Building the road to a regional zoonoses strategy:
a survey of zoonoses programs in the Americas

THESIS

Presented in Partial Fulfillment of the Requirements for the Degree Master of Public Health in the Graduate School of The Ohio State University

By

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The Ohio State University

2016

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Abstract

Introduction and Purpose: In recent years, global public health security has been threatened by a number of emerging zoonotic diseases including H5N1 and H1N1 influenza, SARS/MERS, and Ebola. Additionally, endemic zoonoses, such as rabies, burden countries year after year, placing demands on limited finances and personnel. Due to this resource limitation, prioritization exercises are important to focusing zoonoses control and eradication efforts in developing countries, such as those in Latin American and the Caribbean. To learn more about the prioritization processes of Latin American and Caribbean countries (LACs), a survey was conducted which collected information on priority emerging and endemic zoonoses, countries’ prioritization criteria and methodologies, and suggestions to strengthen countries’ capacities and the regional approach to zoonoses control.

Methods: The Pan American Health Organization (PAHO) sent the online questionnaire to the zoonoses program managers of the Ministries of Health (MOH) and Ministries of Agriculture (MAg) of 33 LACs from January to April of 2015. The questionnaire comprised 36 single, multiple choice and open-ended questions to inform the objectives of the survey. A descriptive exploratory analysis was completed in R (i386 3.1.2).
**Findings:** Fifty-four ministries (26 MOH, 25 MAg, and 3 combined responses) in 31 LAC countries responded to the survey. Within these 31 countries, 22 (85%) had specialized zoonoses units in the MOHs, 5 (20%) in the MAgs, and 2 (67%) had a specialized zoonoses unit in a combined entity.

Thirty-two ministries responded that they conduct formal prioritization exercises for **endemic zoonoses**, most of them annually (69%). The three priority endemic zoonoses for the MOHs were leptospirosis, rabies, and brucellosis while the three priorities for the MAgs were brucellosis, rabies, and tuberculosis. Diagnosis for rabies and leptospirosis were cited as the capacities most in need of development. The most wanting cross-cutting capacity was coordination between stakeholders.

Twenty-eight ministries performed formal prioritization exercises for **emerging zoonoses**. The three priority emerging zoonoses for the MOHs were Ebola, avian influenza, and Chikungunya while the three priorities for the MAgs were avian influenza, bovine spongiform encephalopathy (BSE) and West Nile virus. Surveillance for avian influenza and Ebola, and diagnosis for BSE were cited as the capacities most wanting.

**Implications:** The survey is the first comprehensive effort to date to inform the status of zoonoses programs in LAC, and provides the evidence to build a regional strategy and identify capacity needs. A number of improvements appear evident: i) standardization of
prioritization approaches, surveillance definitions and evaluation processes to support comparisons, ii) greater communication and coordination between countries, and iii) a platform to inform zoonoses occurrence in the region and the status of the region’s capacities.
Acknowledgments

We would like to express our appreciation for the participating Ministries of Agriculture and Ministries of Health as well as the PAHO zoonoses focal points in all participating countries. Finally, we would like to acknowledge the David L. Boren Fellowship, sponsored by the National Security Education Program, for their support of the lead author during her research.
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Fields of Study

Major Field: Public Health
Specialization: Veterinary Public Health
Table of Contents

Abstract ................................................................................................................................. ii

Acknowledgments ................................................................................................................... v

Vita ........................................................................................................................................ vi

List of Tables ........................................................................................................................... viii

List of Figures .......................................................................................................................... ix

Chapter 1: Introduction and Literature Review ..................................................................... 1

Chapter 2: Survey Generation and Analysis ......................................................................... 22

  2.1 Materials and Methods ................................................................................................. 22

  2.2 Results ............................................................................................................................ 25

  2.3 Discussion ....................................................................................................................... 36

References ............................................................................................................................... 47

Appendix A: Figures and Tables ............................................................................................ 52

Appendix B: Zoonoses Questionnaire .................................................................................... 66
List of Tables

Table 1. List of endemic zoonotic diseases and their frequency in regards to their prioritization by the Ministries of Health and Agriculture and combined entities in Latin America and Caribbean countries.......................................................... 53

Table 2. List of emerging zoonotic diseases and their frequency in regards to their prioritization by the Ministries of Health and Agriculture and combined entities in Latin American and Caribbean countries.......................................................... 59
List of Figures

Figure 1. The top five endemic zoonotic disease priorities across Latin American and Caribbean countries as indicated by 54 Ministries of Health and Agriculture, and combined entities in the region. ................................................................. 54

Figure 2. Comparison between the Ministries of Health and Agriculture in regards to the top five endemic zoonotic disease priorities in Latin American and Caribbean countries (percentage represents total respondents received from both ministries (n=51)). .......... 55

Figure 3. Comparison between the Ministries of Health and Agriculture (n=51) in Latin American and Caribbean countries in regards to the top criteria used to prioritize endemic zoonotic diseases................................................................. 56

Figure 4. Top capacities that require improvement for each of the top five endemic priority zoonoses based on the opinions of the Ministries of Health and Agriculture and combined entities in Latin American and Caribbean countries ........................................ 57

Figure 5. A radar chart comparison of the top five priority endemic zoonoses for Latin American and Caribbean countries in regards to formal collaborations, knowledge of surveillance sensitivity, diagnosis and surveillance needs........................................... 58
Figure 6. The top five emerging zoonotic disease priorities across Latin American and Caribbean countries as indicated by 54 Ministries of Health and Agriculture, and combined entities in the region................................................................. 60

Figure 7. Comparison between the Ministries of Health and Agriculture (n=51) in Latin American and Caribbean countries in regards to the top impacts considered when prioritizing emerging zoonoses........................................................................ 61

Figure 8. Top capacities that require improvement for each of the top five emerging priority zoonoses based on the opinions of the Ministries of Health and Agriculture and combined entities in Latin American and Caribbean countries................................. 62

Figure 9. Probability of introduction for the top emerging zoonotic diseases in Latin American and Caribbean countries according to the Ministries of Health, Agriculture, and combined entities ......................................................................................................... 63

Figure 10. A radar chart comparison of the top five priority emerging zoonoses of Latin American and Caribbean countries in regards to the percentage completing simulation exercises, with a contingency plan, with a formal collaboration, the probability of introduction, and surveillance needs................................................................. 64

Figure 11. A radar chart comparison of prioritization, planning, and collaboration activities completed by the Ministries of Health and Agriculture in Latin American and Caribbean countries in regards to endemic and emerging zoonoses ....................... 65
Emerging Zoonotic Diseases

In recent years, global public health security has been threatened by zoonotic disease emergence as exemplified by outbreaks of H5N1 and H1N1 influenza, SARS/MERS, and most recently Ebola. While the impact of the emergence and re-emergence of these diseases is generally well-publicized, the sheer number of emerging zoonotic diseases has been cause for analysis. Multiple articles have been published estimating the proportion of emerging human pathogens that are zoonotic. For example, as early as 2001, a risk assessment evaluating which human pathogens were likely to emerge concluded that 75% would be zoonotic (Taylor et al 2001). Similarly, Jones et al determined that 60% of emerging infectious diseases (EIDs) events in humans have an animal origin (Jones et al 2008). Recent estimates suggest that 70% of the emerging transmissible diseases among humans are zoonotic (Wang et al 2014).

Although the majority of articles documenting the emergence of zoonoses are recently published, the emergence of zoonoses and its potentially devastating impacts on human society is not new. Historical documents tell of the past emergence of zoonoses such as anthrax and bubonic plague. The latter, in particular, is well known for its high mortality
rate and as a cause of the Dark Ages. The concern today is the high recorded proportion of emerging diseases that are zoonotic or have an animal origin. Over 300 EIDs have emerged since 1940 and their incidence has increased significantly over time (Jones et al 2008). The rising number of emerging zoonoses may be driven by “modernization of farming practices, particularly in the developing world, habitat destruction, human encroachment and climate change,” (Wang et al 2014) with many of these practices intensifying to support a growing population (Cutler et al 2010).

Latin American and Caribbean countries (LAC) are not impervious to the effect of emerging zoonoses. Seventy percent of the public health emergencies reported to the World Health Organization (WHO) from 2007 to 2008 in the Americas were classified as zoonoses or communicable diseases common to humans and animals (Schneider et al 2011). Additionally, Schneider et al cite examples of rabies re-emerging within Costa Rica and Argentina, which had previously controlled the disease (2011). While much of the recent emphasis has been on emerging zoonoses, endemic zoonoses are not to be forgotten. Within the Americas, there is a large power parity between rich and poor with 8.6% of the population living in extreme poverty (on less than 1 USD per day) but an overall average Gross National Income of $8,304 (PAHO 2009). While some nations may be capable of controlling or eradicating endemic diseases, they are still susceptible to reintroduction from neighboring countries and trading partners who could still have such diseases circulating. Zoonoses do not respect countries borders and should be
viewed not only as a threat to national security but also as a threat to regional and international security.

**Endemic Zoonotic Diseases**

Emerging zoonoses are often a greater concern than endemic diseases to donors (i.e. non-governmental organizations, philanthropies, etc) and decision-makers. However, the impact of endemic zoonoses on poor farmers is magnitudes increased compared to emerging zoonoses (Grace et al 2012). In particular, many zoonoses are part of the group of neglected tropical diseases (NTDs) that “affect mainly poor and marginalized populations in low-resource settings” (WHO 2015), with their presence reflecting clear inequalities in health. In fact, there is a strong association between zoonoses, poverty, hunger, and livestock-keeping (Grace et al 2012). Endemic zoonoses more frequently affect poor populations, causing millions of deaths each year along with around a billion illnesses (Grace et al 2012).

Within the Americas, a stunning 29% of the population live below the poverty line (around 2 USD per day) (PAHO 2013), leaving them more susceptible to these endemic diseases. This equates to an estimated 200 million people (PAHO 2013). Of these, an estimated 127 million people are living on less than two dollars per day (PAHO 2009). Due to the high number of individuals living in poverty in LACs, a focus on endemic zoonoses is imperative. Populations in poverty in LACs are most affected by zoonoses as they may not have access to quality health services, are exposed to the poor
environmental conditions, and are often engaged in animal production (PAHO 2013). It has been suggested that the burden of NTDs in LACs in particular, likely exceeds the burden from malaria, tuberculosis, and possibly HIV (Hotez et al 2008). The WHO estimates that the region of the Americas has 8.8% of worldwide burden of neglected infectious diseases and states that zoonoses occur in all countries within the region (PAHO 2013).

Despite the obvious importance of focusing on emerging and endemic diseases in LACs, there are no national or regional disease burden estimates in LACs for many zoonoses (Hotez 2008). Grace et al also notes the current lack of endemic zoonoses measurements and discusses the need to assess the societal burden of endemic zoonotic diseases to better plan and implement disease control (2012). As Hotez et al mention in their review of NTDs in Central America and Panama, the first step in relieving the health and economic burden of NTDs is collecting information regarding the true prevalence and incidence of NTDs (2014). Without this information, it is difficult to prepare appropriate plans for disease control and prevention.

**International Policy on Zoonotic Diseases**

The International Health Regulations (IHR), a binding instrument of international law for all WHO member states, require countries to strengthen their capacities, such as surveillance, preparedness and response, to address any health risk regardless of source (WHO 2011). This includes zoonoses. On an annual basis, countries complete a
questionnaire that monitors progress in the implementation of their core capacities (WHO 2015). Capacities to address zoonoses are captured under “Core Capability 10” which consists of the component “Capacity to detect and respond to zoonotic events of national or international concern”. Questions specifically register the presence/absence of a list of priority zoonotic diseases, a national plan/strategy to deal with zoonoses, and zoonotic disease surveillance. The questionnaire also asked numerous questions regarding the collaboration between the animal and human health components including the presence of a designated animal health focal point who coordinates with the Ministry of Health. The questionnaire specifically asks whether there is a “functional mechanism to ensure joint collaboration between animal and human surveillance units and laboratories” (WHO 2015). Through this questionnaire, an initial overview of zoonoses capacities in each country is possible.

Results from the 2013 survey showed that 97% of the countries within the Americas region reported coordination within the government for the detection and response to zoonotic events (WHO 2013). Coordination in this sense can be defined as organization within the government to adequately detect and respond to zoonotic events. Also 94% responded that there is a list of priority zoonoses, and 94% indicated that a mechanism to respond to zoonoses has been established by both animal and human sector diseases (WHO 2013). Regarding the exchange of zoonotic diseases information between the animal and human sectors, 83% responded that the system was both timely and systematic (WHO 2013). In addition to using the data to look at the demographics of the
region, each country is scored based on their responses (range 0-100). In the yearly reports on implementation, the 2013 average for “Core Capability 10” was 85 with a range of 33 to 100 (WHO 2013). In 2014, the average was not given but the data ranged from 67 to 100 (WHO 2015). In both years’ reports, not all countries had responded by the time the report was published. Given the wide scope of this annual questionnaire, covering multiple core capacities and expanding well beyond zoonoses, the questionnaire is limited in regards to specific information on policies. In other words, the questionnaire falls short of capturing details of the prioritization exercises conducted and priority zoonoses per country, among other questions of interest that would inform a comprehensive landscape review of zoonoses capacities in the region.

Regionally, in the Strategic Plan 2014-2019 of the Pan-American Health Organization (PAHO), the first category focuses on communicable diseases and involves reducing the burden of neglect, tropical, and zoonotic diseases (PAHO 2013). In addition, PAHO’s fifth category, ‘Preparedness, Surveillance, and Response,’ would also include zoonoses within the aim of ‘Reducing mortality, morbidity, and societal disruption resulting from epidemics, disasters, conflicts, and environmental and food-related emergencies’ (PAHO 2013). In general, PAHO/WHO focuses primarily on interventions to prevent disease occurrence in humans, but within this document they acknowledge the need for continued multi-professional, integrated surveillance and control activities, between animal and human sectors (PAHO 2013).
‘One Health’ and its Importance to Zoonotic Disease Policy

To meet the requirements of the IHR, which includes identifying and controlling zoonoses as well as dealing with numerous other public health issues, different sectors are required to work together (WHO 2011). Specifically, within “Capability 10,” the section focusing on zoonotic diseases in the IHR, a number of questions address the collaboration between animal and human surveillance units and laboratories. This collaboration is generally called ‘One Health’ (OH) and specifically calls for interdisciplinary work between animal, human, and ecosystem professionals for the improvement of the health of all. On the international level, there is a one health collaboration known as ‘The Tripartite’ which is made up of the Food and Agriculture Organization (FAO), the World Organization for Animal Health (OIE), and the World Health Organization (WHO) (FAO-OIE-WHO 2010, Mumford 2013). The WHO in particular, defines ‘One Health’ as the human - animal - ecosystem interface (HAEI) which ‘encompasses all direct and indirect human exposure to animals and animal products and to the various environments and ecosystems we all share’ (WHO, Accessed January 2016).

One Health Surveillance

Zoonoses, by definition, originate within animal populations so there is always an opportunity to detect these pathogens in such populations before their transmission to humans (Halliday et al 2012) and this opportunity should not be missed. In the case of emerging transboundary zoonoses, human and veterinary medicine must cooperate to
generate appropriate surveillance, control and response efforts (Wang et al 2014). Yet, during a systematic review of surveillance systems for emerging zoonoses in 2010, Vrbova et al determined that very few of these documented emerging surveillance systems actually concurrently examined both human and animal data (36 of 194; 19%). Additionally, only 30% of the identified systems evaluated for unknown pathogens using syndromic surveillance (22% for detection of both known and unknown pathogens and 8% for only unknown) (Vrbova et al 2010). A more recent literature review identified and described 20 zoonotic disease surveillance or monitoring systems which combined animal and human data and noted that the majority of data was collected for a different purpose (Wendt et al 2014).

The necessity of surveillance for emerging pathogens within animal populations does not require an argument, but it may require adaptation to meet the needs of each sector. For example, the sharing of agricultural surveillance data with those analyzing human data must be appropriately coordinated to be useful. Vrbova et al noted that animal health surveillance is not likely to be useful for public health practice unless information on potential human exposures, and its extent, is added to animal health data to give public health the information it needs to take action (2013). The adaptations necessary to improve utility of animal health data for public health analysis should likely be considered prior to data collection.
In reality, developing countries likely have other challenges and may not focus on adapting surveillance for optimal intersectoral utility. For example, populations within developing countries may be faced with choosing best health practices and safe-guarding their livelihood. Specifically, the study by Halliday et al found that there is a decreased reporting of emerging diseases in developing countries (2012). The study suggests that reporting cases in these developing countries is likely met by a limited national capacity to respond to the pathogen and may result in economic penalization including trade embargos, a decrease in tourism, and a loss of international reputation (Halliday et al 2012). These repercussions are certainly deterrents to reporting disease cases for those who rely on animal and animal product sales for their livelihood. In actuality, this challenge, involving the decreased reporting of emerging diseases, returns to the issue of limited funding and resources, which are the root issues for public health practice in developing countries and populations.

**Prioritization of Zoonotic Diseases**

As capital is finite, a means of prioritizing the use of resources, personnel, and funds to appropriately confront both endemic and potentially emerging zoonoses is essential. Yet, the prioritization of diseases can be complicated and may require intensive time and resources depending on the methodology used. Furthermore, the challenge in prioritizing diseases lies in the broad range of impacts that the diseases can have and how these perceived impacts vary in scale and importance in the view of different policy-makers.
Multiple methodologies have been developed or adapted from decision science to meet these variable goals and objectives.

Recently numerous articles have been published describing the methods for prioritization of zoonotic diseases. These can be divided into quantitative, semi-quantitative, and qualitative based on the means of selecting and weighing criteria, scoring of diseases, and the type of data (Rist et al 2014, Bordier et al 2015). Because more than one characteristic can be used to describe the methodologies, the prioritization methods may fall in one category or the other depending on the nature of the criteria data, questions, and their assessment. For example, the Delphi Method has been categorized as a qualitative method of prioritization (Rist et al 2014) but studies that have used this technique may self-identify as semi-quantitative (Krause et al 2008). Similarly, the Multi-Criteria Decision Analysis (MCDA), a category which encompasses numerous methods of prioritization, is normally described as semi-quantitative or quantitative.

**Qualitative methods** generally rely on subject experts or a consensus of group members. One example is a group of subject matter experts without a formalized methodology or the Delphi Method. A qualitative panel of experts is generally the simplest to use as it relies on experience and judgement of the participants. This method also is very subjective and is neither repeatable nor transparent (Bordier et al 2015). Particularly, a lack of transparency can be an issue when there is an unclear separation with decision-makers’ subjective opinions (Brookes et al 2015) due to the fact that they may place more
or less weight on a specific area solely because they are partial to a disease. Cognitive biases may also be involved when determining priority diseases using qualitative methodology (Brookes et al 2015). Yet, due to a lack of training, time, experience, or data, qualitative prioritization may be the most appropriate in some situations. One particular challenge of this method is finding a group of experts who are broadly experienced. The medical profession, and increasingly the veterinary profession, are often specialized and far-removed from certain pathogens and diseases. Due to this fragmentation, it may be difficult to find experts who are not subjectively biased towards their professional focus and who also have sufficient disease/pathogen related knowledge (Krause et al 2008).

Alternatively, the Delphi Method, as applied by Krause et al, utilized a panel of experts to score pathogens (-1, 0, 1) using 12 criteria (i.e. incidence, severity, mortality, etc.) (2008). Generally, in Delphi exercises, this expert panel continues through multiple rounds of individual scoring and discussion until consensus is reached (Hsu and Sanford 2007). The pathogen scores reached by the panel in Krause et al were then multiplied by the criteria weight (or relative importance), which the authors determined independently and prior to the scoring. Weights varied from 10.7 given to incidence of disease to 3.4 given to evidence of pathogenesis. The pathogens were then ranked based on weighted and unweighted scores. Some pathogens’ ranks did vary based on the application of weights. The authors note that the addition of weights focuses the exercise towards the objective of the prioritization exercise and can likely be adapted for separate groups.
However, in order to maintain objectivity, they recommend determining the value of these weights prior to and independently of scoring the pathogens. In a response to the study, Del Rio et al suggested the use of MCDA methods instead of the Delphi Method because due to the lack of granularity of the scale as well as the need to include uncertainty (2011).

An additional limitation of Krause’s study is the application of criteria which are normally used to separately prioritize emerging or endemic zoonoses. Generally, emerging and endemic diseases are not prioritized using the same criteria. The criteria needed to prioritize emerging and endemic diseases are very different thus, to consider both in the same prioritization exercise is a challenge. In their technical report regarding prioritization of emerging diseases, the European Centre for Disease Prevention and Control (ECDC) suggests that any selected criteria reflect the aims of the risk-ranking exercise (ECDC 2015) and thus should be specific to the zoonoses situation, whether it is emerging or endemic. Because of this, many prioritization studies separate emerging and endemic zoonoses to avoid the conflicting criteria.

Finally, cost can be a barrier to the Delphi Method. The EDCD cites the method as being resource-intensive due to the cost of multiple experts, time-consuming, and potentially logistically challenging if meeting face-to-face (ECDC 2015). When the WHO published their key steps for prioritization of communicable disease, using the Delphi Method, in 2006, they recommended budgeting for these costs (WHO 2006). Regardless, the cost
may make the Delphi Method inhibitory for developing countries, especially as other prioritization methods are available.

**Semi-Quantitative methods** rely on individual preference but pathogens are ranked in relation to one another (Rist et al 2014) based on one or more criteria. For example, rabies may be ranked over brucellosis based on the criteria of case fatality rate. The main advantage of semi-quantitative analysis may be the ability to systematically prioritize diseases despite missing data (Cito et al 2015). While semi-quantitative methods are meant to increase transparency and repeatability, as compared to qualitative, they often do not fully achieve this goal. For example, when the criteria are combined there is often a need to weight the criteria which requires subject experts and introduces subjectivity into the analysis (Bordier et al 2015). Additionally, comparative relationships between the different criteria classes may be assumed but are not supported by data (Havelaar et al 2010). As all criteria do not have the same level of importance, a weight must be applied and there may not be an easy means of combining the different criteria.

In their analysis of foodborne zoonoses, Cardoen et al used a semi-quantitative method to avoid the issues of subjectivity and unreliability associated with qualitative methods as well as a lack of complete data for all 51 pathogens (2009). In this analysis, experts scored the list of zoonoses based on five author-selected criteria using a numeric scale. Separately, seven food chain risk managers applied weights to the five criteria. Weighting the criteria gives preference or added importance to some criteria over others. This
addition of weights is a strategy to allow policy makers, or in this case risk managers, to express a preference for one or more criteria. Finally, the mean score of each zoonosis was then found, with and without weighting the criteria. While scoring by experts is generally a qualitative method, the study used a large number of experts who were directly supplied with epidemiological ‘help’ information based on the pathogens and the five criteria selected. These experts were required to give their responses in a standardized, evidence-based format using the help information which was supplied (Cardoen et al 2009).

McKenzie et al used the OIE Import Risk Analysis framework semi-quantitative method consisting of three steps: hazard identification, risk assessment, and ranking the pathogens to prioritize wildlife pathogens for surveillance (2007). In the final stage, a group of experts used criteria or ‘factors’ to rank the pathogens (McKenzie et al 2007). These criteria included the probability of entry to New Zealand (NZ), and then asked the experts to consider the likelihood and consequences of spread (two separate criteria) on free-living wildlife, captive wildlife, livestock, humans, and companion animals (2007). A semi-quantitative method was used because epidemiological information was lacking for many of the pathogens, which made it difficult to calculate probabilities for all risk pathways. To improve transparency, the authors used the OIE standardized risk assessment framework, which is readily available, and also publicly released the scoring system and criteria. No weighting of criteria was included in this initial assessment but the authors note that this addition may be a future refinement (McKenzie et al 2007).
Humblet et al also used a semi-quantitative MCDA method to prioritize diseases of food-producing animals (2012). Five aspects of a pathogen were considered: epidemiology, prevention/control, economy/trade, zoonotic characteristics, and effects on society. Each aspect was broken down into pertinent criteria \( n=57 \) (i.e., illness rate, case fatality rate, agent specificity, etc.) which were weighted by a multi-disciplinary panel of experts. These weights were then applied to the one hundred animal diseases and zoonoses. The unique part of the study was the multi-disciplinarity of the expert group which included animal and human epidemiologists, chief veterinary officers, experts in agricultural economics, animal welfare, biodiversity, and social aspects of diseases (Humblet et al 2012).

Del Rio et al described how the Veterinary Risk Group in the UK’s Department of Environment, Food, and Rural Affairs (DEFRA) analyzes reports of threats and vulnerabilities (2013). Using MCDA, the interactive Excel tool (e-THiR) was developed based off the existing national Emerging Threat Highlight Report (ETHiR), which analyzes threats and vulnerabilities to animal health. The criteria used include three modules: i) impacts on areas which would require government intervention (public health, animal welfare, society at large, international trade), ii) capabilities (evidence assessment, resources, and counter-measures), and finally, iii) expert assessment of public perception (personal concern, public concern, and discontent). The method was developed to deal with a variety of threats and vulnerabilities and thus, purposely fails to
consider the probability of occurrence or its timeframe. The criteria included focused on flexibility to allow prioritization of a variety of threats but the tool could incorporate extensions in the future and be completed in a timely manner (Del Rio et al 2013). In fact, Cito et al suggests that the DEFRA approach, specifically due to division of the three distinct criteria, would be appropriate for companion animal prioritization assessments after adaptation (2015).

Despite considering using the e-THiR method developed by DEFRA, Cito et al elected to use the semi-quantitative method developed by the World Organization for Animal Health (OIE) to prioritize companion animal zoonoses (Cito et al 2015, OIE 2010). The method was selected due to the lack of sufficient quantitative data for their focus companion animal zoonoses and also because OIE had recently conducted capacity training on the method (Cito et al 2015). In particular, the OIE method limits the need for quantitative data because when combining countries or regions, the same data may not be available throughout, so it is a valuable method to use when quantitative data is not available (OIE 2010). After generating a list of applicable companion animal zoonoses, the list was further divided into viruses, bacteria, and parasitic infections and analyzed by the experts in that field to obtain a list of priority diseases. Because the study was unable to achieve consensus between expert groups due to time and resources, a challenge of semi-quantitative methods, the three lists of pathogens (virus, bacteria, and parasites) could not be combined (Cito et al 2015). This disconnect between the lists suggests that future prioritization efforts should not divide the diseases based on the etiologic agent,
albeit the experts may be too specialized to participate. Additional challenges recognized by the authors involved the combination of endemic, emerging, and exotic diseases, with differing impacts. The authors also suggest the need for variable weight parameters based on differing political and national concerns (Cito et al 2015).

Quantitative methods are based on scales which are designed to reflect objective values (Rist et al 2014). One method is to assign a value to a previously decided criterion depending on importance. These criteria can then be combined, objectively, based on epidemiological data regarding the disease. Because the diseases are generally anonymous throughout the analysis, there is a decreased risk of introducing biases related to the subject experts. Additionally, the diseases can be compared and ranked against a numerical scale. The benefits of quantitative analysis include objectivity and transparency. Additionally, an analysis can be conducted after the prioritization to determine what additional epidemiological data is required (Cito et al 2015). Therefore, quantitative methods generally require more data and data of greater detail.

Havelaar et al used an MCDA quantitative method to prioritize emerging zoonoses in the Netherlands (2010). Seven criteria were used to generate a risk score for each zoonotic pathogen. The seven criteria were based on a flow chart which began with the probability of introduction to the country (the Netherlands) and ended with public health impact. These criteria were further divided into levels based on epidemiological data from published literature, as available. While the prioritization was a quantitative exercise,
when epidemiological data were unavailable, expert opinion had to be used to assign the levels to the pathogen. Pathogens were assigned to more than one level, if necessary, to express uncertainty. Scenarios were then presented to experts or professional students to determine weights for the different criteria. Using these weights, a risk score was calculated for each pathogen and normalized. One of the specific benefits of using this methodology was increased discriminative power by using the full scale to prioritize the diseases (Havelaar et al 2010). Humblet et al did critique this methodology because it failed to include risk as perceived by the public (2012).

Within the Americas region, Ng and Sargeant published two prioritizations exercises conducted in the United States and Canada involving public participants and health professionals (2012 and 2013, respectively). These two prioritization exercises used 21 criteria, scored by conjoint analysis (CA) by the public or the health professionals, to prioritize 62 diseases. Both groups considered case fatality in humans and incidence in the last five years in humans to be the most influential criteria to prioritize zoonoses. The researchers then used the CA-scores to prioritize the 62 diseases, attempting to eliminate biases associated with names (Ng and Sargeant 2012 and 2013). While the use of criteria analysis should help avoid bias, epidemiological data to support the criteria is often lacking. In recent years, many developed countries have moved towards quantitative prioritization methods, but these countries also have improved access to epidemiological data which may be lacking in developing countries (Rist et al 2014).
To combat this lack of data, Rist et al created a quantitative decision tree model specifically for those “working in areas where quantitative data on zoonoses are scarce and ties between human and animal health may be underutilized” (2014). The ‘One Health Zoonotic Disease Prioritization’ (OHZDP) tool uses qualitative and semi-quantitative methods to select and rank five criteria, but ultimately, the decision tree, a quantitative method, is used to prioritize the diseases (Rist et al 2014). In this method, a group of stakeholders develop their criteria and a question for each criterion. The questions can only lead to answers which are binomial (yes/no) or multinomial answers that are ordinal. The same stakeholders rank the criteria individually and then their rankings are combined to sequentially rank the criteria. The zoonotic diseases are finally ranked by the weighted criteria. The tool is an attempt to increase the objectivity of the prioritization process and while also balancing the challenges of limited surveillance data. An additional benefit is the rapid turnaround time (Rist et al 2014).

**Prioritization in Latin America**

Within LACs, very few articles have been published regarding the current prioritization exercises. One published prioritization exercise came from Colombia and used the prioritization method described in Krause et al 2008 (Cediel et al 2013). The panel of experts chose preventability as their top weighted criteria and the top prioritized disease were determined to be influenza (H1N1), salmonellosis, *E. coli* infection, and leptospirosis.
Beyond the exercise completed in Colombia, there is a distinct lack of published prioritization exercises from LACs. The reasons for this lack of published prioritization exercises may include that the countries are not completing systematic prioritization exercises or the countries are not publishing the results of these exercises potentially due to a lack of time/personnel, resources, or national approval to do so. Yet, as developing countries often have less access to resources, the need to prioritize is, arguably, of even greater importance.

To fill this gap, the Zoonoses Unit, stationed at the Pan-American Center for Foot-and-Mouth Disease, a center of the Pan American Health Organization (PAHO), conducted a survey in LACs. For that purpose, this author assisted in designing, developing, and deploying the survey, and also analyzed and interpreted the data collected. Such information will be very valuable as it collected information on priority emerging and endemic zoonoses, countries’ prioritization criteria and methodologies, as well as suggestions to strengthen countries capacities and regional approaches to zoonoses control, all to better prioritize the resources and technical cooperation of PAHO.

The objectives of this study included: 1.) determining the zoonotic disease priorities in the region, 2.) better understanding of the national zoonotic disease programs in LACs and their disease prioritization methodologies, and finally, 3.) determining the necessities and objectives of the countries. The goal is to take the first step in identifying how American countries can strengthen their capability to manage zoonoses risks, by first
capturing information regarding their national zoonoses programs, priorities, and capacities. To the best of our knowledge, this is the first time that such an exhaustive and regionally wide exercise of data gathering on zoonoses related indicators has been conducted in the region.
Chapter 2: Survey Generation and Analysis

2.1 Materials and Methods:

Survey Design:

The countries were surveyed by a fillable PDF survey, comprised of 36 single, multiple choice and open-ended questions translated into English, Spanish, and Portuguese, using Adobe Forms Central® (See Appendix 2). The questionnaire included a cover sheet explaining the objectives of the survey and clarifying that the identity of individual countries would be protected and that the data would be presented in an aggregated form for the region. The cover sheet also explained that the survey could either be submitted electronically by selecting a ‘submit’ button or could be downloaded and completed as a PDF and emailed. The emails of the PANAFTOSA contacts were provided for any participant questions or for submitting completed PDF surveys. Participants were also informed that the survey would save their responses if they chose to complete it in multiple sittings.

A pool of question was first generated by the author and a PAHO Zoonoses Expert. The questions were then ordered and this survey draft was piloted by five separate PAHO/WHO experts. The finalized survey first collected demographic data of the
respondents and secondly, information regarding program resources. Third, the survey collected data regarding priority zoonoses starting with endemic zoonoses and followed by emerging. Endemic and emerging zoonoses were considered separately due to the variable criteria which can be used to prioritize each. Next, a general section asked participants about current collaborations and future ideas for improving zoonoses control regionally. The survey concluded with a glossary which included terms such as ‘emerging,’ ‘endemic,’ and ‘prioritize’ (See Appendix B).

Survey Deployment:
The survey target population included all zoonosis program managers or lead personnel within the Ministry of Health and/or Ministry of Agriculture of 33 Latin American and Caribbean countries.

An email with the PDF questionnaire (Appendix B) and the link to the online questionnaire was distributed on January 8, 2015 to the network of PAHO zoonoses focal points located in country offices across the region. These PAHO focal points then distributed the survey to the corresponding ministries/departments (health and/or agriculture) in their jurisdictions. The questionnaire remained open until February 13, 2015, approximately 5 weeks later. A conference call was held January 26 (English) and 27 (Spanish) with the PAHO offices to answer any questions. All PAHO zoonoses focal points who did not participate in the meeting were individually contacted via telephone or email. Additionally, a final phone and email reminder was sent on February 11th to all
PAHO focal points. After the official closure of the survey on February 11th, all PAHO focal points of non-responding countries or countries with only one ministry responding (n= 30) were followed up by email or telephone to discuss reminding the ministries to complete the survey. Ministries were allowed to turn in the survey after the official closure date and the last survey was received on April 1, 2015.

Data Management:
Responses from the countries were translated into a single language for analysis. Each response was categorized by region with Central America (Mexico south to Panama), Caribbean (Caribbean islands as well as Guyana and Suriname), and South America. Additionally, the population and gross domestic product (GDP) of each country were added to the dataset (World Bank, http://data.worldbank.org/indicator). For open-ended free text questions, we coded the responses into categories. Priority diseases were re-codded into broad disease names for analysis; for example, rabies related responses including bovine, canine, or sylvatic rabies were coded as ‘Rabies’. Additionally, if the ministry chose a vector-borne non-zoonotic disease among their prioritized diseases, they were included in the analysis. Similarly, any prioritized diseases which were neither zoonotic nor vectorborne, were categorized as ‘other’.

Statistical Analysis:
The data was analyzed using R open access software (R Core Team, Vienna, Austria) and JMP 11.0.0 (SAS Institute Inc., Cary, NC). Simple data exploratory analyses were
conducted including: frequency tables for each of the variables, comparisons between responses from the ministries of health and agriculture, correlations between the GDP and zoonoses spending, as well as regionally aggregated results. When comparing the MOH and MAg in regards to those with specialized zoonoses units, completing prioritization exercises, contingency planning, completing simulation exercises, and having formal Memorandums of Understanding (MOU), we used Pearson’s Chi² with a cut-off value of 0.05. For any value with a frequency less than 5, a Fisher’s Exact Test was used instead.

2.2 Results

General Description:
Fifty-four ministries (26 MOH, 25 MAg, and 3 combined responses) in 31 (93.9%) of 33 target LACs responded to the survey. Responses from national zoonoses groups formed from personnel from both ministries were labelled as ‘combined’ for the purposes of this analysis.

Twenty-two (85%) MOH, 5 (20%) MAg, and 2 (67%) combined entities indicated they had specialized zoonoses units. A comparison of proportions indicated that the MOH had a significantly higher proportion of specialized zoonotic units than the MAg (Fisher’s Exact p<0.0001). The budget available for zoonotic diseases programs at the national level ranged from 69,000 to 6,683,000 USD with a median of 447,000 USD. The median budget across the respondents was 500,500 USD (41,000 to 6,683,000 USD) for health
ministries and 302,000 USD (Range 6,800 to 4,457,000 USD) for agricultural ministries (p=0.1971 using Kruskal-Wallis Rank Sums). Budget was highly correlated with country GDP (MOH r=.69, p=0.009; MAg r=.54, p= 0.048). Across all 54 respondents, national level zoonosis expenditure was 0.0034% of the national GDP, with a mean of 0.0042% for the health ministries and 0.0024% for agricultural ministries (Range 0.000027 – 0.027%).

The median number of full-time senior management staff working on the national zoonoses programs was 1 (range 0-12), 4 for technical staff (range 0-150), and 1.5 for administrative/supporting staff (range 0-57).

**Endemic zoonoses**

Of the 54 ministries that responded to the survey, 32 (63%) perform prioritization exercises for endemic diseases; 17 (65%) by MOHs, 13 (52%) by MAgS, and 2 (66%) by combined entities (Figure 11). A comparison of proportions of MOHs and MAgS completing formal prioritization exercises for endemic zoonoses did not find a significant difference (p = 0.3316). When asked how often they prioritize, 22 (69%) prioritize annually, 2 (6%) prioritize ever 2-3 years, and 5 (16%) prioritize every 5-10 years. Additionally, 4 (13%) ministries responded that they prioritize after an outbreak or at undefined interval from the last prioritization.
When asked to list the three priority endemic zoonoses, 145 responses were received, identifying a total of 25 unique diseases (See Table 1). The disease category ‘rabies’ (including rabies (n=24), bovine rabies (n=5) and canine rabies (n=1)), was the most listed disease (n=30/145, 21% of responses); followed by ‘leptospirosis’ (leptospirosis (24), Leptospira icterohemorragiae (1)) in second (25/145, 19%); disease category ‘brucellosis’ (including brucellosis (14), bovine brucellosis (4), and caprine brucellosis (1)) was third (19/145, 13%); disease category ‘tuberculosis’ (including tuberculosis (7), and bovine tuberculosis (6)) was fourth (13/145, 9%); and fifth was ‘Salmonella’ (Salmonella (9), Salmonella enterica (1) and Salmonella Enteritidis (1) 9/145, 6%).

When comparing ministries, the most frequently reported endemic zoonoses disease categories by MOHs were leptospirosis (18/70 priorities listed by the MOH, 26%), rabies (15/70 MOH priorities, 21%), brucellosis and salmonellosis (each with 4/70 MOH priorities, 6%). For MAgs, the most frequently reported priority endemic zoonoses disease categories were brucellosis (15/66 MAg priorities, 23%), rabies (13/66 MAg priorities, 20%), and tuberculosis (10/66 MAg priorities, 15%).

For their endemic priority zoonoses, the Ministries of Health generated 70 responses with the majority listing all top three priorities (20/26 MOHs responding, 77%). However, not all MOHs listed all three zoonoses they would consider top priorities. Some MOHs only provided two priority endemic zoonoses (7.7%, 2/26), one priority endemic zoonosis (2/26, 7.7%), or did not respond with any priority zoonoses (2/26, 7.7%). Within the Ministries of Agriculture, 66 responses were submitted with the majority responding with
all three endemic zoonoses priorities (20/25 MAgs responding, 96%). But as with the
MOHs, not all MAgs provided all three zoonoses that they would consider top priorities.
Some MAgs only listed two priority endemic zoonoses (8%, 2/25), one priority endemic
zoonosis (2/25, 8%), or did not respond with any priority zoonoses (1/25, 4%). Two
countries listed two third priorities, so only the first was analyzed and the second was
disregarded.

On average, ministries used 4.72 different criteria (4 = median). The number of criteria
used by the ministries to prioritize ranged from 0-14. The criterion most frequently used
was human incidence (90 responses/145 endemic priorities selected, used for 62% of
priorities) followed by economic impact (69/145 endemic priorities, 48%), animal
prevalence (68/145 endemic priorities, 47%) and human severity (66/145 endemic
priorities, 46%). The top four utilized criteria by the MOH were human incidence, human
severity, human mortality, and human prevalence, and the top four criteria used by the
MAg were economic impact, animal prevalence, human incidence, and animal incidence
(Figure 3). Ministries also wrote in criteria such as diagnostic availability, feasibility of
control, available resources, unified criteria with the other ministry, effect on small
producers, and lethality in humans.

For those respondents using more than one criterion to prioritize endemic zoonoses, they
were asked to describe how their ministry combined the multiple criteria and were
allowed to provide one or more methods. Most ministries reported using expert opinion
to combine the prioritization criteria (19/32 ministries, 59%), while other ministries reported that they used multi-criteria decision analysis (MCDA) (8/32 ministries, 25%) or epidemiology values (5/32 ministries, 16%), and three reported using other techniques (3/32 ministries, 9%) including producer demands, an analysis of indicators, and meetings regarding control and prevention. The other ministries (22/54, 41%) do not conduct prioritization exercises.

Of fifty-four respondents, thirty-one ministries reported that they had a current formal agreement or Memorandum of Understanding (MOU) with other government ministries for the coordinated prediction, prevention, detection, and intervention of their priority zoonoses. For their first priority endemic zoonoses, 61% (31 MOUs/51 first priorities) had a formal MOU, 49% for the second priority endemic zoonoses (24/49 second priorities), and 54% for the third priority zoonoses. This means that roughly of all LAC priority endemic zoonoses have current formal MOUs for coordinated government action between one or more ministries.

Diagnosis and laboratory capabilities was cited by most ministries (See Figure 4) as the most important disease-specific capacity requiring improvement for rabies, leptospirosis, and brucellosis. Of those choosing the top five priorities, many responded that they evaluated the sensitivity of the surveillance system: for rabies (27/30 prioritizing rabies, 90%), for leptospirosis (11/25 prioritizing leptospirosis, 44%), for brucellosis (14/19 prioritizing brucellosis, 74%), for tuberculosis (7/13, 54%), and for Salmonella (8/9,
When comparing the top five priority endemic zoonoses, rabies, again, was the priority with the highest percentage of current MOUs, but was also listed as the top zoonoses priority most in need of improved diagnostic capabilities. Comparatively, improved surveillance was requested most by the ministries prioritizing *Salmonella* (Figure 5).

**Emerging zoonoses**

Of the 54 respondents, 31 (57%) completed formal prioritization exercises for emerging zoonoses; 14 (54%) by MOHs, 16 (64%) by MAgs, and 1 (33%) by combined entities. Ministries replied that they used criteria such as *probability of introduction* (30/54 ministries, 56%), *impact* (29/54, 54%), *followed by risk pathways for introduction to their country* (9/54, 17%) in the prioritization of emerging zoonoses. Ministries also wrote in criteria such as *international sanitary regulations, the probability of rapid transmission,* and *economic impact* among others. Of those ministries that reported the use of the *impact* criterion for prioritization, *impacts on public health, society,* and the *economy* were the most frequently reported by MOHs; for MAg were *impacts on public health, economy,* and *society* (See Figure 7). Other impacts used by both ministries to prioritize included the *impact on tourism, animal health and agriculture, international relations,* and *food security.*

When asked to identify their top emerging zoonoses, 130 responses were received, which included 25 unique emerging zoonoses priorities (See Table 2). The overall most
frequently prioritized emerging zoonoses were avian influenza (AI) (31 prioritizing/130 emerging responses, 24%), Ebola Virus Disease (EVD) (19/130, 15%), and bovine spongiform encephalopathy (BSE) (15/130, 130%) (See Figure 6). The most frequently reported emerging zoonoses by MOHs were EVD (14 MOHs selecting EVD/58 MOH priorities selected, 24%), AI (11/58, 19%), and Chikungunya (8/58, 14%). For MAgs, the top emerging zoonotic priorities were AI (18/66 MAg priorities selected, 27%), BSE (10/66, 15%), and West Nile virus and rabies (7/66, 11% each).

When comparing the ministries, the MAgs were more likely to complete prioritization for emerging zoonoses than the MOHs but the difference in proportions was not significant (p=0.4614, See Figure 11). For their emerging priority zoonoses, Ministries of Health listed 58 priorities, with 58% providing all three emerging zoonoses as requested (15/26). However, 23% (6/26) only provided two emerging zoonoses priorities, 3.8% (1/26) provided one emerging zoonosis, and 15.4% (4/26) provided no priority emerging zoonoses. In contrast, all MAgs provided one or more emerging priority zoonoses. Within the Ministries of Agriculture, 66 priorities were listed, with 68% (17/25) listing all three priority zoonoses, 28% (7/25) only provided two priority zoonoses, and 4% (1/25) listed only one emerging zoonosis priority.

When countries were asked for their top disease-specific capacities requiring improvement for each priority emerging zoonosis (See Figures 8 and 10), surveillance for avian influenza and Ebola, and diagnosis for BSE and WNV and both diagnosis and
surveillance for Chikungunya were quoted as the capacities which most needed improvement. Interestingly, when comparing the capacities most needing improvement, it was determined that the ministries were significantly more likely to cite surveillance as needing improvement for emerging zoonoses. In contrast, diagnosis was cited as the most needed improvement for endemic zoonoses (p-value=0.0005)

Although only 9 ministries consider risk pathways when prioritizing emerging conditions (9/54 ministries who prioritized emerging zoonoses, 17%), when asked for a risk pathway, many respondents identified logical pathways of introduction into their country for their priority emerging zoonoses, with most citing migration of wild birds, tourism, or trade. Thirty-seven ministries responded that they had an up-to-date contingency plan for their top priority emerging zoonoses (37/50 top priorities, 74%), for their second (27/47 second priorities, 57%), and for their third priority (17/33 third priorities, 52%). Thirty ministries reported that they had conducted a simulation exercise in the last five years for their top priority emerging zoonoses (30/54 ministries, 60%), for the second disease listed as a priority (10/47 second priorities, 21%), and for the third disease (3/33 third priorities, 9%). Twenty-seven ministries reported that they had a current formal agreement or Memorandum of Understanding with other government ministries for the coordinated prediction, prevention, detection, and intervention of their first priority endemic zoonotic disease (27/50 top priorities, 54%), their second prioritized disease (17/47 second priorities, 36%), or their third priority (13/33 third priorities, 40%). On comparison of the ministries, the MOHs were more likely to have established a formal MOU (p=0.0041);
however, in regards to having a contingency plan or having completed a simulation exercise for their priorities emerging zoonoses, there was not a significant difference between the MOHs and MAgs (p=0.1702 and 0.4436, respectively) (Figure 11).

Ministries were asked to select the probability of introduction of their priority emerging zoonoses into their countries (range of very improbable to very probable) (See Figure 9). Of those choosing AI, approximately 40% of the ministries reported as the introduction as probable (8 ministries/21 reporting probabilities for AI). Of those choosing EVD, 65% considered the introduction very improbable or improbable (9/14 ministries) vs. 14% who replied EVD introduction was probable or very probable (2/14 ministries). Of those selecting BSE, 67% considered BSE introduction as very improbable or improbable (9/12 ministries). For WNV, 44% considered it very improbable or improbable (4/9 ministries) while 56% considered it moderate to probable. For Chikungunya, 15% (2/7 ministries) considered introduction very improbable with 71% replying that is was probable or very probable (5/7 ministries) (Figure 9). While ministries were asked for the timeframe regarding the probability of introduction, the majority did not know or chose not to answer the question.

When comparing the five priority emerging zoonoses (Figure 10), a comparatively higher proportion of ministries that prioritized Chikungunya considered its’ emergence probable or very probable. Yet, when comparing the proportion that completed a simulation exercise or had a contingency plan, the top two priority emerging zoonoses, AI and EVD,
ranked higher than the other top five priorities. Overall, roughly 50% of prioritizing ministries reported that they had a formal MOU for these zoonoses. Additionally, roughly 50% of prioritizing ministries responded that they would like to improve surveillance for AI, EVD, and WNV (Figure 10).

**General**

Ministries were asked as to whether they considered equity in their prioritization and allocation of resources for the control of zoonoses, whether endemic or emerging. Eighteen (33%) ministries, including the MOH (12/26 MOHs that responded to the survey, 46%) and MAg (6/25 MAgs that responded to the survey, 23%) stated that they consider equity issues in their definition of priorities and allocation of resources.

Forty-three respondents reported that they are currently conducting syndromic surveillance including the MOH (22/26 MOH survey responders, 88%) and the MAg (21/25 MAg survey respondents, 84%).

Thirty-four ministries (67%) reported their relationship with the other ministries involved in the control of zoonoses in their countries as productive or very productive, and 17 (33%) as minimally productive with few attempts of coordination. No ministry reported the absence of any coordination with other ministries. Only 24 ministries have a formal written agreement with universities (24/54 respondents, 44%), with non-governmental organization (13/54 respondents, 24%), with the private sector (18/54 respondents, 33%),
with other organizations (10/54 respondents, 19%) including scientific groups, the central

government, regional authorities, emergency committees, and the community. Ministries

were asked to produce suggestions of activities to improve coordination and collaboration

with the other ministries for the control of zoonoses. Sixty-two suggestions were

recorded and among the most cited were: formalizing collaboration such as through an

MOU (n=14, 26%), regular meetings (10, 19%), data sharing (10, 19%), and planning
together (7, 13%). Additional suggestions included forming an interagency group, joint
capacity training, improving communication, improving one ministry in particular,
increasing resources, and others. When asked to describe the non-disease specific, most
wanting cross-cutting capacity, the majority of respondents, (32, 59%), described
improved coordination between stakeholders, followed by surveillance (6, 11%),
education (4, 7%), and diagnosis (3, 6%).

The majority of respondents (48, 89%) allocated very high or high value to a regular
report on the occurrence of zoonoses in the Americas region which would contain the
information gathered in this report. Six allocated some value (11%), and no ministry
allocated little or no value to the publication and dissemination of such report. When
asked what other evidence or information to include in such report, suggestions included
information regarding epidemiology of the zoonoses in the region (12, 27%), on control
(12, 27%), economic impact (5, 10%), and collaborations (5, 10%).
2.3 Discussion:

Prior to this survey, little was known about national zoonotic disease programs in LACs. In light of this gap, PAHO conducted a survey of LACs to capture information regarding their national zoonoses programs, prioritization methods used, priority zoonoses, and most-needed capacities. Within LACs, a number of diseases were chosen as the top endemic and emerging priorities in the LACS as well as specific capacities to improve plus information regarding the methodology and criteria used to prioritize said diseases was reported. By documenting this data, we hope to take the first step in identifying how LACs can strengthen their capacities to manage zoonoses risks, standardize their prioritization approaches, and create an opportunity for improved communication and coordination between countries and stakeholders.

Prioritization of Endemic Zoonoses

As public health resources are finite, a means of prioritizing the use of resources, personnel, and funds is necessary. A recent publication describes the prioritization exercise completed in Colombia (Cediel et al 2013) but beyond this exercise, there is a distinct lack of published prioritization exercises from LACs. Worldwide, numerous articles have been published describing prioritization of zoonotic diseases utilizing or recommending semi-quantitative and quantitative methods (Cardoen et al 2009, Cito et al 2015, Del Rio et al 2013, Havelaar et al 2010, Humblet et al 2012, McKenzie et al 2007, Ng and Sargaent 2012 and 2013, OIE 2010, Rist et al 2014). This is in contrast to the results found in this questionnaire, where expert opinion, a qualitative methodology, was
found to be the most used methodology for prioritizing endemic zoonoses (19/54 ministries, 35%). We cannot be certain why the countries continue to use expert opinion rather than moving to the more commonly accepted quantitative and semi-quantitative methods. Potential restraints secondary to finances, a lack of available time or personnel, or a lack of information and/or expertise on these methods could be reasons for continuing to use expert opinion. In particular, semi-quantitative methodologies have been cited to have time, information, and financial challenges but a recently developed technique has attempted to surmount these limitations (Rist et al 2014). Interestingly, MCDA was reported as the second most commonly used technique and thus, is not unknown in the region.

Criteria used for prioritization of endemic zoonoses also varied between countries. In the LACs, the top criteria were human incidence (62% of priorities) followed by economic impact (48%), animal prevalence (47%) and human severity (46%). Comparatively, within the Americas region, Ng and Sargeant published two prioritization exercises conducted in the United States and Canada involving public participants and health professionals (2012 and 2013, respectively). Using conjoint analysis, these two prioritization exercises used 21 criteria which were ranked by the public or the health professionals to prioritize 62 diseases. Both groups considered case fatality in humans and incidence in the last five years in humans to be the most influential criteria to prioritize zoonoses (Ng and Sargeant 2012 and 2013). These criteria show a snapshot of the differences in the criteria between the regions. The criteria selected by the individuals
in the paper by Ng and Sargaent (2012 and 2013) focused on the health impacts of zoonoses on humans. In comparison, while the survey conducted here of LACs did rank human incidence as the top criterion, economic impact was the second most selected. This second criterion, economic impact, recapitulates the necessity to consider cost and best use of resources in regards to zoonoses disease prevention and control programs particularly in developing countries. Interestingly, this could be compared to a top criterion in a Colombian prioritization exercise, where the panel of experts chose preventability as their top weighted criteria (Cediel et al 2013). Perhaps by focusing on preventability, the experts similarly aimed for the best use of limited financial and personnel resources.

There were also variable responses within the top endemic zoonoses prioritized. Within LACs, top endemic diseases were determined to be rabies (21% of responses), followed by leptospirosis (19%), and brucellosis (13%) and top emerging diseases were avian influenza (23%), EVD (15%), and BSE (13%). Unfortunately, as stated earlier, very few articles have been published regarding the current ongoing prioritization exercises in LACs. Therefore, it is difficult to compare or confirm these results. In the exercise conducted in Colombia, a panel of experts prioritized zoonotic diseases such as influenza (H1N1), followed by salmonellosis, *Escherichia coli* infection, and leptospirosis (Cediel et al 2013). Similarly, the results of our questionnaire also found that all of these pathogens were top priorities by one or more LACs with avian influenza being the top emerging pathogen and leptospirosis being in the top three endemic priorities.
Prioritization of Emerging Zoonoses

In general, emerging zoonotic disease priorities are determined by calculating risk through consideration of probability of entry, impacts, and vulnerabilities of the country. In LACs, the ministries prioritized avian influenza (23%), EVD (15%), and BSE (13%) as the top emerging zoonoses and the probability of introduction matched these priorities. However, it is interesting to note that the majority did not know or were unable to provide the timeframe for this probability. Conversely, many countries were able to provide reasonable risk pathways although it is unknown how often and thoroughly they assess these pathways. While many provided a risk pathway, few actually considered them in their analysis of risk (9/54 ministries who prioritized emerging zoonoses, 17%) and when they did use them in their analysis, we cannot be sure how they combine this into their calculation of risk or priority. Finally, the most important capacity to improve in regards to emerging zoonoses was asked as a means of considering vulnerabilities. Surveillance was the top capacity for improvement for AI and EVD and diagnostic as the top capacity for BSE. Unfortunately, the questionnaire did not ask if and how the ministries combined these (probability, impact, and vulnerability) to calculate the risk of the emerging zoonoses. This needs to be included in future questionnaires.

Collaboration

‘One Health’ (OH) calls for the integration of animal, human, and environmental evidence and efforts for the effective and most efficient prevention, surveillance and control of pathogens at the human-animal-environment interface. Prior to such
integration, there is a need to map out, across the main stakeholders, specifically the Ministries of Health and Agriculture, the current programs, structures, and resources that would support unified efficient control and prevention of zoonoses. Regarding this collaboration, the IHR Core Capacity monitoring framework (WHO 2015), asks numerous questions regarding the collaboration between the animal and human health components including the presence of a designated animal health focal points who coordinates with the Ministry of Health. Yet the IHR monitoring framework fails to collect an assessment of the success of this collaboration and how it could be improved.

To fill this need, ministries were asked to rank the relationship their Ministry has with the Ministry of Health or Agriculture. None of the ministries ranked their collaboration with the other ministry as non-existent. In fact, the majority of ministries ranked the collaboration relationship as very or overall productive (63%). Yet, many ministries suggested improvements such as through an MOU (14/62 total suggestions submitted, 26%), regular meetings between the ministries (10/62, 19%), data sharing (10/62, 19%), and planning together (7/62, 13%). The quantity of comments shows that there is room for improvement but that there is a lack of consensus as to how to improve collaboration.

Of these, data sharing was suggested and is of specific interest because it may be the most constructive suggestion. Many of the other suggestions, (e.g. an MOU, regular meetings, and planning together) require some degree of data sharing to be successful. However, while important, data sharing will be challenging due to the potentially
differing objectives of the ministries. For example, the differing criteria used by the two ministries to prioritize the endemic zoonoses emphasizes the differing priorities of the ministries. Yet, there has been evidence that animal data may help identify EIDs before they emerge in human populations (Halliday et al 2012). With few LACs Ministries of Agriculture actually having a group dedicated to zoonoses (20%), the collection and sharing data which is beneficial to both parties will be a challenge. Using the information in the present survey, potentially a platform could be organized to integrate animal health evidence to detect public health events earlier.

According to the responses given, the MOHs seems to perform better on a number of fronts when compared to the MAgs. (See Figure 11). For example, in regards to endemic zoonoses, there was a higher proportion of MOHs performing prioritization exercises for endemic zoonoses than MAgs ($p=0.3316$). However, the ministries did perform equally well on establishing formal MOUs for their endemic priorities. In contrast, the difference between the ministries was more prominent in regards to emerging zoonoses. While the MOH was less likely to have performed prioritization exercises when compared to the MAg, the MOH was more likely to have completed contingency planning, simulation exercises for their priority zoonoses and established formal MOUs than MAgs ($p=0.1706$, $0.4436$, and $0.0041$, respectively). Overall, other than the prioritization of emerging zoonoses, the MOH seems to be equally or better prepared and more connected than the MAg in regards to their priority zoonoses. This may partially be due to MOHs having many more specialized zoonoses units (22/26 MOH respondents, 85%) compared to
MAgs (5/25 MAg respondents, 20%). Additionally, the MOHs received improved funding for their zoonoses units (median 500,500 USD, range 41,000 to 6,683,000 USD) compared to the MAg (median 302,000 USD, range 6,800 to 4,457,000 USD). Unfortunately, in regards to zoonoses, prioritization, contingency planning, and simulation exercises should likely be performed in collaboration between the ministries as the outbreak is unlikely to be limited solely to humans or animals.

Limitations

One of the challenges of the survey were the variability in responses between national governments. Although the questionnaire specifically asked for human resources and available budget at the central level, given the difficulty of capturing national level resources due decentralization of health services, it is possible that some countries provided countrywide information as shown by the large upper range value. While this is unfortunate, this does give us an initial overview of the financial and personnel resources available on the national level. When calculated in terms of GDP, even if countrywide resources were included, the reader will notice that in most cases these zoonoses groups are relatively financially limited for dealing with zoonoses on a national level.

An additional concern was the number of ministries which chose vector-borne, non-zoonotic, diseases. The survey specifically requested that respondents think about the food-borne, sylvatic, and vector-borne zoonoses but was not intended to include non-zoonotic pathogens. The reality is that many national zoonotic groups are often combined
with or a subset of existing divisions of the ministry, such as vector-borne diseases. While we acknowledge that Chikungunya and dengue are non-zoonotic, vector-borne diseases, they are included here for completeness as they are both important diseases in LACs and show only further potential with global climate change. However, when other non-zoonotic diseases, non-vector-borne diseases were listed as priorities by LACs (i.e. snake bite, classical swine fever), these were included in the category other. In addition, some minimally zoonotic diseases were also listed by LACs, likely due to economic and trade ramification, and they were included as they do have some, however small, zoonotic component (i.e. foot-and-mouth disease and Newcastle disease).

Similarly, the survey requested detailed disease information regarding priority diseases, including species and subspecies, but this was not always provided. For example, the majority of ministries responded only ‘rabies’ without further specifying the variant type or target species. Sylvatic and canine rabies generally have very different epidemiologically and ecologically. Therefore, surveillance and control techniques generally are not the same between the two programs. This lack of specification by the ministries may be due to the variability in approaches taken by each country in their zoonoses programs as some may prioritize all variants of rabies while others may prioritize more specifically. As we did not have an initial baseline of diseases, allowing the countries to write in their responses was an important part of the questionnaire. To avoid this issue in subsequent surveys, the diseases, and their possible variations, should be provided to the respondents to avoid confusion.
An additional challenge of the survey occurred due to timing. During the administration of the survey, the EVD pandemic was at its peak and countries worldwide were preparing for the possible introduction of the virus. Presently, the concern for EVD has diminished and if this same survey would be administered now, it is highly likely that EVD may not still be a top emerging priority. Nevertheless, while the risk may have diminished, the occurrence of the next zoonotic pandemic is only a matter of time and requires an efficient means of regional collaboration. Finally, the delay between survey completion and final article publication in a peer-reviewed journal highlights the need for an efficient, rapid means of regional communication for zoonotic diseases.

**Recommendations**

Based on data collected from this survey, we are suggesting a regular data capture mechanism on specific disease epidemiological and program related indicators in combination with a regular report on zoonoses for the region. Examples of such reports includes the weekly Communicable Disease Threats Report released by the European Centre for Disease Prevention and Control where prominent worldwide disease outbreak data are combined and prepared in a standardized format for visualization (http://ecdc.europa.eu/cdtr). While many countries prepare their own reports and the OIE prepares a report in regards to specific animal related diseases, there is a gap related to zoonoses in LACs, specifically information regarding program indicators and capacities.
Another possibility would be a network such as those overseen by Connecting Organizations for Regional Disease Surveillance (CORDS) (http://www.cordsnetwork.org/). CORDS links regional disease surveillance networks in six different regions of the world, helping the experts in these regions share capacity building techniques, surveillance tools and strategies, best practices, personnel training, and disease surveillance information. By building a trust-based organization where experts can comfortably share information, the networks aim to improve timely and efficient exchange of disease surveillance information (Gresham et al 2013). Initiating a similar concept in LACs and connecting these national zoonoses groups via a regional network, would certainly lead to improved coordination of efforts and capacities while also speeding proper identification and management of EIDs. Utilization of a developed platform to implement a more advanced and exhaustive means of monitoring is one means of improving the national capacity and assisting them in meeting IHR zoonosis specific requirements.

The focus of the national programs needs to move towards information sharing to support better risk management and to data sharing to support joint analysis and response in the prevention and control of zoonoses. To this end, potential future steps include drafting a regional zoonoses strategy, creating a regional data capture system, and organizing a regional network. Continued progress requires moving from checklists to granular measures of performance development and implementation that take into account
dependencies between capacities, non-linear processes and consider the critical role of people, organizations and cultures.

**Closing**

Overall, the results of this survey demonstrate the variability in national approaches to zoonotic diseases and their prioritization. This heterogeneity in the responses is of particular interest as it may indicate discrepancies that could translate into vulnerabilities that could lead to greater occurrence of zoonoses. Unfortunately, zoonotic pathogens do not respect country boundaries and coordination of approaches would lead to improved control and eradication programs as well as a conservation of resources. A number of improvements appeared evident: i) standardization of prioritization approaches, surveillance definitions and evaluation processes to support comparisons, ii) greater communication and coordination between countries, and iii) a platform to inform zoonoses occurrence in the region and the status of the region’s capacities. Thus, the development of a regional strategy for zoonoses (both endemic and exotic) utilizing information collected here would increase efforts, advocacy, and promote prompt identification and management of EIDs and improvement of endemic programs.
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Appendix A: Figures and Tables
Table 1. List of endemic zoonotic diseases and their frequency in regards to their prioritization by the Ministries of Health and Agriculture and combined entities in Latin America and Caribbean countries. First, second, and third refer to the priority level of the zoonotic diseases and total is a sum of all the times that disease was prioritized in such categories.

| Endemic                          | First | Second | Third | Total |
|----------------------------------|-------|--------|-------|-------|
| 1 RABIES\(^a\)                   | 22    | 2      | 6     | 30    |
| 2 LEPTOSPIROSIS\(^b\)            | 4     | 11     | 10    | 25    |
| 3 BRUCELLOSIS\(^c\)              | 7     | 6      | 6     | 19    |
| 4 TUBERCULOSIS\(^d\)             | 2     | 7      | 4     | 13    |
| 5 SALMONELLA\(^e\)               | 5     | 3      | 3     | 11    |
| 6 HIDATIDOSIS                    | 4     | 0      | 2     | 6     |
| 7 CAMPYLOBACTERIA\(^f\)          | 0     | 1      | 4     | 5     |
| 8 ESCHERICHIA COLI\(^g\)         | 1     | 4      | 0     | 5     |
| 9 INFLUENZA\(^h\)                | 1     | 1      | 2     | 4     |
| 10 CHAGAS                        | 0     | 3      | 0     | 3     |
| 11 LEISHMANNIASIS                | 2     | 1      | 0     | 3     |
| 12 VENEZUELAN EQUINE ENCEPHALITIS| 0     | 2      | 0     | 2     |
| 13 TRICHINELLA SPIRALIS          | 0     | 0      | 2     | 2     |
| 14 HANTAVIRUS                    | 0     | 0      | 2     | 2     |
| 15 PLAGUE                        | 0     | 2      | 0     | 2     |
| 16 ANTHRAX                       | 0     | 1      | 1     | 2     |
| 17 CHIKUNGUNYA                  | 2     | 0      | 0     | 2     |
| 18 EQUINE ENCEPHALITIS           | 0     | 1      | 0     | 1     |
| 19 DENGUE                        | 1     | 0      | 0     | 1     |
| 20 HELMINTHS                     | 0     | 0      | 1     | 1     |
| 21 FOOD BORNE ILLNESS            | 0     | 0      | 1     | 1     |
| 22 TOXOPLASMOSIS                 | 0     | 1      | 0     | 1     |
| 23 FASCIOLIOSIS                  | 0     | 1      | 0     | 1     |
| 24 ERYSEPELAS                    | 0     | 1      | 0     | 1     |
| 25 BURKOLDERIA MALLEI            | 0     | 1      | 0     | 1     |
| 26 OTHER\(^i\)                  | 0     | 0      | 1     | 1     |

\(^a\)The disease category ‘rabies’ includes rabies (n=24), bovine rabies (n=5) and canine rabies (n=1).
\(^b\)The disease category ‘leptospirosis’ includes leptospirosis (24) and *Leptospira icterohemorragiae* (1).
\(^c\)The disease category ‘brucellosis’ includes brucellosis (14), bovine brucellosis (4), and caprine brucellosis (1).
\(^d\)The disease category ‘tuberculosis’ includes tuberculosis (7) and bovine tuberculosis (6).
\(^e\)The disease category ‘Salmonella’ includes *Salmonella* (9), *Salmonella enterica* (1), and *Salmonella Enteritidis* (1).
\(^f\)The category *Campylobacteria* includes *Campylobacter* (3) and *Campylobacteria jejuni* (2).
\(^g\)The disease category ‘Escherichia coli’ includes both *E. coli* (3) and *E. coli* O157:H7 (2).
\(^h\)The category ‘influenza’ includes influenza (2) and avian influenza (2).
\(^i\)The disease category ‘other’ includes snake bite, which is not zoonotic.
Figure 1: The top five endemic zoonotic disease priorities across Latin American and Caribbean countries as indicated by 54 Ministries of Health and Agriculture, and combined entities in the region.
Figure 2: Comparison between the Ministries of Health and Agriculture in regards to the top five endemic zoonotic disease priorities in Latin American and Caribbean countries (percentage represents total respondents received from both ministries (n=51)).
Figure 3: Comparison between the Ministries of Health and Agriculture (n=51) in Latin American and Caribbean countries in regards to the top criteria used to prioritize endemic zoonotic diseases (human prevalence, humprev; human incidence, huminc; human severity, humsev; human mortality, hummort; DALYs, humdaly; society impact, soc; animal prevalence, animprev; animal incidence, animincid; animal mortality, animmort; animal welfare, animwelf; public opinion, pubopin; economic impact, econ).
Figure 4. Top capacities that require improvement for each of the top five endemic priority zoonoses based on the opinions of the Ministries of Health and Agriculture and combined entities in Latin American and Caribbean countries (control, cont; coordination, coor; diagnosis, diag; education, edu; and surveillance, surv). Responses that fell outside these categories were categorized as other. Percentage represents total respondents received (n=54).
Figure 5. A radar chart comparison of the top five priority endemic zoonoses for Latin American and Caribbean countries in regards to formal collaborations, knowledge of surveillance sensitivity, diagnosis and surveillance needs.
Table 2: List of emerging zoonotic diseases and their frequency in regards to their prioritization by the Ministries of Health and Agriculture and combined entities in Latin American and Caribbean countries. First, second, and third refer to the priority level of the zoonotic diseases and total is a sum of all the times that disease was prioritized in such categories.

| Emerging                      | First | Second | Third | Total |
|-------------------------------|-------|--------|-------|-------|
| 1 AVIAN INFLUENZA             | 18    | 9      | 4     | 31    |
| 2 EBOLA VIRAL DISEASE         | 14    | 2      | 3     | 19    |
| 3 BOVINE SPONGIFORM ENCEPHALITIS | 4    | 6      | 5     | 15    |
| 4 CHIKUNGUNYA                 | 1     | 10     | 1     | 12    |
| 5 WEST NILE VIRUS             | 1     | 5      | 5     | 11    |
| 6 RABIESa                     | 4     | 3      | 2     | 9     |
| 7 HANTAVIRUS                  | 0     | 1      | 3     | 4     |
| 8 DENGUE                      | 3     | 0      | 0     | 3     |
| 9 EQUINE ENCEPHALITIS         | 0     | 0      | 2     | 2     |
| 10 TRICHINELLA SPIRALIS       | 0     | 2      | 0     | 2     |
| 11 MERS COVb                  | 0     | 1      | 1     | 2     |
| 12 LYME DISEASE               | 0     | 1      | 1     | 2     |
| 13 CREUTZFELDT JACOB          | 0     | 1      | 1     | 2     |
| 14 LEPTOSPIROSIS              | 1     | 0      | 1     | 2     |
| 15 LEISHMANIASIS              | 1     | 0      | 1     | 2     |
| 16 SAINT LOUIS ENCEPHALITIS VIRUS | 0    | 0      | 1     | 1     |
| 17 FOOD BORNE ILLNESS         | 0     | 0      | 1     | 1     |
| 18 ECHINOCOCCUS               | 0     | 0      | 1     | 1     |
| 19 ANTHRAX                    | 0     | 0      | 1     | 1     |
| 20 TAENIA                     | 0     | 1      | 0     | 1     |
| 21 SCREWWORM                  | 0     | 1      | 0     | 1     |
| 22 SALMONELLA                 | 0     | 1      | 0     | 1     |
| 23 INFLUENZA                  | 1     | 0      | 0     | 1     |
| 24 ESCHERICHIA COLI            | 1     | 0      | 0     | 1     |
| 25 BRUCELLOSIS                | 1     | 0      | 0     | 1     |
| 26 OTHERc                     | 0     | 3      | 1     | 4     |

*The disease category ‘rabies’ includes rabies (n=7), bovine rabies (1) and canine rabies (1).
*Middle East Respiratory Syndrome Coronavirus
*The disease category ‘other’ includes classical swine fever, foot-and-mouth disease, Newcastle disease, and antimicrobial resistance.
Figure 6: The top five emerging zoonotic disease priorities across Latin American and Caribbean countries as indicated by 54 Ministries of Health and Agriculture, and combined entities in the region.
Figure 7: Comparison between the Ministries of Health and Agriculture (n=51) in Latin American and Caribbean countries in regards to the top impacts considered when prioritizing emerging zoonoses (impact on public health, pubhlth; the impact on society, society; the impact economically, econ; the impact on the environment, envi; the impact on public opinion, pubopin; and others including: impact on tourism, animal health and agriculture, international relations, and food security).
Figure 8. Top capacities that require improvement for each of the top five emerging priority zoonoses based on the opinions of the Ministries of Health and Agriculture and combined entities in Latin American and Caribbean countries (control, cont; coordination, coor; diagnosis, diag; education, edu; and surveillance, surv). Responses that fell outside these categories were categorized as other. Percentage represents total respondents received (n=54).
Figure 9. Probability of introduction for the top emerging zoonotic diseases in Latin American and Caribbean countries according to the Ministries of Health, Agriculture, and combined entities (very improbable (probability < 0.20), improbable (0.20-0.40), moderate (0.41-0.60), probable (0.61-0.80), and very probable (0.81-1.00)).
Figure 10. A radar chart comparison of the top five priority emerging zoonoses of Latin American and Caribbean countries in regards to the percentage completing simulation exercises, with a contingency plan, with a formal collaboration, the probability of introduction, and surveillance needs.
Figure 11. A radar chart comparison of prioritization, planning, and collaboration activities completed by the Ministries of Health and Agriculture in Latin American and Caribbean countries in regards to endemic and emerging zoonoses.
Appendix B: Zoonoses Questionnaire

Please refer to the supplemental file for the original survey in English.