported surveillance systems. The reported positive and negative features regarding these systems are displayed in Table 3.3. Repeated positive features were related to the ease of: system use, navigation, information input and access. Repeated negative features included: lack of flexibility, repetitive data entry, difficult to search information, too time consuming to use, lack of organization and inability to perform functions such as generate reports.

In the open response question that asked respondents to list the three top attributes from their previous list of attributes, 21 themes of attributes were identified. The frequency of the responses matching one of the attribute themes is listed in Table 3.4. Thirteen 'new' or not previously defined attributes were identified. The new attributes included: 'ease of system use', 'ease of data entry', 'standardized data format', 'data accuracy', 'data integrity', 'minimum data', 'stakeholder engagement', 'disease control', 'data use tools', 'reporting capacity', 'searchable', 'analysis capacity' and 'routine use'. Twenty-one open responses had single entries and were classified as 'other'. The attributes of 'ease of system use' and 'ease of data entry' were found to be similar and related to the focus group and literature sourced attribute of 'simplicity'. The research team members decided based upon the frequency of respondents reporting 'user friendly' and 'ease of use' and lack of a similar importance rating for 'simplicity' that respondents considered these qualities of an IMS as separate entities.

The respondent ratings for the purpose of an animal disease outbreak IMS (0 least important to 10 most important) are displayed in Table 3.5. Information management was defined as the highest rated purpose with a mean of 9.8 and median of 10.0. The lowest rated purpose was knowledge management with a mean of 6.7, median of 7.0, minimum of 0.0 and maximum of 10.0.

The ratings for the 35 focus group and literature sourced attributes are summarized in Table 3.6. Twenty-one attributes received a median rating of importance of 10.0 (10 = most important). The attribute with the highest mean rating was a subcomponent of data storage (description: The system has the ability for the use and storage of data related to the disease event) with a mean of 9.7 (N = 60). The lowest rated attribute was a subcomponent of cost effectiveness (description: Cost-effectiveness is an important attribute in assessing the relative value of an IMS) with a mean of 7.7 (N = 60). The difference in means between the highest and lowest rated attribute was 2.0 and difference in median between the highest and lowest rated attribute was 2.0.

For the open response question asking respondents if there were any other attributes of an animal disease outbreak IMS they felt were important, 2 responses were received. The first response identified the importance of a system to require little training to be able to use effectively and efficiently. The second response stated the importance of a system to be adaptable but at the same time not lose historical information within older or archived versions.

The final comprehensive list of attributes and associated definitions for use in the second survey is available in Table 3.7. To create the final list, the 35 focus group and literature sourced attributes and subcomponents (Table 3.1) were condensed to 22 attributes and the 13 newly identified attributes from the open responses (Table 3.4) were condensed to 12 for a total of 34. In some cases, attributes were renamed to improve clarity. One exception to condensing attributes into a single attribute title and definition occurred for 'data defined'. The subcomponents were separated into the two distinct attributes of ‘consistent data definition’ and ‘understandable vocabulary’ due to both attributes receiving high ratings in the first survey.

3.3.3 Survey 2: Determination of Key Attributes of an Animal Disease Information Management System

A total of 103 completed responses were received and another 63 incomplete surveys were logged within the survey response report in FluidSurveys™. The survey URL was sent to an estimated 354 persons with an estimated response rate of 29%.

The respondents included 69 (67%) from federal government, specifically 64% from the CFIA, 3 from PHAC and 2 from other federal departments. Nine respondents (9%) were from academia, 8 (8%) from provincial or territorial government, 16 (15%) from animal industry organizations and 1 indicated ‘other’ (N = 103). Twenty-seven respondents (28%) were from Ontario, 18 (19%) from Saskatchewan, 12 (13%) Alberta, 9 (9%) Manitoba, 9 (9%) Quebec, 9 (9%) British Columbia, 4 (4%) New Brunswick, 1 (1%) Newfoundland and Labrador, 6 (6%) Prince Edward Island, and 1 (1%) were from the Yukon. Seven respondents did not report their location (N = 96).

The respondents’ experience with animal (or human) disease events or outbreaks, use of surveillance based database/IMSs (animal disease based or other) and involvement in regulatory disease prevention or control (human or animal related) is summarized in Table 3.2. Respondents described experience with 32 different IMS with similar systems reported in Survey 1.

For the IMS user type (N = 95), 33 (35%), indicated they were exclusively end users, 15 (16%) reported themselves as exclusively data entry and sorting users, 11 (12%) identified themselves as both end users and data analysts, 8 (9%) as exclusively data analysis users, 8 (9%) a combination of data entry, sorting, end user and data analysis, 6 (6%) both data entry and end users, 4 (4%) all user types, 3 (3%) both data entry and sorting and data analysis, 3 (3%)

exclusively system program developers and support and 2 (2%) considered themselves as ‘other’. Two individuals indicated ‘not applicable’ to the question and 8 did not respond.

For the identification of the top 10 attributes by frequency of being ranked #1-5, each respondent (103) ranked the five most important attributes for a total of 513 rankings (Table 3.8). Two rankings were incomplete (i.e. respondent only ranked four most important attributes instead of 5). All attributes were ranked within the five most important (rank #1-5) at least once. The attribute with the highest frequency of ranking as the five most important (rank #1-5) was ‘User friendly’ with a total count of 40 (N = 513). This was followed by ‘effectiveness’ with a total count of 35, ‘reliability’ (32), ‘data accuracy’ (30) and ‘accessibility’ (27). Figure 3.2 depicts the 10 attributes with the highest frequency of ranking as the five most important attributes of an IMS.

For the identification of the top 10 attributes by frequency of being ranked as the most important attribute (rank #1), a total of 103 rankings were made (Table 3.8). Figure 3.3 demonstrates the 10 attributes with the highest frequency of being ranked as the most important attribute (rank #1). ‘User friendly’ received the highest frequency of ranking with a total count of 15 (N = 103). This was followed by ‘effectiveness’ (12), ‘data accuracy’ (10), ‘reliability’ (8) and data security (7). Table 3.8 presents the comparison of the two methods of defining the top 10 key attributes by frequency of ranking. The attributes identified in both are: ‘user friendly’, ‘effectiveness’, ‘data accuracy’, ‘reliability’, ‘timeliness’ and ‘accessibility’.

The results of the attributes ranked as least important (rank #1-5) are listed in Table 3.10 and the comparison the 10 least important attributes by frequency of ranking as least important (rank #1) and five least important (rank #1-5) are presented in Table 3.11. A diagram of descending order of frequency of ranking in the five most important and the corresponding frequency of ranking in the five least important is demonstrated in Figure 3.4. In general, attributes with the highest frequency of ranking with the five most important have the lowest frequency of being ranking as least important.

The hierarchy of attributes and identification of the key attributes are displayed in Figure 3.5. The tier 1 of the hierarchy identified the key attributes (in descending order of importance) of ‘user friendly’, ‘effectiveness’, ‘data accuracy’, ‘reliability’, ‘accessibility’ and ‘timeliness’. The top 2 tiers mirror those attributes identified in the top 10 rankings in Table 3.9 and the bottom 2 tiers mirror those attributes identified in the bottom 10 rankings in Table 3.11.

In the final question, respondents were allowed an opportunity to present any attributes they felt were not covered in the provided list and if they would have ranked the attribute(s) in the top five most important identify the ranking it would have received. The following six attributes were identified: ‘disease control performance measurement tool’, ‘data stewardship’, ‘risk analysis and epidemiology related disease progression’, ‘relevance’ and ‘decision maker commitment’. ‘Relevance’ and ‘data stewardship’ were the only attributes for which there was an importance ranking of 1. The only response for which a respondent offered a description of the attribute was ‘relevance’. All others were not accompanied by the respondent’s description of the attribute meaning.

3.4 Discussion

The identification of a comprehensive list of attributes of an animal disease outbreak IMS and further determination of those most important or ‘key’ is an important step to define the main qualitative characteristics to further convert into specific measurable criteria for system evaluation or aid the development of new systems (Centers for Disease Control and Prevention (CDC), 2004; German et al., 2001; Health Canada and Health Surveillance Coordinating

Committee (HSCC) Population and Public Health Branch, 2004; Thacker et al., 1988). This study identified a comprehensive list of 34 attributes of an animal disease outbreak IMS. The key attributes of greatest importance to the stakeholders surveyed included: ‘user friendly’, ‘effectiveness’, ‘data accuracy’, ‘reliability’, ‘accessibility’ and ‘timeliness’. Due to the relative newness of available technology to perform complex information management, an established definition and list of attributes of an animal disease outbreak IMS were lacking. This study provided a definition and the Canadian animal health stakeholder perspective for the primary purpose of an animal disease outbreak IMS.

The primary purpose of an animal disease outbreak IMS identified was information management. However, the alternate choices of knowledge management, outbreak management, disease surveillance capacity and ‘all’ received overall ratings of importance to suggest that while information management may be the obvious and primary purpose of an animal disease outbreak IMS, the other purposes are important and may have a secondary role within the system.

The final list of 34 attributes and associated definitions provide an important foundation of animal disease outbreak IMS attributes not previously described or defined. The comprehensiveness of the list was ensured by the use of three separate avenues to identify attributes including: use of focus group, literature sourced and stakeholder open response. The inclusiveness of this list was further supported by the few missing attributes reported on the second survey.

The use of a hierarchical algorithm to determine the key attributes and determination of importance of all 34 attributes provided a holistic perspective of the full list of attributes and a balanced approach of identifying the key attributes. The identification of the key attributes of ‘user friendly’ and ‘timeliness’ suggest stakeholders desire the use of the system to be easy to use in a timely manner. The attributes of ‘data accuracy’, ‘effectiveness’ and ‘accessibility’ relate specifically to the information within the system and indicate importance for the information to be accurate, accessible and valuable to aid decision making processes. Finally, the key attribute of ‘reliability’ relates to the system functioning and importance of the system being reliable and able to consistently function under defined conditions.

The attributes of ‘user friendly’ and ‘effectiveness’ received the most frequent ranking of importance (rank #1 and ranks #1-5) suggesting these two attributes are essential regardless of unique features of individual IMS. This is mirrored in human and animal health surveillance systems where attributes with the related definitions of ‘simplicity’, ‘usefulness’, ‘system effectiveness’ are commonly found as core attributes for system evaluation (German et al., 2001; Health Canada and Health Surveillance Coordinating Committee (HSCC) Population and Public Health Branch, 2004; Thacker et al., 1988; World Health Organization (WHO), 1997). The finding of ‘user friendly’ as the top ranked attribute suggests users want a system that is easy to enter, find and extract data. The finding of ‘effectiveness’ as the second most important attribute suggests respondents placed a high priority on the system achieving what it’s intended to accomplish and its ability to provide valuable information for use in further actions and decision-making.

Some may argue attributes not ranked in the top ranking lists might still warrant greater importance or priority. This is a valid concern and reflects comments from both surveys where respondents indicated it was difficult to rank the attributes as they all held a degree of importance. Due to the uniqueness of each system, key attributes can and will change according to the system objectives, purpose and user needs. For this reason, the method of incorporating all attributes into a hierarchical key attribute determination allowed for a holistic approach to defining core attributes while maintaining the comprehensive list of attributes. The tiered approach suggests those attributes found in upper tiers should be strongly considered as a key attributes of the IMS regardless of system uniqueness and other attributes may be selected depending on the system's unique features.

The first survey presented interesting findings with all of the focus group and literature sourced attributes receiving a rating of greater than 7 (scale of 0 as least important and 10 as most important). This demonstrated that stakeholders generally viewed all attributes as having a degree of importance. It is also interesting to note that with the first survey, the attribute with the highest mean for importance was data storage capacity. However, this finding was not reflected in the results of the second survey. It is possible the addition of the new attributes presented in the second survey changed the respondent's ranking of level of importance. The first survey also provided insight regarding the inference and nuance of wording used to name an attribute. In the open response question asking respondents to list their top three attributes of an animal disease outbreak IMS, respondents repeatedly reported 'user friendly' and 'ease of system use.' The related attribute of 'simplicity' was identified in the focus group and literature derived attributes but there was disparity between its rating and frequency of report of 'user friendly' as a top three attribute. This finding suggested respondents considered different meaning between a 'user friendly' and 'simplicity'. Thus, the semantics of the comprehensive list of attributes was changed to include the attribute of 'user friendly' in addition to 'simplicity'.

The respondents for both surveys demonstrated appropriate knowledge and expertise with animal (or human) disease events, surveillance or IMS's and regulatory disease prevention and/or control to qualify opinions expressed. The representation of the respondents from all the

Canadian provinces and territories was also appropriate with roughly equal representation of eastern to western Canadian provinces (using the Manitoba-Ontario border as the cut point).

There are limitations and bias to the results worth mentioning. First the organization representation of respondents demonstrated strong representation by CFIA or government bodies in general. It is possible, the overall opinion of the comprehensive list of and key attributes of an animal disease outbreak IMS are that of CFIA instead of the collective Canadian animal health stakeholder group. However, in the current Canadian animal disease outbreak response environment, government regulatory bodies are the primary developers of animal disease outbreak IMS's With the strong input of CFIA, it is possible for some attributes, such as 'stakeholder engagement', belong in a much higher tier for other stakeholders such as animal industry groups. Along the same line of representation bias, the majority of CFIA respondents reported familiarity with CEMRS, the CFIA specific IMS. As a result, experience specific to CEMRS, either positive or negative, would further bias the CFIA respondents in ranking of the attributes.

Another limitation to report was the IMS user types were not equally represented. The low representation of the system programming, development and support user type resulted in the majority of the opinions expressed were those of the system users not the system developers. However, it is possible that system users account for the majority of IMS users and therefore have an important voice in the defining purpose and attributes of an animal disease outbreak IMS.

Respondent fatigue was possible in both surveys with the reported time to completion being over 30 minutes for both surveys. The ranking of the attributes in the second survey were presented in a series of three ranking exercises in an attempt to make the question more visually appealing to the viewer. However, by doing so, it may have not have represented the respondent's true 'top' ranked attributes should they have been provided the entire list of attributes. The attributes themselves warrant discussion about potential introduction of bias. While every effort was taken to obtain attributes from a literature based resource or via an agreed upon research team attribute name and definition, it is possible some attributes were not intuitive by name as to the meaning. An example of this limitation is the attribute of 'minimum data'. In this example, this attribute's title may not be apparent to the reader as to the attribute's associated definition. As a result, if respondents did not read the definition of the attribute, they may have ranked according to their personal understanding. The alternate use of 'required minimum data' or similar title may have added clarity to this attribute's meaning. The overlap of meaning of some attributes and associations between attributes may have made the choice of choosing one attribute over another difficult. Combining some attributes and reducing the number of attributes in a list may have been less confusing to the respondent and resulted in a different hierarchy of importance.

Overall, a comprehensive animal disease outbreak IMS attribute list with definitions provides an important starting point for providing a resource for system development and evaluation. The attributes determined through this research were general enough to have applicability to characteristics of any IMS designed for the management of information related to a disease or health event. There is little doubt the field of information technology is an ever expanding field and will continue to change with new technologies (Mukhi et al., 2007). Further discussion, with agreement amongst animal health regulators on universal definitions of these attributes, is recommended to facilitate communication between system developers and system users (Drewe et al., 2012; Hoinville et al., 2013). Much like the foundational discussions in health surveillance systems related to the defining of attributes for the purpose of evaluation, this research provides the start of dialogue around the same topic relating to an animal disease outbreak IMS (German et al., 2001; Thacker et al., 1988).

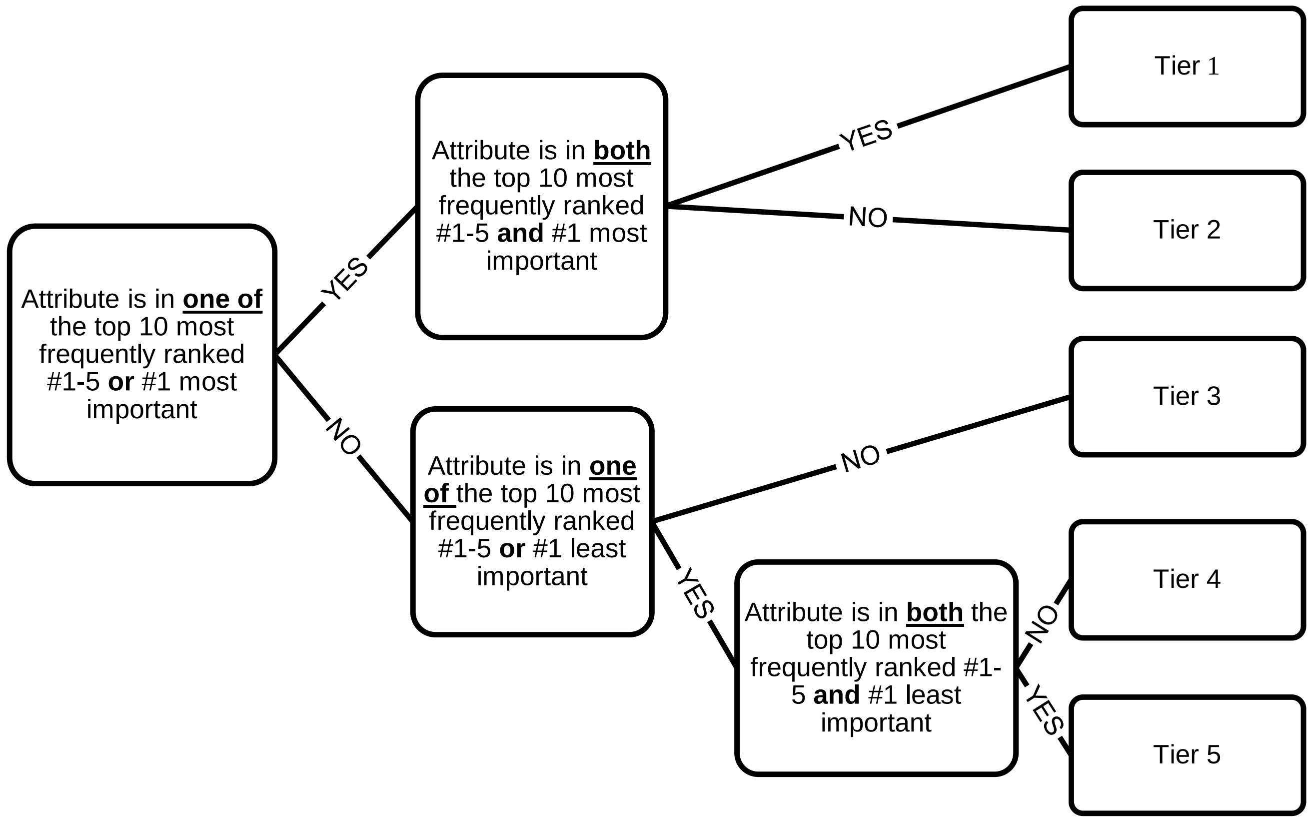

Figure 3.1. Algorithm to determine the key attributes of an animal disease outbreak information management system hierarchy.

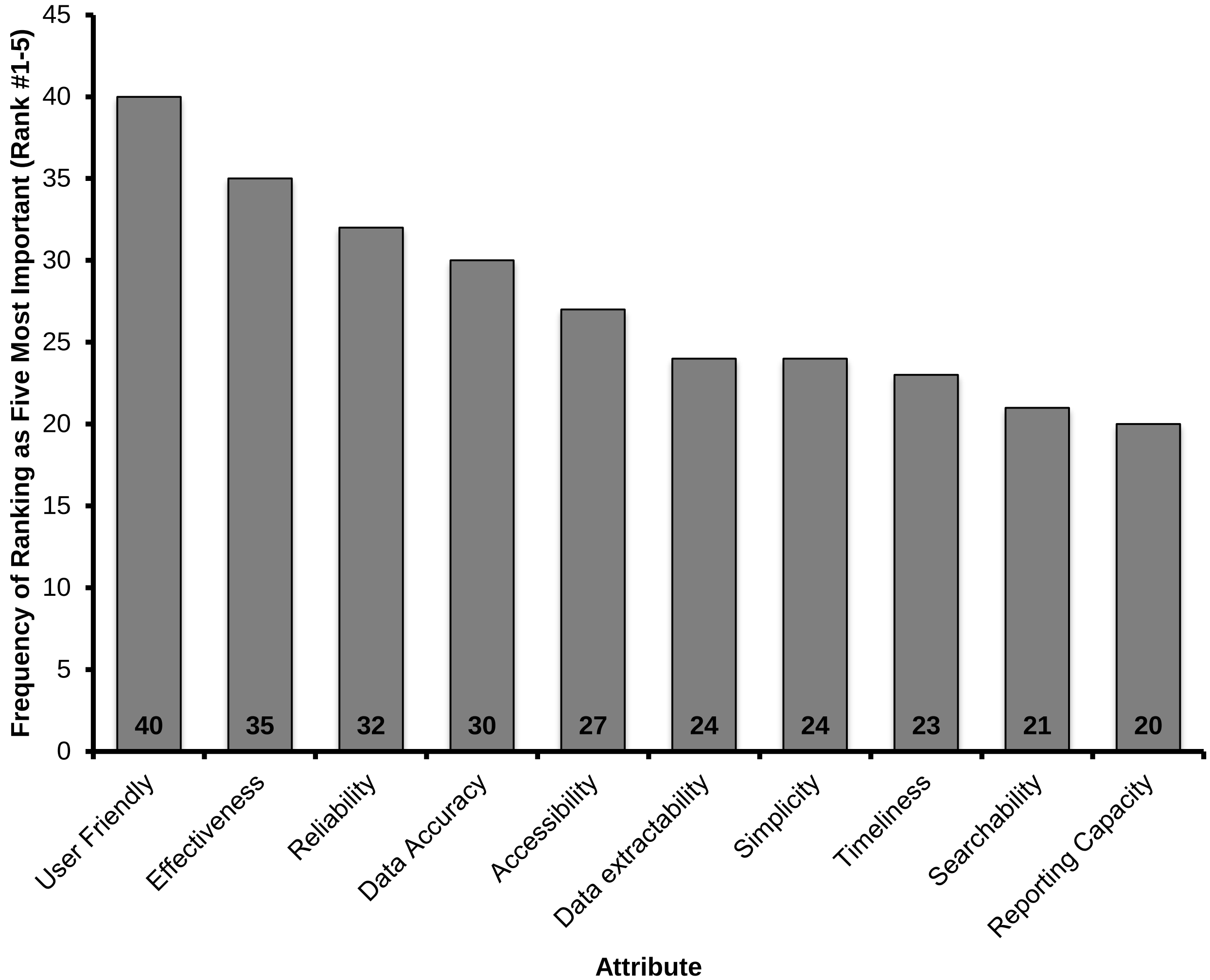

Figure 3.2. Top ten attributes of an animal disease outbreak information management system with the highest frequency of ranking as the five most important (rank #1-5) in descending order based on Survey 2 (n=513).

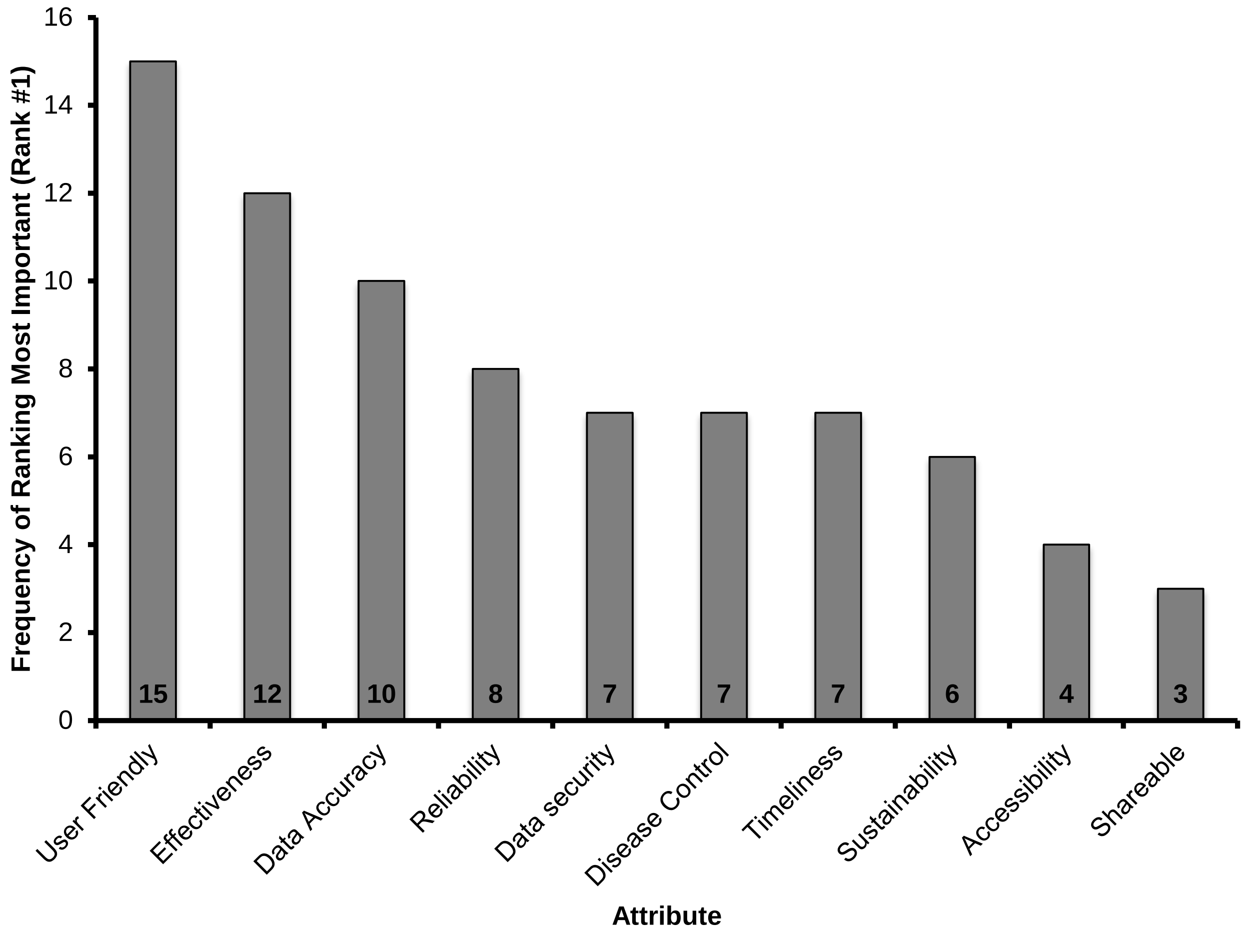

Figure 3.3. Top ten attributes of an animal disease outbreak information management system with the highest frequency of ranking as the most important (rank #1) in descending order based on Survey 2 (n=103).

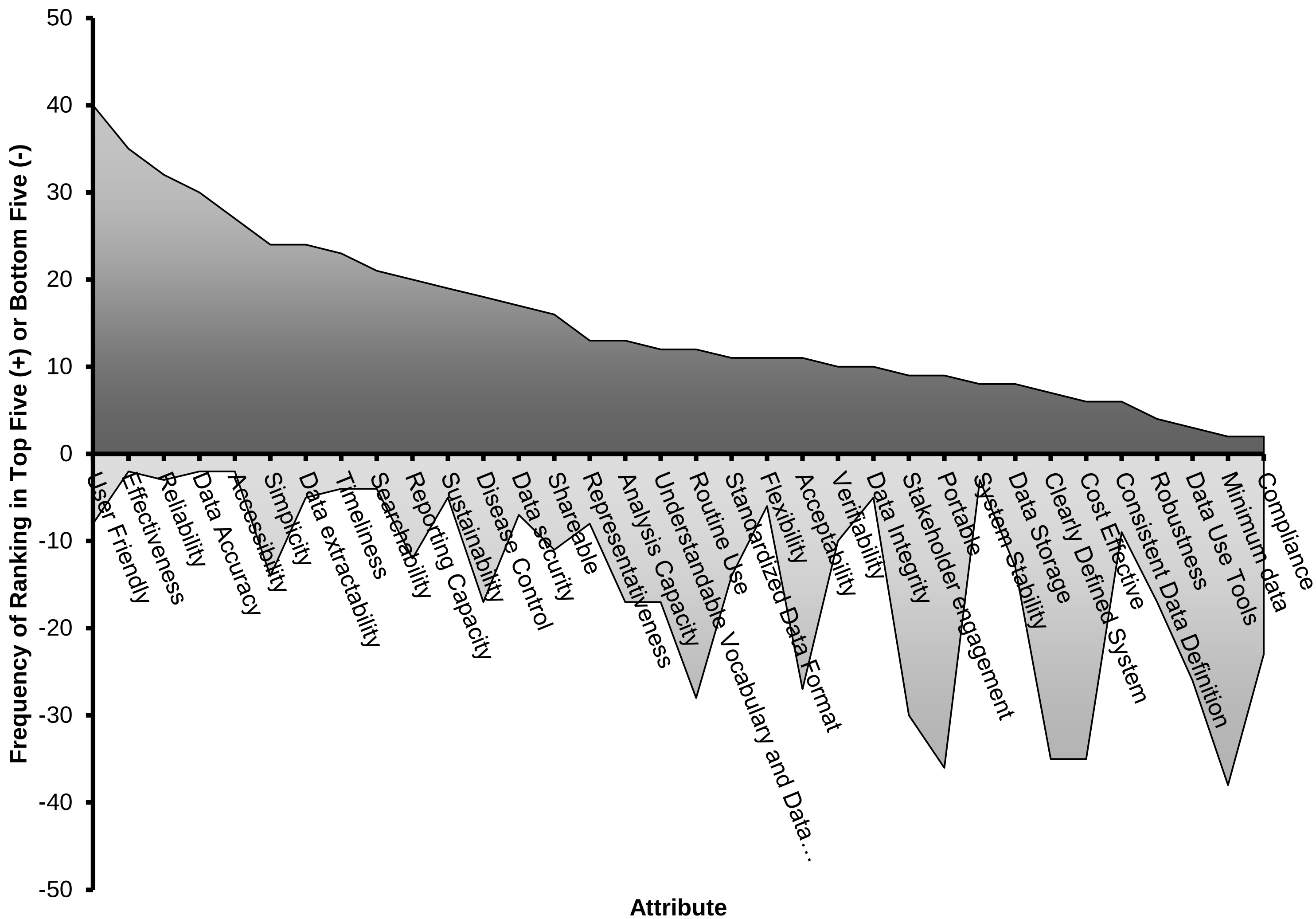

Figure 3.4. Distribution of frequency in descending order of the ten most frequently ranked as the five most important (+) and associated frequency of ranking as the five least important (-) among the 34 attributes of an animal disease outbreak information management system based on Survey 2 (n=513).

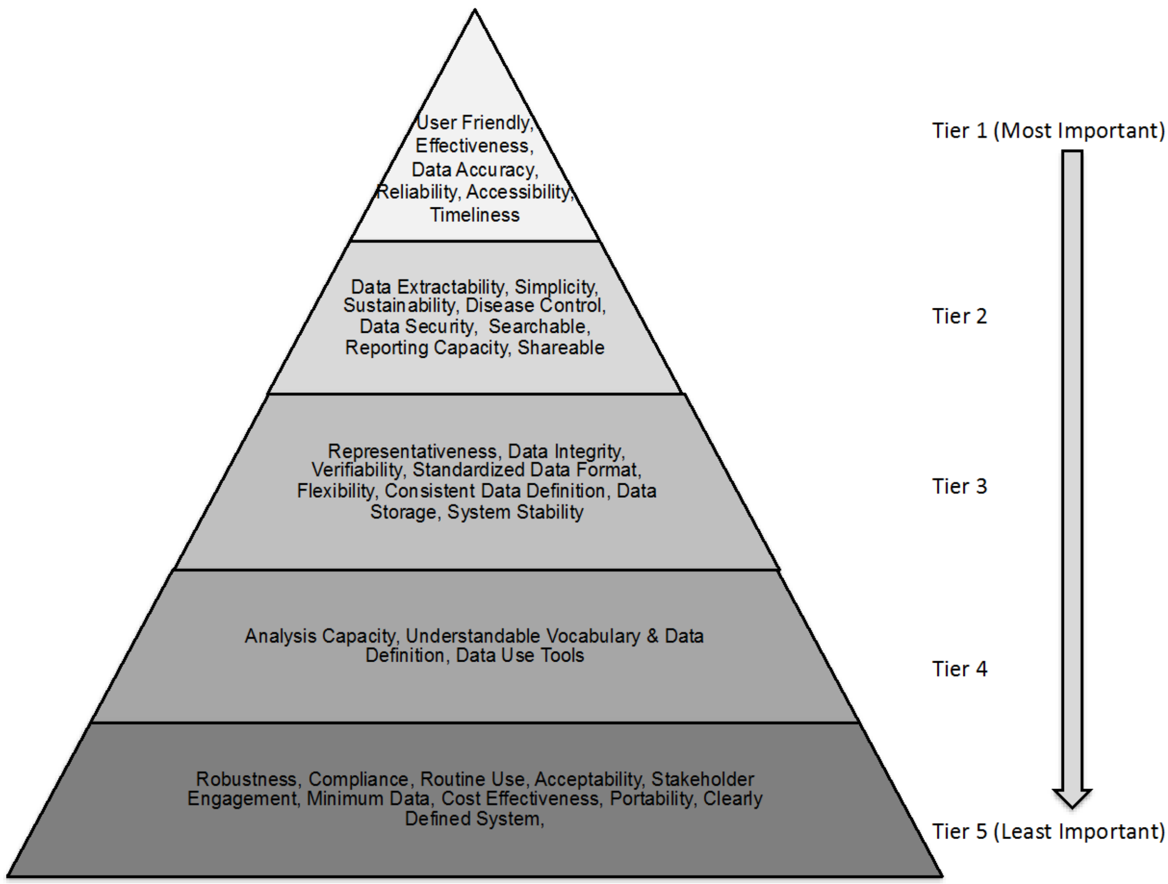

Figure 3.5. Hierarchy of the 34 attributes of an animal disease outbreak information management system in descending order of importance based on algorithm of frequency of importance ranking.

Table 3.1. Focus group and literature sourced animal information management system attributes and definitions used in Survey 1.

Attribute	Subcomponents	Description	Attribute Source
Acceptability	-	The system must be recognized and accepted by all stakeholders identified as users of the system (i.e. managers, data entry personnel, partners).	Centers for Disease Control and Prevention (CDC), 2004; German et al., 2001; Thacker et al., 1988; World Health Organization (WHO), 1997
Accessibility	Easy access	There must be easy accessibility for users of the information management system (i.e. web-based platform)	Mukhi et al., 2011
	Multi-user access	The system must be accessible by multiple users at one time	Mukhi et al., 2011
Clearly defined system	Overall purpose	It is important that the system readily identifies the overall purpose of the system	Centers for Disease Control and Prevention (CDC), 2004
	Stakeholders defined	It is important that the system readily identifies the complete list of stakeholders of the system (including those who provide data into the system and those who use the information within the system)	Centers for Disease Control and Prevention (CDC), 2004
	Aspects of system defined	It is important that aspects of the operation of the system are described in detail for all users of the system	Focus group derived
Compliance	-	The system must adhere to all legislation related to individual privacy (i.e. Privacy Act) and storage of personal information	Health Canada, 2004
Cost effectiveness	Effective	Cost-effectiveness (ranging from development, maintenance and upgrades associated with the animal information management system) is an important attribute in assessing the relative value of an information management system	Drewe et al., 2012
	Cost efficient	The system must be efficient in providing benefits relative to the direct and indirect costs associated with the system	Thacker et al., 1988
Data defined	Consistent	The information management system has data defined consistently throughout the system	Transport for London, 2007
	Understandable	The definitions and vocabulary used within the system is understandable and available to all users	Focus Group Derived

Continued

Continued Table 3.1. Focus group and literature sourced animal information management system attributes and definitions used in Survey 1.

Attribute	Subcomponents	Description	Attribute Source
Data extractability	-	The system has the ability to extract or export information from the system	Mukhi et al., 2011
Data security	Within system security	It is important that the date within the system is secure (i.e. available only to those defined users)	Drewe et al., 2012
	User rights defined	It is important that access or user defined rights are available within the system (i.e. user access and edit rights can be restricted within the system)	Focus group derived
Data storage	During event	The system has the ability for the use and storage of data related to the disease event	Mukhi et al., 2007
	Archive capacity	The system has the capacity for storage and accessibility for archival purposes of data related to the disease event	Mukhi et al., 2007
Flexibility	-	The system must be easily adaptable to meet new needs of the system or event	Centers for Disease Control and Prevention (CDC), 2004; Drewe et al., 2012; German et al., 2001
Linkage capacity	-	The system can link and share information between jurisdictions (i.e. federal and provincial jurisdictions)	Mukhi et al., 2011
Portability	-	The system should have the capacity to be duplicated or repeated under other settings (i.e. the system could be deployed to similar systems)	Centers for Disease Control and Prevention (CDC), 2004; Drewe et al., 2012
Reliability	Information traceability	The information entered into the system is traceable for whom the information was entered and accessed by	Focus group derived
	Information reliability	Information within the system must be able to be proven reliable and credible (i.e. proof of evidence, available electronic records, log book records)	Drewe et al., 2015; German et al., 2001
Representativeness	Disease event	The system accurately describes and captures information regarding the disease event	Drewe et al., 2012; German et al., 2001; Thacker et al., 1988
	Data attribution	Consistent data attribution is an important feature within the system (i.e. dates are entered in a consistent format)	Transport for London, 2007
	Completeness	An indication of completeness of the information pertaining to the disease event is important	German et al., 2001
Robustness	-	It is important the system has capacity for multiple utility (i.e. ability to capture information on multiple disease events)	Mukhi et al., 2011

Continued

Continued Table 3.1. Focus group and literature sourced animal information management system attributes and definitions used in Survey 1.

Attribute	Subcomponents	Description	Attribute Source
Shareable between database	-	It is important that the system can share data between different databases (i.e. laboratory linkage for upload of diagnostic test results)	Drewe et al., 2015; Mukhi et al., 2011
Simplicity	-	An animal information management system must be simple, easy to use, navigate and implement	Drewe et al., 2012; German et al., 2001; Health Canada, 2004; Thacker et al., 1988; World Health Organization, 1997
Sustainability	Over time	The system is able to be maintained and ongoing over a long period of time	J A Drewe et al., 2013
	Support	The system has financial, technological and leadership support for long-term maintenance and sustainability	Yasnoff et al., 2000
System effectiveness	Intended purpose	It is important the system is successful at achieving its intended purpose (i.e. if the system is designated as both a means to manage information related to the disease and the project management of disease control activities, it is successful at accomplishing both purposes)	German et al., 2001; Health Canada, 2004; Thacker et al., 1988; World Health Organization (WHO), 1997
	Valuable information	It is important the system is useful for provision of valuable information required for actions or decision making processes related to the disease event	Focus group derived
System stability	-	The system is stable throughout consistent operation of the system, expanded user access and information storage (i.e. minimal downtime to users)	Centers for Disease Control and Prevention (CDC), 2004; German et al., 2001; Health Canada, 2004; World Health Organization (WHO), 1997
Timeliness	-	The interval of time required to use the system, enter or upload information and have data available to all users must be minimal	Centers for Disease Control and Prevention (CDC), 2004; Drewe et al., 2015; German et al., 2001; Health Canada, 2004; Thacker et al., 1988
Verifiability	Information accuracy	Information within the system must be accurate, consistent and based upon pre-determined methodologies	Focus group derived
	External validity	Information within the system must be able to be validated by external sources and analyzed within the proper contextual framework (i.e. government audit requesting information for verification)	Focus group derived

Table 3.2. Frequency of respondent experience with surveillance based information management systems, regulatory disease control and disease outbreaks for Surveys 1 and 2.

Experience	Survey	N	Daily (%)	Periodically (%)	Yearly (%)	Sporadically (%)	Not Applicable (%)
Use of surveillance based information management system	1	60	15 (25%)	12 (20%)	2(3%)	23 (38%)	8 (13%)
	2	99	22 (22%)	18 (18%)	7(7%)	38 (39%)	14 (14%)
Involvement in regulatory disease prevention or control	1	57	30 (53%)	11 (19%)	5 (9%)	7 (12%)	4 (7%)
	2	103	28 (27%)	25 (24%)	7 (7%)	30 (29%)	13 (13%)
Involvement with animal (or human) disease events or outbreaks	1[a]	-	-	-	-	-	-
	2	96	16 (17%)	18 (19%)	8 (8%)	48 (50%)	6 (6%)

[a] Question presented in open response format.

Table 3.3. List of positive and negative features of known information management systems reported in Survey 1.

Positive Features	Negative Features
Ability to attach relevant information	Difficulty in searching for information within the system
Ability to connect to laboratory database and import lab results	Expensive to maintain
Ability to produce reports, graphs or tables of data	Inability to export information
Accepted widely amongst stakeholders	Inability to interface with other systems (i.e. laboratory databases) or stakeholders
Adaptability (system can be customized)	Inability to modify or customize the system according to disease event
Allows for management of actions associated with the disease event	Inclusion of too much information within the system
Collaborative between stakeholders	Incomplete data within the system
Data entry is standardized	Information within the system is not 'real time' (i.e. days behind the actual event)
Easily accessible	Infrequent use of the system leading to issues in user and system readiness
Easy to enter data	Lack of funding or managerial support to maintain the system
Easy to navigate and use	Lack of stakeholder engagement or user willingness to participate
Easy to search information	Lack of standardized data fields
Information can be shared between stakeholders	Language use varies (not available in official languages)
Information integrity (i.e. allows for maintenance of a master file)	Limited capacity (i.e. cannot hold enough information)
Minimal training required to use the system effectively	Limited or no ability for functions such as generating reports, maps or graphs
Real-time or timeliness to data entry and information availability	No means to confirm data within the system is correct
Records data entry or system use	Not easy to use
Required fields or minimum data set	Poorly organized
Scope of the system is national	Repetitive data entry
Single data entry	System based upon out-of-date forms or policies
Storage and retrieval system (i.e. can input documents easily, documents can be stored in one location)	System instability (i.e. system malfunction or shutdown)
Storage capacity (i.e. central repository of information)	System training required prior to use
System flexibility (can be used for more than one disease)	Time consuming (system is slow in operability, data entry or information retrieval is slow)
Well-organized	

Table 3.4 Stakeholder identified animal disease outbreak information management system attributes and frequency of reporting as a top three most important attribute in the open response from Survey 1.

Attribute	Total Count
Ease of system use[a]	38
Ease of data entry[a]	23
Minimum data[a]	12
Reporting capacity[a]	11
Flexibility	10
Shareable	10
Timeliness	10
Analysis capacity[a]	9
Searchable[a]	9
Data use tools[a]	7
Standardized data format[a]	7
Data accuracy[a]	6
Routine use[a]	6
Robustness	5
Accessible	4
Data security	3
Disease control[a]	3
Stakeholder engagement[a]	2
Capacity	2
Sustainable	1
Data integrity[a]	1

[a] Newly identified attributes

Table 3.5. Descriptive statistics of responses to purpose of an animal disease outbreak information management system (rating from 0 to 10 with 0 = strongly disagree and 10 = strongly agree) in Survey 1.

Information Management System Purpose	N	Mean	Median	Min	Max	Standard Deviation	Range
Information management	60	9.78	10	8	10	0.56	2
Knowledge management	60	6.68	7	0	10	2.73	10
Surveillance capacity	60	7.95	8	0	10	2.32	10
Outbreak management	60	8.25	9	1	10	2.06	9
All	59	7.80	8	0	10	2.32	10

Table 3.6. Descriptive statistics of responses to rating of importance of Survey 1 attributes of an animal disease information management system (rating from 0 to 10 with 0=strongly disagree and 10= strongly agree) sorted by highest to lowest mean for Survey 1.

Information Management System Attribute	N	Mean	Median	Min	Max	Standard Deviation	Range
Data storage-during event	60	9.65	10	5	10	0.84	5
Representativeness- of disease event	60	9.63	10	7	10	0.74	3
Data extractability	59	9.58	10	5	10	0.89	5
Data security within system	60	9.52	10	6	10	0.89	4
Sustainability-support	60	9.47	10	6	10	0.98	4
Shareable	59	9.46	10	5	10	0.99	5
Data definition- consistent	59	9.44	10	6	10	0.92	4
Accessibility- multi-user	60	9.42	10	3	10	1.41	7
System effectiveness-valuable information	60	9.4	10	7	10	0.97	3
Data definition- understandable	60	9.38	10	5	10	1.04	5
Representativeness-data attribution	60	9.33	10	5	10	1.12	5
Accessibility- easy access	60	9.33	10	4	10	1.22	6
Robustness	60	9.33	10	6	10	1.07	4
Simplicity	60	9.32	10	3	10	1.43	7
Timeliness	60	9.32	10	4	10	1.23	6
Sustainability-over time	59	9.29	10	6	10	1.04	4
Flexibility	59	9.27	10	5	10	1.03	5
Data storage- Archive capacity	60	9.22	10	5	10	1.37	5
Stability	60	9.17	10	5	10	1.09	5
System effectiveness- intended purpose	59	9.07	10	0	10	1.68	10
Data security-user rights defined	59	8.92	9	4	10	1.39	6
Compliance	60	8.88	10	5	10	1.55	5
Verifiability-information accuracy	60	8.85	9	5	10	1.34	5
Reliability- information reliability	60	8.82	9	4	10	1.49	6
Acceptability	60	8.73	9	3	10	1.65	7
Representativeness-information completeness	59	8.73	9	5	10	1.45	5
Reliability-information traceability	59	8.44	9	2	10	1.82	8
Linkage capacity	59	8.42	9	3	10	1.79	7
Clearly defined system- overall purpose	60	8.4	9	0	10	2.02	10
Verifiability- external validity	60	8.27	9	1	10	1.94	9
Cost effectiveness- cost efficient	60	8.12	8	2	10	1.54	8
Clearly defined system-aspects of system defined	60	8.1	8	0	10	1.79	10
Portability	59	7.81	8	1	10	1.88	9
Clearly defined system- stakeholders defined	60	7.77	8	0	10	2.39	10
Cost effectiveness- effective	60	7.67	8	3	10	1.87	7

Table 3.7. Final list of animal disease outbreak information management system attributes and definitions.

Attribute	Description
Acceptability	The system is recognized and accepted by all stakeholders identified as users of the system (i.e. partners, data entry personnel and managers)
Accessibility	It is easy to access to the system (i.e. web-based platform) and it is accessible to multiple users at the same time
Analysis capacity	The system has the capacity to perform statistical analysis on data inputted or data can be easily linked or exported to statistical software
Clearly defined system	The system readily identifies the overall purpose of the system
Compliance	The system adheres to all legislation related to individual privacy (i.e. Privacy Act) and storage of personal information
Consistent data definition	Data have a common definition throughout the entire system (i.e. defining the use of the acronym of AI as meaning avian influenza versus alternate meaning of artificial insemination)
Cost effective	The system is efficient in providing benefits relative to the direct and indirect costs associated with the system
Data accuracy	Data within the system is accurate and reflects the information provided by source
Data extractability	The system has the ability to extract or export information from the system
Data integrity	Maintaining and assuring the accuracy and consistency of data over its entire life-cycle (Boritz, 2005)
Data security	Data within the system are secure (i.e. available only to defined users) and user edit/access rights can be defined within the system
Data storage	The system has the ability and capacity for the storage of data related to the disease event (i.e. for archival purposes or immediate use)
Data use tools	The system has tools available to apply to raw data inputted (i.e. GIS mapping capacity)
Disease control	The system has the capacity to facilitate disease control measures (i.e. monitor progress of investigation and control actions on a specific premises)
Effectiveness	The system is useful for provision of valuable information required for actions or decision making processes related to the disease event and achieves its intended purpose
Flexibility	The system is easily adaptable to meet new needs of the event or system
Minimum data	The system has minimum data input as defined for the specific application (i.e. unique identifier, client, farm)(Kloeze et al., 2012)
Portable	The system has the capacity to be duplicated or repeated under other settings (i.e. the system could be deployed to similar situations)
Reliability	The system is dependable or able function under defined conditions for a specific period of time and has consistent, repeatable performance.
Reporting capacity	The system has the ability to generate reports from the information within
Representativeness	The system accurately describes and captures complete information regarding the disease event

Continued

Continued Table 3.7. Final animal disease outbreak information management system attributes and definitions for Survey 2.

Attribute	Description
Robustness	The system has capacity for multiple utility and expansion (i.e. the ability to capture information on multiple disease events)
Routine use	The system is routinely used by users (users includes data input, data analysis, information users)
Searchable	The system has the capacity to search for information
Shareable	The system can share data between stakeholders and different databases (i.e. laboratory linkage for upload of diagnostic tests results)
Simplicity	The system is simple, free from complexity, easy to navigate and implement
Stakeholder engagement	The system has input, co-operation and develop of by stakeholder group
Standardized data format	Data are entered into the system in a consistent format (i.e. date always is entered as YY/MM/DD)
Sustainability	The system is maintained and has financial, technological and leadership support for long term maintenance
System stability	The system is stable throughout consistent operation of the system, expanded user access and information storage (i.e. minimal downtime to users)
Timeliness	The interval of time required to use the system, enter or upload information and have data available to all users is minimal
Understandable vocabulary and definition	The vocabulary and definitions used within the system are understandable and available to all users (i.e. avoidance of technical terminology where possible, available glossary)
User friendly	The system is easy to use (i.e. easy to enter data, navigate and retrieve data)
Verifiability	Information within the system must be able to be validated or proven as accurate

Table 3.8. Frequency of each attribute ranking as five most important attributes (rank #1=most important attribute) and total count of attribute top five ranking in Survey 2.

Attribute	Rank #1	Rank #2	Rank #3	Rank #4	Rank #5	Top Five Ranking Total Count
User friendly	15	9	8	4	4	40
Effectiveness	12	4	6	8	5	35
Reliability	8	4	10	7	3	32
Data accuracy	10	11	6	2	1	30
Accessibility	4	2	5	10	6	27
Data extractability	2	5	1	6	10	24
Simplicity	1	9	3	4	7	24
Timeliness	7	4	4	3	5	23
Searchable	1	7	3	6	4	21
Reporting capacity	1	3	4	8	4	20
Sustainability	6	2	3	1	7	19
Disease control	7	2	4	4	1	18
Data security	7	2	1	2	5	17
Shareable	3	5	3	2	3	16
Representativeness	2	1	4	2	4	13
Analysis capacity	-	2	4	5	2	13
Understandable vocabulary and data definition	-	2	4	2	4	12
Routine use	2	2	2	1	5	12
Flexibility	-	2	4	4	1	11
Acceptability	-	2	2	4	3	11
Standardized data format	1	3	2	4	1	11
Verifiability	3	3	3	1	-	10
Data integrity	3	3	1	1	2	10
Portable	-	2	2	3	2	9
Stakeholder engagement	3	3	1	-	2	9
Data storage	-	-	3	1	4	8
System stability	-	3	1	3	1	8
Clearly defined system	1	2	3	1	-	7
Consistent data definition	2	-	1	-	3	6
Cost effective	1	3	1	1	-	6
Robustness	-	-	1	1	2	4
Data use tools	-	-	1	1	1	3
Compliance	1	-	1	-	-	2
Minimum data	-	1	1	-	-	2
Total	103	103	103	102	102	513

Table 3.9. Summary of the top 10 attributes of an animal disease information management system for the frequency or being ranked as five most important (rank #1-5) and most important (rank #1) in Survey 2.

Rank (Descending order with 1 Being Most Important)	Attribute Ranked in the Five Most Important (Frequency) (N = 513)	Attributes Ranked as Most Important-Rank #1(Frequency) (N = 103)
1	User friendly (40)	User friendly (15)
2	Effectiveness (35)	Effectiveness (12)
3	Reliability (32)	Data accuracy (10)
4	Data accuracy (30)	Reliability (8)
5	Accessibility (27)	Data security (7), Disease control (7) and Timeliness (7)[a]
6	Simplicity (24) and Data extractability (24)[a]	- [a]
7	- [a]	- [a]
8	Timeliness (23)	Sustainability (6)
9	Searchable (21)	Accessibility (4)
10	Reporting capacity (20)	Shareable (3)

[a] Attributes with equal frequency are placed at the same ranking level and include the subsequent appropriate ranks

Table 3.10. Frequency of each attribute ranking as five least important attributes (rank #1=least important attribute) and total count of least important ranking in Survey 2.

Attribute	Rank #1 (Least Important)	Rank #2	Rank #3	Rank #4	Rank #5 (Fifth least important)	Total Count of Least Important Ranking
Minimum data	6	10	9	6	7	38
Portability	9	5	8	6	8	36
Cost effectiveness	10	6	3	7	9	35
Clearly defined system	12	6	6	4	7	35
Stakeholder engagement	7	6	5	4	8	30
Routine use	5	6	5	7	5	28
Acceptability	8	1	9	7	2	27
Data use tools	2	9	2	7	6	26
Compliance	3	4	5	7	4	23
Understandable vocabulary & data definition	2	3	2	6	4	17
Robustness	5	5	4	2	1	17
Analysis capacity	1	4	3	3	6	17
Disease control	4	2	6	2	3	17
Simplicity	3	2	4	2	3	14
Standardized data format	2	2	2	4	4	14
Data storage	2	2	4	2	3	13
Reporting capacity	2	2	1	6	1	12
Shareable	3	3	2	2	1	11
Verifiability	-	4	1	3	2	10
Consistent data definition	1	2	2	2	2	9
Representativeness	2	5	-	-	1	8
User friendly	-	2	-	3	3	8
Data security	2		3	2	-	7
Flexibility	-	3	3	-	-	6
Data extractability	1	1	1	2	-	5
Sustainability	-	-	2	2	1	5
Data integrity	1	-	1	1	2	5
Timeliness	-	-	2	-	2	4
Searchable	-	1	1	-	2	4
Reliability	-	-	2	-	1	3
System stability	1	-	1	-	1	3
Accessibility	-	-	1	1	-	2
Effectiveness	-	-	-	-	2	2
Data accuracy	1	-	-	1	-	2
Total	95	96	100	101	101	493

Table 3.11. Summary of the top 10 least important attributes of an animal disease information management system by the frequency or being ranked as five least important (rank #1-5) and least important (rank #1) in Survey 2.

Rank (Descending order with 1 Being Least Important)	Attribute Ranked in the Five Least Important (Frequency) (N = 493)	Attribute Ranked as Least Important (Frequency) (N = 95)
1	Minimum data (38)	Clearly defined system (12)
2	Portability (36)	Cost effectiveness (10)
3	Cost effectiveness (35) and Clearly defined system (35)[a]	Portability (9)
4	- [a]	Acceptability (8)
5	Stakeholder engagement (30)	Stakeholder engagement (7)
6	Routine use (28)	Minimum data (6)
7	Acceptability (27)	Routine use (5) and Robustness (5)[a]
8	Data use tools (26)	- [a]
9	Compliance (23)	Disease control (4)
10	Analysis capacity (17), Disease control (17), Robustness (17) and Understandable vocabulary and data definition (17)[b]	Compliance (3)

[a] Attributes with equal frequency are placed at the same ranking level and include the subsequent appropriate ranks
[b] Attributes with equal frequency

CHAPTER 4: GENERAL DISCUSSION AND FUTURE RESEARCH

4.1 Introduction

This thesis described the comparison of information quality resulting from different questionnaire methods in an initial investigation of a Canadian federally reportable disease and defined a comprehensive and key list of attributes of an animal disease outbreak based information management system (IMS).

The occurrence of an animal disease outbreak, particularly a federally reportable disease, can have great impact on a country's economy, the animal agriculture industry sector and associated regulatory government agencies (Levings, 2012). In the UK, the foot-and-mouth disease (FMD) outbreak in 2001 cost $21 billion (Gyles, 2010). In the event of a serious animal disease outbreak, the ability to collect complete and accurate information related to the disease event is critical for assisting timely and appropriate disease control and to communicate with key stakeholders (Canadian Food Inspection Agency, 2012d; Kloeze et al., 2010; Kroschewski et al., 2006; Lessard, 1988; Levings, 2012; MacDonald, 2012; Office of the Auditor General of Canada, 2010; Spickler et al., 2010; World Health Organization (WHO), 2014; World Organisation for Animal Health (OIE), 2014). Preparedness in emergency and information management for animal health events is essential for economic stability, food security and public health (Bowman and Arnoldi, 1999).

In Canada, the Canadian Food Inspection Agency (CFIA) is responsible for responding to federally reportable animal diseases as defined by the *Health of Animals Act* and the *Health of Animals Regulations* (Canadian Food Inspection Agency, 2011; Kloeze et al., 2012; Office of the Auditor General of Canada, 2010; Spickler et al., 2010). Intensive disease control measures are required for reportable diseases occurring as an outbreak or where eradication is the primary objective (Canadian Food Inspection Agency, 2012a; Office of the Auditor General of Canada, 2010; Spickler et al., 2010). The collection and management of information via epidemiologic investigation of the event becomes critical to perform effective disease outbreak management (Gesteland et al., 2002; Kloeze et al., 2010; Martin, 1995; Teich, 2002; Yasnoff et al., 2000). The information must be accurate, timely, complete and available from multiple sources (Levings, 2012; Yasnoff et al., 2000). Questionnaires and information management systems should be regarded as tools to conduct the epidemiologic investigation and assist the disease control measures (Centers for Disease Control and Prevention (CDC), 2014; Joint FAO/IAEA Programme Division of Nuclear Techniques in Food and Agriculture, 2014; Martin, 1995; Putt et al., 1987). Both are becoming increasingly important for the collection and management of information related to a disease event (Centers for Disease Control and Prevention (CDC), 2014; Dohoo, 1993; IEA European Questionnaire Group et al., 1998; Kukafka et al., 2007; Mukhi et al., 2007, 2011).

The objectives of this study were to: 1) compare the information quality (completeness and accuracy) between differing questionnaire methodologies and modes of completion, 2) identify a comprehensive list of attributes of an animal disease outbreak, and 3) determine the key attributes most important to animal health stakeholders.

4.2 Key Findings of the Study

Chapter 2 compared the information quality between differing questionnaire methodologies and modes of completion. Several important epidemiological features were identified with this study. First, as long as the questionnaire contained disease-specific questions, a significant difference, specifically an increase in information quality was found as compared to the use of generically designed questions. In contrast, when the disease-specific questions were removed, the information quality was significantly affected with the greatest impact on reduced completeness and accuracy of information in the trace-in and trace-out critical information categories. The findings suggest the questionnaire needs to have questions specific to the disease under investigation to ensure information quality is not compromised. The finding of no significant differences in the completeness and accuracy of information between the use of an electronically completed disease-specific questionnaire and hard copy handwritten generic and disease-specific questionnaire coincide with findings of information quality being more affected by the questionnaire construct, and specificity of the questions over the mode of completion (Dillman et al., 2009; Stehr-Green et al., 2012).

Chapter 3 focused on the management phase of the information cycle related to an animal disease outbreak IMS and identified that the main purpose of the system is information management. This chapter further identified 34 attributes and associated definitions of an animal disease outbreak IMS through literature review of applicable attributes, a series of focus group sessions and a survey of Canadian animal health stakeholders for identification of additional qualities. A separate survey of Canadian animal health stakeholders determined the key attributes of ‘user friendly’, ‘effectiveness’, ‘accessibility’, ‘data accuracy’, ‘reliability’ and ‘timeliness’. These finding suggested the attributes of greatest importance were based on the use of the system, information within the system and system functioning. For the use of the system, stakeholders placed importance on the system’s ability to be easy to use in a timely manner. For information within the system, stakeholders identified the importance of needing information within the system to be accurate, accessible and valuable to disease control decisions. Finally, the stakeholders placed importance on the system functioning to be reliable and able to consistently operate under defined conditions. The work in this chapter helped to identify foundational qualitative elements and key attributes of an animal disease outbreak IMS to act as guidance for subsequent evaluation of pre-existing systems and creation of new systems (Centers for Disease Control and Prevention (CDC), 2004; Drewe et al., 2012; German et al., 2001; Health Canada and Health Surveillance Coordinating Committee (HSCC) Population and Public Health Branch, 2004; Lombardo and Buckridge, 2007; Thacker et al., 1988).

4.3 Project Limitations

There were various study design elements to consider as project limitations. First, in the questionnaire methodology comparison study, the heavy focus on CFIA and Canadian federally reportable disease introduces questionable external application of the study results outside of a CFIA federally reportable disease situation.

The use of an interviewer for questionnaire delivery introduced a wide variety of bias and introduced a source of measurement error. In this study, the interviewers introduced bias through the use of question paraphrasing, deviations from the questionnaire chronology, omission of questions or responses and failure to record the respondent’s true response. The slightest change to the questionnaire chronology, question intent or interpretation of respondent’s true response can compromise questionnaire validation (Harris and Brown, 2010; Meadows, 2003). The actor was forced to introduce bias by deviating from the scripted responses in cases where the interviewer deviated from questionnaire chronology, asked new questions or changed the original intent of the question. As such, the introduction of interviewer and respondent bias presented a challenge to the true representation of information quality based upon the questionnaire alone. The questionnaires used for the study introduced limitations due to the question construct requiring a degree of question paraphrasing. The questionnaires also lacked mandatory field completion allowing interviewers to omit questions and responses.

In Chapter 3, limitations included the skewed representation of respondents for stakeholder representation and IMS user type. The majority of the stakeholder representation was by federal government, specifically the CFIA. The majority IMS user types were end users with limited representation from system programming and development user types. It was difficult to quantify an exact response rate for both surveys due to the method of survey deployment; however, the estimated response rate for both surveys was not optimal. In both surveys, respondent fatigue was possible and therefore subject to response bias. Response bias was also possible for those respondents who ranked attributes based upon the name alone (i.e. they did not read the associated definition). In these cases, the respondent ranked the attribute on their personal perception of the attribute instead of the associated definition.

4.4 Future Research

A few areas of future work were identified to further the questionnaire methodology comparison study findings. Future research in the area of defining acceptable information quality cut points or an acceptable range of information quality through methods such as Bayesian analysis would be beneficial. It is recommended for further research to consider defining the minimum amount of complete and accurate information required to assist the disease event management and the epidemiologic investigation of case and exposure source finding. Future research is recommended to further isolate the questionnaire's influence on information quality and to limit the introduction of interviewer bias. This type of research would benefit from the use of questionnaires designed with scripted questions (i.e. not requiring interviewer's use of paraphrasing) and mandatory completion of critical elements combined with the stringent training of the interviewer to follow the questionnaire both chronologically and verbatim. The questionnaire comparison trial focused on the effects of the questionnaire on information quality;

however, the interaction between interviewer, respondent and questionnaire collectively affect the quality of information collected. Further research is required to obtain a holistic view of the influence of each element on information quality. Specifically, the interviewer characteristics associated with high information quality.

The animal disease outbreak IMS study would benefit from a similar study performed on an international scale or within another country's animal health stakeholder group to determine wide scale agreement or recommended modification to the full list of attributes and those identified as key to the Canadian animal health stakeholder. Many attributes are related and a system's performance in one attribute can positively or negatively affect associated attributes. For example, a system that is user friendly is expected to have a high compliance rate amongst the expected system users, which will subsequently increase the success of other system attributes such as 'effectiveness', 'acceptability', 'routine use' and 'representativeness'. Therefore, it is possible for attributes to be further categorized into themes or act as proxy for other attributes. Further work is recommended to explore the association between attributes.

4.5 Implications

Due to the critical nature of requiring information to be accurate, complete and available in a disease outbreak, the results of both chapters provide important considerations for the tools and systems used in an animal disease outbreak. In the questionnaire methodology comparison, the inclusion of disease-specific questions in an animal disease investigation questionnaire increases information accuracy and completeness, specifically, for epidemiologic tracing information. This finding has implications for the CFIA to consider the addition of disease-specific questions in the initial investigation questionnaire for all federally reportable diseases.

Beyond, implications to the CFIA, other bodies responsible for disease investigation should consider a similar application of disease-specific questions in the questionnaire.

The implications of the animal disease outbreak IMS study may be considered as foundational in assisting the evaluation and creation of systems specific to animal disease outbreak information management. This study identified new attributes specific to an animal disease outbreak IMS in addition to those pre-existing for human and animal surveillance system evaluation. Dohoo (1993) describes "the biggest limitation to the effective use of available data is the lack of infrastructure to collate, process and distribute the data" for monitoring livestock health and production. The same statement can be applied to information related to animal disease outbreaks. This research furthers progress into the tools necessary for information management related to an animal disease epidemiologic investigation and disease outbreak management.

4.6 Conclusion

Information is a critical element of effective investigation and response to an animal disease outbreak. Therefore, properly developed tools to assist the information collection and management process are critical to ensure a successful response. The study's focus on information collection through the exploration of information quality achieved with the use of an interviewer delivered questionnaire in an animal disease investigation, furthers our knowledge in how to design the tools to collect complete and accurate information. In the area of information management, the study's defining of attributes of an animal disease outbreak IMS provided valuable guidance for the evaluation of an animal disease outbreak information management system to ensure a system's usefulness in advance of an outbreak. Both elements of this research provided a valuable source of intelligence regarding the improvement and validation of essential tools required to perform effective information collection and management in an animal disease outbreak event (Aspevig, 2014; Bowman and Arnoldi, 1999; Kloeze et al., 2010; Levings, 2012; Lumpkin and Magnuson, 2014; Office of the Auditor General of Canada, 2010; United Nations Office for the Coordination of Humanitarian Affairs, 2002).

REFERENCES

Alwin, D.F., 2011. Evaluating the Reliability and Validity of Survey Interview Data Approach, in: Madans, J., Miller, K., Maitland, A., Willis, G. (Eds.), Question Evaluation Methods: Contributing to the Science of Data Quality. Wiley, Hyattsville, Maryland, pp. 263–293.

Animal and Plant Health Inspection Service (APHIS), 2003. EMRS – Emergency Management Response System [WWW Document]. EMRS Man. Routine FAD/EDI Investig. URL http://www.aphis.usda.gov/vs/ep/EMRS_for_Routine_FAD_Investigations.htm (accessed 4.21.15).

Appleton, J. V, 2006. Analysing qualitative interview data: addressing issues of validity and reliability. J. Adv. Nurs. 22, 993–997.

Aspevig, J., 2014. Project Management and Public Health Informatics, in: Magnuson, J.A., Fu, P.C.. J. (Eds.), Public Health Informatics and Information Systems. Springer, London, pp. 211–231.

Bartlett, P.C., Judge, L.J., 1997. The role of epidemiology in public health. Rev. Sci. Tech. 16, 331–6.

Baumal, R., Benbassat, J., 2008. Current trends in the educational approach for teaching interviewing skills to medical students. Isr. Med. Assoc. J. IMAJ 10, 552–555.

Bent, D.H., 1995. Changing Attitudes Toward Information Management: They Just Don't Seem to Get It, in: Annual Conference of the Canadian Association for Information Science (CAIS/ACIS). Edmonton, AB.

Boritz, J.E., 2005. IS practitioners' views on core concepts of information integrity. Int. J. Account. Inf. Syst. 6, 260–279. doi:10.1016/j.accinf.2005.07.001

Bowman, Q.P., Arnoldi, J.M., 1999. Management of animal health emergencies in North America: prevention, preparedness, response and recovery. Rev. Sci. Tech. 18, 76–103.

Breakwell, G.M., Hammond, S., Fife-Schaw, C., Smith, J.A. (Eds.), 2006. Research Methods in Psychology, 3rd ed. SAGE, London.

Bryman, A., 2008. Social research methods. Oxford University Press, Oxford.

Canadian Food Inspection Agency, 2013a. Section 1.7 The Interview-Common Procedures Manual.

Canadian Food Inspection Agency, 2013b. Section II: Analysis of Program Activities by Strategic Outcome [WWW Document]. 2011-2012 Dep. Perform. Rep. URL http://www.inspection.gc.ca/about-the-cfia/accountability/reports-to-parliament/2011-2012-dpr/eng/1348777953917/1348778053447?chap=4 (accessed 5.22.14).

Canadian Food Inspection Agency, 2012a. Foot-and-Mouth Disease Hazard Specific Plan [WWW Document]. URL http://www.inspection.gc.ca/animals/terrestrial-animals/diseases/reportable/foot-and-mouth-disease/plan/eng/1332174353793/1332174430101?chap=1 (accessed 5.14.14).

Canadian Food Inspection Agency, 2012b. Section 4 Disease Investigation-Common Procedures Manual.

Canadian Food Inspection Agency, 2012c. Section 4.3 Movement Tracing Investigations-Common Procedures Manual.

Canadian Food Inspection Agency, 2012d. Report on the Outbreak of Notifiable Avian Influenza (H5N2) in Manitoba, Canada, November 2010 [WWW Document]. Dis. Incidents. URL http://www.inspection.gc.ca/animals/terrestrial-animals/diseases/reportable/ai/disease-incidents/manitoba/eng/1335291194317/1335291616652#tc3_1_1 (accessed 5.14.14).

Canadian Food Inspection Agency, 2011. Reportable Diseases - Animals - Canadian Food Inspection Agency [WWW Document]. URL http://www.inspection.gc.ca/animals/terrestrial-animals/diseases/reportable/eng/1303768471142/1303768544412 (accessed 5.14.14).

Centers for Disease Control and Prevention, 2013. Testing Hypotheses [WWW Document]. Foodborne Outbreaks. URL http://www.cdc.gov/foodsafety/outbreaks/investigating-outbreaks/investigations/hypotheses.html (accessed 6.26.14).

Centers for Disease Control and Prevention (CDC), 2014. Generating Hypotheses, Investigations, Investigating Outbreaks [WWW Document]. Foodborne Outbreaks. URL http://www.cdc.gov/foodsafety/outbreaks/investigating-outbreaks/investigations/sources.html (accessed 6.25.14).

Centers for Disease Control and Prevention (CDC), 2004. Framework for Evaluating Public Health Surveillance Systems for Early Detection of Outbreaks: Recommendations from the CDC Working Group [WWW Document]. MMWR. URL http://www.cdc.gov/mmwr/preview/mmwrhtml/rr5305a1.htm (accessed 2.18.14).

Centers for Disease Control and Prevention (CDC), n.d. Self Study Modules for Effective TB Interviewing [WWW Document]. URL http://www.cdc.gov/tb/publications/guidestoolkits/Interviewing/selfstudy/module1/toc.htm (accessed 9.22.14).

Corbin, M.J., Griffin, D., 2006. Assessing performance of feedlot operations using epidemiology. Vet. Clin. North Am. Food Anim. Pract. 22, 35–51.

Del Rocio Amezcua, M., Pearl, D.L., Friendship, R.M., McNab, W.B., 2010. Evaluation of a veterinary-based syndromic surveillance system implemented for swine. Can. J. Vet. Res. 74, 241–51.

Dillman, D.A., Smyth, J.D., 2007. Design effects in the transition to web-based surveys. Am. J. Prev. Med. 32, S90–96.

Dillman, D.A., Smyth, J.D., Christian, L.M., 2009. Internet, Mail, and Mixed-Mode Surveys: the tailored design method, 3rd ed. John Wiley & Sons, Hoboken, NJ.

Dohoo, I.R., 1993. Monitoring livestock health and production: service-epidemiology's last frontier? Prev Vet Med 18, 43–52.

Dohoo, I.R., Martin, W., Stryhn, H., 2009. Veterinary Epidemiologic Research, 2nd ed. ed. Charlottetown, P.E.I. :University of Prince Edward Island.

Drewe, J.A., Hoinville, L.J., Cook, A.J.C., Floyd, T., Gunn, G., Stärk, K.D.C., 2015. SERVAL: A New Framework for the Evaluation of Animal Health Surveillance. Transbound. Emerg. Dis. 62, 33–45.

Drewe, J.A., Hoinville, L.J., Cook, A.J.C., Floyd, T., Stärk, K.D.C., 2012. Evaluation of animal and public health surveillance systems: a systematic review. Epidemiol. Infect. 140, 575–90.

Dwyer, D.M., Groves, C., Blythe, D., 2014. Outbreak Epidemiology, in: Infectious Disease Epidemiology: Theory and Practice. Jones & Bartlett Publishers, pp. 105–127.

Facilitator Tool Kit [WWW Document], n.d. URL http://oqi.wisc.edu/resourcelibrary/uploads/resources/Facilitator Tool Kit.pdf (accessed 3.28.13).

Fink, A., 2003. The Survey Handbook- The Survey Kit, 2nd ed. SAGE, Thousand Oaks.

Food and Agriculture Organization of the United Nations, 1997. Chapter 5: Personal Interviews, in: Crawford, I.M. (Ed.), Marketing Research and Information Systems. (Marketing and Agribusiness Texts-4). Food and Agriculture Organization of the United Nations, Rome.

Fraga, S., Lucas, R., Costa, D., Barros, H., 2013. Interviewer effects when investigating abuse were not compatible with effect modification but instead with confounding. J. Clin. Epidemiol. 66, 911–8.

Franklin, M., Halevy, A., Maier, D., 2005. From databases to dataspaces. ACM SIGMOD Rec. 34, 27–33.

Fu, P.C.. J., Tolentino, H., Franzke, L.H., 2014. Evaluation for Public Health Informatics, in: Magnuson, J.A., Fu, P.C.. J. (Eds.), Public Health Informatics and Information Systems. Springer, London, pp. 233–254.

Gay, C.C., 2009. Field disease investigation-A differentiating and integrative approach to problems in animal populations. Prev. Vet. Med. 88, 84–9.

Gerami, M., 2010. Knowledge Management. Int. J. Comput. Sci. Inf. Secur. 7, 234.

German, R.R., Lee, L.M., Milstein, R.L., Pertowski, C.A., Waller, M.N., 2001. Updated Guidelines for Evaluating Public Health Surveillance Systems: recommendations from the Guidelines Working Group. MMWR-Recommendations and Reports 50, 1–35.

Gesteland, P.H., Wagner, M.M., Chapman, W.W., Espino, J.U., Tsui, F.-C., Gardner, R.M., Rolfs, R.T., Dato, V., James, B.C., Haug, P.J., 2002. Rapid deployment of an electronic disease surveillance system in the state of Utah for the 2002 Olympic Winter Games. Proc. AMIA Symp. 285–9.

Gibbs, A., 1997. Focus Groups [WWW Document]. Soc. Res. Updat. Sociol. Surrey. URL http://sru.soc.surrey.ac.uk/SRU19.html (accessed 5.14.14).

Gordon, K., 2007. Principle of Data Management, 2nd ed. The British Computer Society, Swindon.

Government of Alberta, 2003. Information Assets in the Government of Alberta: A Management Framework. Edmonton, AB.

Government of Canada, T.B. of C.S., 2008. Policy on Information Management.

Gyles, C., 2010. Agroterrorism. Can. Vet. J. 51, 347–8.

Harris, L.R., Brown, G.T.L., 2010. Mixing interview and questionnaire methods: Practical problems in aligning data. Pract. Assessment, Res. Eval. 15, 1531–7714.

Health Canada, 2003. Learning from SARS: Renewal of Public Health in Canada [WWW Document]. URL http://www.phac-aspc.gc.ca/publicat/sars-sras/naylor/ (accessed 2.12.14).

Health Canada, Health Surveillance Coordinating Committee (HSCC) Population and Public Health Branch, 2004. Framework and Tools for Evaluating Health Surveillance Systems. Health Canada, Ottawa, Ontario.

Hendrikx, P., Gay, E., Chazel, M., Moutou, F., Danan, C., Richomme, C., Boue, F., Souillard, R., Gauchard, F., Dufour, B., 2011. OASIS: an assessment tool of epidemiological surveillance systems in animal health and food safety. Epidemiol. Infect. 139, 1486–1496.

Hintze, J., 2013. PASS .

Hoinville, L.J., Alban, L., Drewe, J.A., Gibbens, J.C., Gustafson, L., Häsler, B., Saegerman, C., Salman, M., Stärk, K.D.C., 2013. Proposed terms and concepts for describing and evaluating animal-health surveillance systems. Prev. Vet. Med. 112, 1–12.

Hopkins, R.S., Magnuson, J.A., 2014. Informatics in Disease Prevention and Epidemiology, in: Magnuson, J.A., Fu, P.C.J. (Eds.), Public Health Informatics and Information Systems. Springer, London, pp. 257–275.

IEA European Questionnaire Group, International Epidemiological Association, Ahrens, W., Bjorner, J., Gronvold, M., Jockel, K.H., Keiding, L., Lauritsen, J.M., Levey-Desroches, S., Manderson, L., Olesen, F., Olson, J., Pukkala, E., Manuela Morales Suarez-Varela, M., Wildner, M., 1998. Epidemiology Deserves Better Questionnaire by the. Aarhus.

Jacoby, A., Thomas, L., Soutter, J., Bamford, C., Steen, N., Thomas, R., Bond, J., 2001. Design and use of questionnaires: a review of best practice applicable to surveys of health service staff and patients. Health Technol. Assess. (Rockv). 5, 1–254.

Joint FAO/IAEA Programme Division of Nuclear Techniques in Food and Agriculture, 2014. Information and Knowledge Management [WWW Document]. Inf. Knowl. Manag. URL http://www-naweb.iaea.org/nafa/aph/knowledge-management.html (accessed 5.7.14).

Jordan, I., de Stricker, U., 2013. Information Management in the Canadian Federal Government: Principles, Practices and the Role of Information Professionals. CURVE 1–45.

Kajornboon, A.B., 2005. Using Interviews as Research Instruments. E-Journal Res. Teach. 2.

Kelton, D.F., 2006. Epidemiology: a foundation for dairy production medicine. Vet. Clin. North Am. Food Anim. Pract. 22, 21–33.

Kloeze, H., Berezowski, J., Bergeron, L., de With, N., Duizer, G., Green, C., McNab, B., VanderKop, M., 2012. A minimum data set of animal health laboratory data to allow for collation and analysis across jurisdictions for the purpose of surveillance. Transbound. Emerg. Dis. 59, 264–8.

Kloeze, H., Mukhi, S.N., Kitching, P., Lees, V.W., Alexandersen, S., 2010. Effective animal health disease surveillance using a network-enabled approach. Transbound. Emerg. Dis. 57, 414–419.

Knight, S., Burn, J., 2005. Developing a Framework for Assessing Information Quality on the World Wide Web. Informing Sci. J. 8, 159–172.

Kroschewski, K., Kramer, M., Micklich, A., Staubach, C., Carmanns, R., Conraths, F.J., 2006. Animal disease outbreak control: the use of crisis management tools. Rev. Sci. Tech. 25, 211–21.

Kukafka, R., Yasnoff, W.A., Revere, D., Turner, A.M., Madhavan, A., Rambo, N., Bugni, P.F., Kimball, A., Fuller, S.S., 2007. Understanding the information needs of public health practitioners: A literature review to inform design of an interactive digital knowledge management system. J. Biomed. Inform. 40, 410–421.

Lee, Y.W., Strong, D.M., Kahn, B.K., Wang, R.Y., 2002. AIMQ: a methodology for information quality assessment. Inf. Manag. 40, 133–146.

Lessard, P., 1988. The characterization of disease outbreaks. Vet Clin North Am Food Anim Pr. 4, 17–32.

Levings, R.L., 2012. Emerging and exotic zoonotic disease preparedness and response in the United States - coordination of the animal health component. Zoonoses Public Health 59 Suppl 2, 80–94.

Lombardo, J.S., Buckridge, D.L., 2007. Canadian Application of Modern Surveillance Informatics, in: Lombardo, J.S., Buckeridge, D.L. (Eds.), Disease Surveillance: A Public Health Informatics Approach. Wiley-Interscience, Hoboken, N.J., pp. 303–333.

Lumpkin, J.R., Magnuson, J.A., 2014. History and Significance of Information Systems and Public Health, in: Magnuson, J.A., Fu, P.C.J. (Eds.), Public Health Informatics and Information Systems. Springer, London, pp. 19–36.

MacDonald, P.D.M., 2012. Introduction to Disease Outbreaks, in: Sliter, T., Reilly, T. (Eds.), Methods in Field Epidemiology. Jones & Bartlett Learning; APHA Press, Burlington, MA, pp. 5–21.

Magnusson, J.A., Merrick, R., Case, J.T., 2014. Public Health Information Standards, in: Magnuson, J.A., Fu, P.C.J. (Eds.), Public Health Informatics and Information Systems. Springer, London, pp. 133–152.

Marshall, G., 2005. The purpose, design and administration of a questionnaire for data collection. Radiography 11, 131–136.

Martin, S.M., 1995. Data management issues for emerging diseases and new tools for managing surveillance and laboratory data. Emergin Infect. Dis. [1080-6040] 1, 124–128.

Maynard, D.W., Schaeffer, N.C., 2006. Standardization-in-Interaction: The Survey Interview, in: Drew, P., Raymond, G., Weinberg, D. (Eds.), Talk and Interaction in Social Research Methods.

McDonald, J.A., Burnett, N., Coronado, V.G., Johnson, R.L., 2003. Questionnaire Design, in: Reproductive Health Epidemiology Series. U. S. Department of Health and Human Services, Centers for Disease Control and Prevention, Atlanta, pp. 3–67.

Meadows, K.A., 2003. So you want to do research? 5: questionnaire design. Br. J. Community Nurs. (BR J COMMUNITY NURS) 8, 562–570.

Merriam-Webster [WWW Document], 2014. . Dictionary. URL http://www.merriam-webster.com/dictionary/information (accessed 12.17.14).

Meuleman, J.R., Caranasos, G.J., 1989. Evaluating the interview performance of internal medicine interns. AAMC Acad. Med. J. Assoc. Am. Med. Coll. 64, 277–279.

Morris, G., Snider, D., Katz, M., 1996. Integrating Public Health Information and Surveillance Systems. J. Public Heal. Manag. Pract. [1078-4659] 2, 24–7.

Mukhi, S., Aramini, J., Kabani, A., 2007. Contributing to communicable diseases intelligence management in Canada: CACMID meeting, March 2007, Halifax, Nova Scotia. Can. J. Infect. Dis. Med. Microbiol. 18, 353–6.

Mukhi, S.N., Chester, T.L.S., Klaver-Kibria, J. DA, Nowicki, D.L., Whitlock, M.L., Mahmud, S.M., Louie, M., Lee, B.E., 2011. Innovative technology for web-based data management during an outbreak. Online J. Public Health Inform. 3.

Murray, P., 1999. Fundamental issues in questionnaire design. Accid. Emerg. Nurs. 7, 148–153.

Naumann, F., Rolker, C., 2000. Assessment Methods for Information Quality Criteria, in: Proceedings of 5th International Conference on Information Quality. pp. 148–162.

Office of the Auditor General of Canada, 2010. Chapter 9 Animal Diseases- Canadian Food Inspection Agency Report to the Auditor General of Canada on Response to Animal Emergencies. Ottawa, Ontario.

Olsen, J., IEA European Questionnaire Group, 1998. Epidemiology deserves better questionnaires. Int. J. Epidemiol. 27, 935.

Oppenheim, A.N., 1992. Questionnaire Design, Interviewing and Attitude Measurement. Bloomsbury Academic, London; New York.

Perry, B., McDermott, J., Randolph, T., 2001. Can epidemiology and economics make a meaningful contribution to national animal-disease control? Prev. Vet. Med. 48, 231–60.

Phellas, C.N., Bloch, A., Seale, C., 2011. Structured methods: interviews, questionnaires and observation, in: Doing Research. pp. 182–202.

Pipino, L.L., Lee, Y.W., Wang, R.Y., 2002. Data quality assessment. Commun. ACM-Supporting community Build. Soc. Cap. 45, 211–218.

Presser, S., Couper, M.P., Lessler, J.T., Martin, E., Martin, J., Rothgeb, J.M., Singer, E., 2004. Methods for Testing and Evaluating Survey Questions. Public Opin. Q. 68, 109–130.

Putt, S.N.H., Shaw, A.P.M., Woods, A.J., Tyler, L., James, A.D., 1987. Veterinary epidemiology and economics in Africa- A manual for use in the design and appraisal of livestock health policy, ILCA Manual No. 3.

Radostits, O.M., Done, S.H., 2007. Veterinary Medicine, 10th ed. Elsevier Saunders, New York.

Richardson, J., 2005. Design and conduct a survey. Complement. Ther. Med. 13, 47–53.

Ruegg, P.L., 2006. Basic epidemiologic concepts related to assessment of animal health and performance. Vet. Clin. North Am. Food Anim. Pract. 22, 1–19.

Schwabe, D.W., Riemann, H.P., Franti, C.E., 1977. Epidemiology in veterinary practice. Philadelphia.

Spickler, R., Roth, J.A., Galyon, J., Lofstedt, J., 2010. Emerging and Exotic Diseases of Animals, 4th Edition. CFSPH Iowa State University.

Stehr-Green, J.K., Stehr-Green, P.A., MacDonald, P.D.M., 2012. Hypothesis-Generating Interviews, in: Sliter, T., Reilly, T. (Eds.), Methods in Field Epidemiology. Jones & Bartlett Learning; APHA Press, Burlington, MA, pp. 97–129.

Technopedia, 2014. What is an Information Management System (IMS)? - Definition from Techopedia [WWW Document]. Dictionary. URL http://www.techopedia.com/definition/26859/information-management-system (accessed 3.17.14).

Teich, J.M., 2002. The Informatics Response in Disaster, Terrorism, and War. J. Am. Med. Informatics Assoc. 9, 97–104.

Thacker, S.B., Parrish, R.G., Trowbridge, F.L., 1988. A method for evaluating systems of epidemiological surveillance. World Health Stat. Q. 41, 11–8.

The Federal Bureau of Investigation (FBI), n.d. Intelligence Cycle [WWW Document]. Intell. Branch. URL http://www.fbi.gov/about-us/intelligence (accessed 8.7.14).

Transport for London, 2007. Data Management Principles.

Turner, A.M., Petrochilos, D., Nelson, D.E., Allen, E., Liddy, E.D., 2009. Access and use of the Internet for health information seeking: a survey of local public health professionals in the northwest. J. Public Health Manag. Pract. 15, 67–69.

United Nations Office for the Coordination of Humanitarian Affairs, 2002. Best Practices in Humanitarian Information Management and Exchange, in: Symposium on Best Practices in Humanitarian Information Exchange. Geneva, Switzerland.

United States Animal Health Association, 2008. Foreign Animal Diseases, 7th ed. Boca Publications Group, Inc., Boca Raton, FL.

Vaziri, R., Mohsenzadeh, M., 2012. A Questionnaire-Based Data Quality Methodology. Int. J. Database Manag. Syst. 4, 55–67.

Waldner, C.L., Campbell, J.R., 2006. Disease outbreak investigation in food animal practice. Vet. Clin. North Am. Food Anim. Pract. 22, 75–101.

Wiseman-Orr, M.L., Scott, E.M., Reid, J., Nolan, A.M., 2006. Validation of a structured questionnaire as an instrument to measure chronic pain in dogs on the basis of effects on health-related quality of life. Am. J. Vet. Res. 67, 1826–1836.

Wobeser, G.A., 2007. Disease Investigation, in: Disease in Wild Animals: Investigation and Management. Springer, pp. 34–182.

World Health Organization (WHO), 2014. Disease outbreaks [WWW Document]. Heal. Top. URL http://www.who.int/topics/disease_outbreaks/en/ (accessed 7.4.14).

World Health Organization (WHO), 2008. Foodborne Disease Outbreaks: Guidelines for Investigation and Control. Geneva, Switzerland.

World Health Organization (WHO), 1997. Protocol for the Evaluation of Epidemiological Survey Systems (WHO/EMC/DIS/97.2), World Health Organization Emerging and other Communicable Diseases, Surveillance and Control. Geneva, Switzerland.

World Organisation for Animal Health (OIE), 2014. Guidelines for Animal Disease Control [WWW Document]. URL http://www.oie.int/fileadmin/Home/eng/Our_scientific_expertise/docs/pdf/A_Guidelines_for_Animal_Disease_Control_final.pdf (accessed 5.8.14).

Yasnoff, W.A., O'Carroll, P.W., Koo, D., Linkins, R.W., Kilbourne, E.M., 2000. Public Health Informatics; Improving and Transforming Public Health in the Information Age. J. Public Heal. Manag. Pract. 6, 67–75.