83rd General Session World Assembly
World organisation for animal health Paris, 24-29 May 2015

83 SG/9
Original: English

THE USE OF INFORMATION TECHNOLOGY IN ANIMAL HEALTH MANAGEMENT, DISEASE REPORTING, SURVEILLANCE, AND EMERGENCY RESPONSE

Tammy R. Beckham and Lindsey K. Holmstrom
Institute for Infectious Animal Diseases, Texas A&M University, College Station, TX, USA

Summary: *Information technologies now available to the global animal health community are revolutionizing the way animal disease data and information is collected, integrated, reported, analyzed, shared, and disseminated to stakeholders. These new technologies offer substantial opportunities for enhancing animal, public and ecosystem health across the globe. Harnessing existing and new technological advances in an effort to ensure timely and accurate disease information collection and dissemination will require resources, development of policy and standards, as well as training for individuals located throughout every level of veterinary services.*

A questionnaire was sent to the Delegates of all 180 OIE Member Countries to assess the impact and the potential of current and new information technologies for advancing animal health and welfare in OIE Member Countries. The questionnaire also evaluated the availability and frequency of use of existing and new technologies as well as the limitations/constraints (administrative, data, and utilization) of each technology within four broad categories. Summarized questionnaire responses indicate that information technologies are widely available to OIE Member Countries but are currently utilized at low levels in animal health relative to their availability. Technologies for data management, online data entry/import, mobile devices, and laboratory information management systems were considered most effective and high priority for additional development and implementation. Technologies for point of care testing, tele-diagnostics, and remote sensing/collection devices were the least utilized technologies and had lower priority for implementation. Data sharing and integration across public health, wildlife, and domestic animal health authorities is occurring to some extent within all OIE regions, however the OIE and Member Countries should work with public health counterparts to expand data integration across these sectors for a One Health approach toward the early detection, rapid identification, response and prevention to diseases at the human-animal interface. Significant resource (financial and personnel) and data limitations among OIE Member Countries are affecting not only the implementation of technologies, but also the utilization of data generated as a result of their use. Many of the limitations/constraints identified could be addressed through technical capacity building, technology guidance, and establishing data standards and guidelines for the implementation and utilization of information technologies, which would strengthen disease surveillance and reporting capabilities in OIE Member Countries for national and global good.

1. Introduction

Over the past decade there has been tremendous advances in information technologies that have the potential to improve animal health and welfare on a global scale. Utilization of these technologies are transforming the manner in which animal disease data and information is collected, integrated, reported, analyzed, shared, and disseminated to stakeholders. The power of information technology systems to collect, filter, process, and present information/data from a number of data sources greatly enhances the decision-making process, animal health situational awareness, anticipation and prediction, and the ability for timely detection and control of animal diseases. These enhancements in turn result in improved animal and public health, increased global food security, and a reduction in economic losses secondary to animal disease and welfare issues.

Technological innovations that are revolutionizing animal health data collection and utilization can be grouped into four broad categories: 1) mobile technologies (m-health); 2) electronic health (e-health) technologies (laboratory information and animal data information management systems); 3) point of care (POC) diagnostic devices; and 4) online media. Availability of and advances in each of these areas (with the exception of POC diagnostics, which were reviewed during the 81st General Session of the World Assembly [Paris, 26-31 May 2013]) (1) are highlighted below.

Rapid advances in mobile technologies and applications have created new opportunities for capturing animal health data from veterinarians, community animal health workers, animal owners/producers, and farmers. According to the International Telecommunication Union (ITU), there are now over five billion wireless subscribers; and over 70% of them reside in low- and middle-income countries. In addition, the Groupe Speciale Mobile (GSM) Association reports commercial wireless signals cover over 85% of the world's population, extending far beyond the reach of the electrical grid (2).

With the growing availability of reliable internet connections, m-health and e-health technologies are being increasingly utilized to capture and analyze animal movements, management and production data, premises identifications, animal identifications, diagnostic test results and much more. Their capabilities offer user-friendly, low-cost, and low-maintenance options for collecting, storing, and analyzing trends in animal health, movements, and management.

Traditional media venues such as newspapers, radio, and television have long been used to communicate health information to the public, and although still utilized heavily in many regions, a new form of messaging has emerged: social media. Social media (twitter, facebook), unlike traditional media formats, is a multi-directional method with the potential for not only disseminating important health messages to veterinarians, animal owners/producers, and the public; but also gathering this same type of information for analysis by veterinary and public health officials.

As many of these new information and communication technologies are developed and implemented to support animal health and welfare, approaches for accessing, implementing, standardizing, utilizing, and harmonizing these systems will be needed.

The OIE, as the world leader in communicating and providing information on global animal and zoonotic diseases, has placed great emphasis on continued enhancement of information technologies and standards in their 2011-2015 OIE Strategic Plan (3). One of the primary objectives in the five year plan is to "communicate timely and accurate animal disease information, including information on zoonoses, by making the best use of scientific data modeling, *modern information technologies, and tracking systems for non-official information*." Implementation of this objective will require the ability to gain timely access to *all* relevant data sources, working with partners to enhance international capacity in disease intelligence, horizon scanning, modeling and forecasting, as well as working with partners to strengthen disease surveillance capacities, including standards, tools and monitoring processes, at national, regional, and global levels. The strategic plan calls for the OIE to encourage the use of new technologies for the reporting of animal disease events at the local level and to develop the standards and guidelines for incorporating this type of data into formal information systems, including the OIE's World Animal Health Information System (WAHIS) (3). Furthermore, supporting the One Health initiative, the OIE commits to working with its partner organizations to establish an international framework that addresses emerging diseases at the animal-human-ecosystems interface by strengthening capacity in surveillance systems, establishing linkages and integration between WAHIS and other information and disease intelligence systems, and providing member incentives for early disease detection and notification.

In an attempt to assess the impact and potential of current and new information technologies and guide future work of the OIE in this area, a questionnaire was distributed to all delegates representing the 180 OIE member countries entitled: *"The Use of Information Technology in Animal Health Management, Disease Reporting, Surveillance, and Emergency Response."*

2. Questionnaire

The Technical Questionnaire for the 83rd General Session *The Use of Information Technology In Animal Health Management, Disease Reporting, Surveillance, and Emergency Response* consisted of 14 questions, the majority which were multi-part questions. The respondents were also allowed to provide free-text entries, where needed, to address each question. The questionnaire was distributed to the Delegates from each OIE Member Country on December 22nd, 2014 in the three official languages of the OIE (English, French, and Spanish). Questionnaires submitted through February 28th, 2015 were included in the analysis. Two questionnaires were submitted after this date and not included in the analysis; however, they were reviewed and determined to have similar responses to questionnaires submitted from their respective region.

Four broad categories of information technology (remote data collection, information management systems, diagnostics, and online media) were addressed in the questionnaire. Within each category specific technologies were listed resulting in nine existing or new/emerging technologies that were evaluated for use across four distinct animal health settings (data management, disease outbreak reporting, active and passive surveillance, and emergency response). The four broad categories and nine technologies represented in the survey are listed below. Definitions for each technology listed in the questionnaire are found in Appendix 1.

Remote Data Collection

- **Mobile devices (mHealth technologies) -** *e.g., smartphones, mobile phones, tablets, Personal Digital Assistants (PDAs), Global Positioning System (GPS) devices, other hand-held devices*
- **Online data entry/import tools -** *e.g., web-based forms, Microsoft Excel spreadsheets, structured/formatted text files*
- **Remote sensing/collection devices -** *e.g., radio frequency identification devices (RFID), identification/barcode readers, biosensors*

Information Management Systems

- **Laboratory Information Management Systems (LIMS)**
- **Animal health and data management software -** *e.g., third-party applications/systems, custom databases, Geographic Information System (GIS), movement databases, sales databases, production level data*

Diagnostics

- **Point of care (POC) testing -** *e.g., pen-side and chute-side tests*
- **Tele-diagnostics** - *e.g., remote monitoring or diagnosis of health*

Online Media

- **Traditional media -** *e.g., online news, libraries, references*
- **Social media** - *e.g., Facebook, Twitter, Instagram, Wikis, blogs, discussion forums, citizen science, crowd sourcing*

The questions were designed to assess the availability and current/potential use of each technology to OIE Member Countries for supporting animal health and welfare within the four categories of animal health settings. The questionnaire also assessed the priority of the country's Central Veterinary Authority (CVA) for implementing and utilizing the technologies. Delegates were asked to comment on the potential impact of utilizing the technologies as well as any administrative, resource, and/or data constraints that would prohibit the development and implementation of each technology within their country. The questionnaire evaluated the use of each technology for data sharing and integration between public health, wildlife and domestic animal health authorities. In order to determine the need for technical capacity building and/or technology guidance, a question was posed as to whether the OIE or an outside source would be needed to help develop and implement the priority technologies. Finally, the delegates were asked to comment on the need for the development of data standards to allow for efficient data sharing and reporting of disease information between Member Countries and the OIE and if these standards should be set in cooperation with the OIE.

3. Responses from OIE Member Countries

Of the 180 OIE Member Countries that were sent the questionnaire, responses were received from 144 for an overall response rate of 80.0%. For data analysis, countries were assigned to one of the five OIE regions: Africa; Americas; Asia, Far East, and Oceania; Europe; and the Middle East. Not all countries within each region returned a completed form. Response rates for each region were: Africa – 66.7%, Americas – 96.7%, Asia, Far East, and Oceania – 80.6%, Europe – 83.0%, and the Middle East – 85.0%. A complete list of countries responding to the questionnaire can be found in Appendix 2.

3.1. Current Utilization of Information Technologies

Advances in POC diagnostics, the global adoption of smart-phone and SMS text technology, GPS, GIS, and the expansive use of social media have all contributed to or have the potential to contribute to a greater animal health situational awareness. In turn, this increased awareness will result in the earlier detection and control of emerging, zoonotic and transboundary diseases, decreased economic losses within the livestock sector, enhanced public health, and increased global food security. Each OIE Member Country was asked to comment on the availability of information technologies, their frequency of use, situations in which they are applied, and the level at which each technology is implemented within their country.

Availability and frequency of use

Of the technologies assessed, those available for use by >75% of responding countries are online data entry/import tools (97.9%), mobile devices (93.6%), animal health and data management software and paper reports sent by mail (92.2% for both), social media (90.8%), traditional media (85.1%), and Laboratory Information Management Systems (LIMS) systems (78.7%; **Figure 1**).

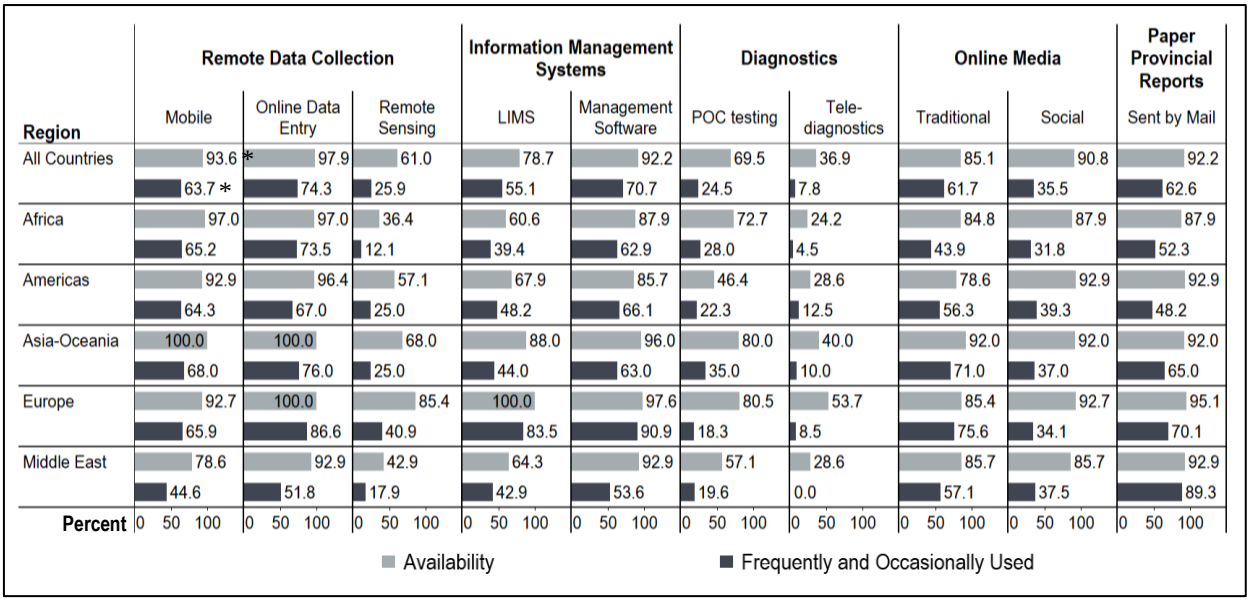

Figure 1. Information technology availability and frequency of use by OIE Region

* Values for Availability were averaged over all animal health settings and represent the percentage responding the listed technology is available for use to Questionnaire Item 1: "Indicate for each type of technology those that are available and their frequency of use in your country within each defined animal health setting". Values for Frequently and Occasionally Used were averaged over all animal health settings and represent the percentage responding to these two response categories.

For information technologies that were available, respondents were also asked to indicate their frequency of use within their country under each of the four animal health settings (animal health management, disease outbreak reporting, active and passive surveillance, and emergency response). The questionnaire asked the frequency of use and defined the options as: "frequently" if used daily to weekly; "occasionally" if used monthly; "rarely" if used semi-annually to annually; and "never" if the technology is available within a country but never used.

Overall, the utilization for each technology is significantly less than its availability ($p<0.001$ in all cases). The two technologies used most frequently by OIE Member Countries across all animal health settings were online data entry/import tools and animal health and data management software. Although 97.9% of respondents reported online data entry/import tools are available within their country, they are only frequently used by 56.0%-59.6% of respondents. Similarly, 92.2% of responding countries indicated animal health and data management software tools are available but their overall use was low (55.3%-56.7%). Other technologies that are frequently utilized by over half of the responding countries are mobile devices during an emergency response (51.8%) and traditional media for disease outbreak reporting (50.4%).

When responses for the "frequently" and "occasionally" used categories were combined, online data entry/import tools and animal health and data management software remained the most utilized technologies (74.3% and 70.7%, respectively; **Figure 1**). The use of both of these technologies was lowest in emergency response settings (68.1% and 66.7%, respectively) and highest in active or passive surveillance (78.0% and 74.5%, respectively). Additional information technologies used occasionally to frequently by >50% of responding countries (and the animal health setting it is most utilized within) were mobile devices, 63.7% (emergency response); paper reports sent by mail, 62.6% (disease outbreak reporting); traditional media, 61.7% (equally used in disease outbreak reporting and emergency response); and LIMS systems, 55.1% (active and passive surveillance). Although the majority of respondents indicated that POC testing (69.5%) and remote sensing/collection devices (61.0%) are available for use, their utilization across all animal health settings were low at 24.5% and 25.9%, respectively. Tele-diagnostics was the least available (36.9%) and least used (7.8%) technology.

As expected, there were differences in availability and frequency of use amongst the five OIE regions. In general, Europe had a greater availability and frequency of use of remote data collection, information management systems, and online media technologies than the other four regions. However, respondents in Africa, the Americas, and Asia, the Far East, and Oceania all indicated a relatively high level of utilization of mobile devices (64.3%-68.0%), online data entry (67.0%-76.0%), and management software (62.9%-66.1%). Of particular note was the low utilization (<48.2%) of LIMS systems in all regions except Europe, where usage was reported at 83.5%.

Other responses mentioned by responding countries for reporting animal health were the use of email (10 responses), phone or fax (6 responses), and other communication channels (*e.g.*, word of mouth, reports sent by transit or third party, or public gatherings/meetings; 6 responses).

Application in routine and outbreak situations

Information technologies are most effective when applied by countries during both routine animal health and outbreak disease situations. Utilization of these technologies daily, during routine animal health management activities helps ensure that users are familiar with the systems and a robust set of data is available when needed during a disease emergency. Among OIE Member Countries, respondents indicated that the technologies most commonly used during both routine and outbreak situations are online data entry/import tools (70.9%), animal health and data management software (68.8%), mobile devices (68.1%), traditional media (63.8%), and LIMS systems (57.4%). Information technologies rarely used during routine and/or disease outbreak situations were tele-diagnostics (58.9%) and remote sensing/collection devices (51.1%). Social media and POC testing were utilized at a lower rate of 39% and 24.8%, respectively. The technology utilization trends were similar throughout each of the five regions; however, a greater utilization in POC testing was reported in the Middle East; Asia, the Far East, and Oceania; and Africa regions when compared to Europe and the Americas.

Level of implementation

The level at which a technology is implemented within a country's Veterinary Services (VS) is critical to understanding how the technology is being used. Each delegate was asked at which level the nine technologies were implemented within Veterinary Services (VS) (*i.e.*, CVA; Provincial, Regional or State authorities; Local authorities; veterinarians; community animal health workers [CAHWs]; and/or animal producers or owners). Overall, mobile devices were the most broadly implemented among all countries. Respondents reported an average percent use within the CVA's office of 77.3%; provincial, regional, or state veterinary authority's offices, 70.9%; local veterinary authority's offices, 69.0%; veterinarians, 70.9%; and animal owners or producers, 51.8%.

Within the three levels of Veterinary Authority's offices (Central; Provincial, Regional, or State; and Local), the information technologies used by the majority of respondents are online data entry/import tools (87.2%, 70.2%, and 61.0%, respectively); animal health and data management software (83.7%, 66.3%, and 50.4%, respectively); traditional media (81.6%, 65.3%, and 53.2%, respectively); and mobile devices (77.3%, 70.9%, and 68.8%, respectively). The majority of countries indicated that LIMS systems were primarily used within the central veterinary diagnostic laboratories (63.1%). However, within the European region, a majority of countries reported that LIMS systems were also utilized within the Provincial, Regional, or State Veterinary laboratories (61.0%). LIMS systems are implemented in less than half of Central Veterinary Laboratories in the Middle East region (35.7%) and in less than 36.0% of Provincial, Regional and/or State laboratories in the Africa, Americas, and Middle East regions.

Among veterinarians, countries responded that mobile devices (70.9%) and online data entry/import tools (56.0%) are the most commonly used technologies. As expected amongst CAHWs, respondents indicated mobile devices are the most commonly used technology, albeit its implementation is at a low level (36.9%). In general, CAHWs make less use of available technologies when compared to other animal health counterparts (*e.g.*, veterinarians or animal owners/producers).

Countries responded that on average, animal owners and producers most often use mobile devices (51.8%), with all other technologies utilized at low (<36%) levels. However, when analysis was performed across regions, it was determined that animal owners and producers in Europe, Asia, Far East, and Oceania, and the Americas utilize both mobile devices and online data entry/import tools at higher percentages whereas in the Middle East and Africa, online data entry by animal owners and producers is very low (Middle East, 14.0%) to non-existent (Africa, 3.0%).

Among the different levels of implementation, countries responded that the information technologies implemented the least are tele-diagnostics (<10.0%), remote sensing/collection devices (<30.0%), and POC testing (<32.0%).

3.2. Impact of Information Technologies

Effectiveness for supporting animal health activities

The overwhelming majority of OIE Member Countries responded that all of the information technologies are effective or would be effective for supporting animal health activities. The three most common information technologies considered "very effective" for supporting animal health activities were mobile devices (85.8%), online data entry/import tools (83.0%), and animal health and data management software (82.3%). Tele-diagnostics was considered to be least effective technology (24.8%). The affirmative response rates for the effectiveness of all other information technologies were between 72.3% and 96.5%.

Importance for advancing animal health and welfare

A large percentage (70.2%-92.9%) of countries reported that mobile devices, online data entry/import tools, LIMS systems, and animal health management software are very important for advancing animal health and welfare in their countries. When "moderately important" was added to the affirmed response, >75% of respondents thought that remote sensing and traditional and social media were also needed to advance animal health and welfare. POC testing and tele-diagnostics were seen as the least important technologies for advancing animal health.

Priority for development or implementation

Of the four broad information technology categories, remote data collection technologies ($p<0.001$) and information management systems ($p<0.001$) were rated as the highest priority for implementation. Of the nine technologies, delegates rated the following as highest priority for development and implementation: animal health and data management software, 71.8%; online data entry/import tools, 71.3%; mobile devices, 64.9%; and LIMS systems, 62.8%. Information technologies identified by countries as "low" priority for implementation were POC testing, tele-diagnostics, and social media.

Activities that information technology would be used to support

OIE Member Countries indicated in the affirmative that information technology would be used in their country to support the following activities: zoonotic, transboundary, and endemic disease surveillance, outbreak or epidemiologic investigations (≥95.0% of respondents); animal population, animal identification, early disease detection, outbreak response and control, animal health permits/certificates, and animal traceability (between 89.4-91.5% of respondents); situational awareness (75.9% of respondents); and farm biosecurity (66.0% of respondents).

3.3. Data Sharing and Integration to Promote Human and Animal Health

Data sharing between public health and domestic animal sources was most common (59.3%), followed by wildlife and domestic animal (40.7%) and public health and wildlife (25.7%; **Table 1**). This same trend was observed across the OIE regions, with the exception of countries within the Middle East region reporting that data sharing and integration between public health and wildlife, and wildlife and domestic animal data sources occurs equally and at lower levels (7.1%) as compared to the other OIE regions. However, data integration between public health and domestic animal within the Middle East was the second highest compared to all five regions at 57.1%. Overall, countries in the Africa and Europe regions reported the highest levels of data sharing and integration for all data sources, followed by Asia, Far East, and Oceania, the Americas, and the Middle East.

Table 1. Utilization of information technology for data sharing and integration by OIE Region

		Region				
Sources for Data Sharing and Integration	**All Countries**	**Africa**	**Europe**	**Asia, Far East, and Oceania**	**Americas**	**Middle East**
Between Public Health and Domestic Animal	59.3*	71.9	63.4	52.0	46.4	57.1
Between Wildlife and Domestic Animal	40.7	50.0	56.1	36.0	28.6	7.1
Between Public Health and Wildlife	25.7	31.7	31.7	24.0	17.9	7.1

* Values represent the percentage responding "Yes" to Questionnaire 12: "Indicate if your Central Veterinary Authority currently uses information technology to integrate data between the listed data sources".

3.4. Limitations/Constraints Impacting Technology Development, Implementation and Utilization

Administrative resources/support

For OIE Member Countries, respondents identified implementation costs as the primary limitation of their CVA for implementing remote data collection, information management systems, and diagnostic technologies. Specifically, countries responded in the affirmative that this limitation affects their CVA's ability to implement mobile devices (67.4%); animal health and data management software (56.0%) and LIMS systems (54.0%); and diagnostics (POC testing, 53.2% and tele-diagnostics, 60.3%).

When analyzed by region, >50% of respondents from the Middle East, Africa, and Asia, Far East, and Oceania regions reported that IT support/expertise, resources/infrastructure, and training were also critical limitations/constraints. Within the Africa region, internet availability was identified as a limitation affecting the ability to utilize both mobile devices and online data entry/import tools.

Other administrative limitations/constraints reported by countries were database security within CVA offices and administrative procedures or legal provisions that hinder technology implementation.

Data requirements

Electronic transfer of data (71.6%), data sharing by data owners (67.4%), and data quality (63.8%) were identified as the as the three most common limitations/constraints for developing, implementing, and utilizing information technologies. The three limitations/constraints reported to impact information technology implementation the least were lack of interoperability of information systems (41.8%), data availability (39.7%), and the ability to protect data (32.6%). Affirmative responses for all other limitations/constraints were as follows: data sensitivity and confidentiality, 58.9%; data access, 57.4%; data stored in non-standardized formats, 57.4%; and verification of data entry and/or data sources, 52.5%.

When the data was analyzed by region, all regions except for Europe agreed that the top three (electronic transfer, data sharing, and data quality) were the greatest limitations. Europe listed data sensitivity/confidentiality and electronic transfer as their top two limitations/constraints, with data sharing and data access (53.7% for both) reported as their third primary limitation. Asia, the Far East, and Oceania and the Middle East regions reported verification of data entry and/or data sources (76.0% and 64.3% for each region, respectively) as a greater limitation compared to the other regions.

Other data requirement limitations noted by respondents included access to remote areas inside countries, knowledge of new technologies available, availability of off-the-shelf technologies, administrative support and resources for technology implementation/utilization, time constraints for data collection, and training.

Data availability

Data collected in electronic format allows for quick and accurate exchange of information to enhance and improve the efficiency of animal health activities. Information technologies provide a means for collecting data not currently available as well as allowing paper-based reporting to be captured in an electronic format. When asked the question on data availability, >80% of OIE Member Countries responded that the following sources are available for use in their country in either paper or electronic format: endemic disease surveillance data, 97.2%; animal health permit or certificate data, 97.2%; zoonotic disease surveillance data, 97.1%; diagnostic laboratory data, 97.1%; animal population data, 95.0%; transboundary disease surveillance data, 87.2%; slaughter data, 87.1%; and animal production data, 80.7%. Within these categories, animal population (87.1%), endemic and zoonotic disease surveillance (82.9% and 82.1%, respectively), and diagnostic laboratory (77.1%) data are most commonly available in an electronic format (**Table 2**). Data sources that are least available for consumption within each country were: farm biosecurity (33.6%), animal traceability (27.9%), genetic (26.4%), animal identification (25.7%), and animal movement (22.9%) data.

When responses were analyzed by region (**Table 2**), Europe reported consistently higher availability of data in electronic format in every category except endemic and transboundary surveillance, environment/climate, animal inventory, animal production, genetic and farm biosecurity. Surveillance for transboundary diseases was significantly lower in the Middle East (57.1%) and the Americas (53.6%) when compared to the average (73.6%) and individual responses from the remaining three regions (Africa [87.5%], Asia, Far East, and Oceania [76.0%], and Europe [80.5%]).

Table 2. Availability of data sources in electronic format by OIE Region

Data Source	All Countries	Region				
		Africa	Americas	Asia, Far East, and Oceania	Europe	Middle East
Animal population	87.1*	84.4	71.4	88.0	97.6	92.9
Surveillance - endemic	82.9	81.3	71.4	92.0	87.8	78.6
Surveillance - zoonotic	82.1	78.1	78.6	84.0	87.8	78.6
Diagnostic laboratory	77.1	65.6	82.1	76.0	87.8	64.3
Surveillance - transboundary	73.6	87.5	53.6	76.0	80.5	57.1
Environment/climate	66.4	50.0	78.6	72.0	70.7	57.1
Animal health permits/certificates	63.6	53.1	64.3	52.0	78.0	64.3
Animal identification	62.1	31.3	60.7	52.0	92.7	64.3
Farm location	60.7	31.3	67.9	52.0	82.9	64.3
Slaughter	60.0	50.0	60.7	44.0	80.5	50.0
Farm identification	59.3	25.0	71.4	52.0	85.4	50.0
Animal movement	58.6	34.4	53.6	44.0	92.7	50.0
Animal traceability	57.1	28.1	57.1	48.0	87.8	50.0
Animal inventory	55.0	31.3	67.9	56.0	65.9	50.0
Animal production	51.4	40.6	57.1	60.0	56.1	35.7
Genetic	36.4	28.1	32.1	48.0	46.3	14.3
Farm biosecurity	29.3	12.5	28.6	48.0	39.0	7.1

* Values represent the percentage responding that the listed data sources are available in their country in electronic format. Grey boxes identify the top data sources electronically available within each OIE Region.

Resource limitations for utilizing data generated from information technologies

The resources required to consume and utilize information (*e.g.*, the burden of other administrative commitments that leaves little time to utilize the data for planning and decision-making) was identified by respondents as the most common limitation/constraint affecting a country's ability to utilize data generated from information technology solutions. When the response rates for "impacts" and "strongly impacts" were combined, 70.2% of OIE Member Countries responded affirmatively. Other limitations identified by >50% of respondents were database design and functionality to meet end-user needs (55.3%), gaps in time series of data (*i.e.*, time between data collection and reporting to the Veterinary Authority, 53.2%), weakness in analytical capabilities to analyze data (52.5%), and incomplete reporting (50.4%).

The combined affirmative response rates including "somewhat impacts", "impacts", and "strongly impacts" for each limitation are as follows: resources needed to utilize information, 93.6%; weakness is dissemination of processed or analyzed data to field staff or other interested parties or targeted entities, 84.4%; weakness in analytical capabilities to analyze data, 82.3%; database design and functionality, 81.6%; gaps in time series of data, 78.0%; incomplete reporting, 76.6%; problems of interpretation and dissemination, 75.2%; technology acceptance, 74.5%; data protection and confidentiality issues, 69.5%; non-collection of important disease data, 68.8%; and system and data security, 67.4%.

Other limitations mentioned by respondents included motivating field staff to use technologies, cost or budget constraints, training, administrative procedures or legal provisions that limit use, and weather conditions (e.g., extreme cold) that adversely affect technology function in the field.

3.5. Requirements for Technology Insertion

Technology insertion is the process of incorporating new or improved technology solutions into existing platforms or systems [5]. When surveyed on needs for technical capacity building assistance and technology advising or guidance, countries responded in the affirmative. The needs were highest for technologies related to remote data collection (76.4%), diagnostics (74.3%), and information management systems (72.1%). In general, countries did not report as strong of a need for capacity building or technology assistance with online media (50.7%). Countries noted that any technical capacity building should include assistance on the application (e.g., capabilities for data analysis) and sustainment of these technologies, of which may need to be tailored to a region and/or country.

An overwhelming majority of all respondent countries (88.6%) reported that data standards should be set in cooperation with the OIE. This would allow for efficient data sharing and reporting of disease information among Member Countries and the OIE. Only 7.9% of countries responded "no" and 3.6% of countries were not sure if data standards are needed.

4. Discussion

OIE is the world leader in communicating and providing information on global animal and zoonotic diseases. Transparency and timely communication of the global animal health events form the foundation for improving animal and public health, food security, and economic stability. The OIE promotes the use of new technologies to support this core objective and in doing so, works with Member Countries to leverage advances for strengthening disease surveillance and reporting capabilities.

Responses from the questionnaire highlight the breadth of information technologies that are available to OIE Member Countries. With the exceptions of remote sensing, POC testing, and tele-diagnostics, the technologies that were evaluated are broadly available (>75%) within the global animal health community. Technologies for data management, online data entry, mobile devices, and LIMS systems are currently considered the most effective and important for supporting animal health in both routine and outbreak situations, and as such, were also identified as high priority technologies for implementation. However, the results of the questionnaire also identified that these same technologies are currently being utilized at significantly low levels relative to their availability. Furthermore, even with the widespread availability of m-health and e-health technologies, there continues to be a substantial amount of paper-based reporting and data management activities.

Identifying and understanding the limitations that are preventing implementation and use of available technologies will be critical to defining the path forward towards broader adoption and use. Not surprisingly, results from the survey indicated that there are significant resource (financial and personnel) and data limitations within the global animal health community that are affecting not only the implementation of technologies, but also the utilization of data generated as a result of their use. Within the Africa, Asia, Far East, and Oceania, and Middle East regions, training, IT support/expertise and internet availability were also identified as common constraints to implementation. The OIE can help address many of these limitations through continued support and promotion of the OIE Performance of Veterinary Services (PVS) pathway and gap analysis tool. The PVS tool can help identify and develop a strategy for addressing gaps in information technology adoption and utilization within OIE Member Countries. Once gaps are identified, the OIE can support training and capacity building through twinning opportunities, regional workshops, and technology demonstrations.

The OIE endorses a One Health approach to enhance animal, public and ecosystem health globally. In support of this effort, they have developed a considerable track record of working with partner organizations (FAO, WHO, and the World Bank) to support and promote the integration of domestic animal, wildlife, and human health data. While results from this survey indicated sharing and integration of health data between these three sectors is occurring to some extent within all OIE regions, it is not at the level needed to support prevention, rapid identification and response to diseases at the human-animal interface. The OIE should continue to promote data sharing and integration within Member Countries and the inclusion of public health counterparts in this process, especially as information technologies are implemented. Key to supporting this effort will be the development of data standards and guidelines. Data standards are documented agreements on the representation, format, definition, structuring, tagging, transmission, manipulation, use, and management of data. Data standards support technology insertion by enhancing data quality and providing a method to

efficiently share information between different entities or information technology systems in a valid, meaningful, transparent, and actionable way. Furthermore, they can address the identified limitation of data quality and ultimately allow for a broader application of information technologies within OIE Member Countries. The overwhelming majority of respondents to the questionnaire support the development of data standards to allow for efficient data sharing and reporting of disease information among Member Countries and the OIE.

Overall, the results of the survey indicate that there is a need to enhance the implementation and use of technologies prioritized to those currently available, as well as opportunity for additional development of new technologies with a specific application to animal health. Information technologies for remote data collection and disease reporting, such as SMS texts messaging and mobile animal health applications ("apps") can provide low cost alternatives for real-time electronic data collection and reporting of animal health events at the local level. These technologies have the capability to provide for early detection of emerging diseases and continued monitoring of events as they occur. Respondents indicated broad utilization of mobile devices by veterinarians, CAHWs, and animal producers/owners, in addition to their central, provincial/regional/state, and local veterinary authority's offices. With the growing availability of this technology, there is a great opportunity to leverage its use for enhancing disease reporting at the local, national, regional, and global levels. Information management systems that integrate with mobile technologies can allow communication to occur multi-directionally, thereby increasing communication from the field to CVA offices and global databases (*i.e.*, OIE [WAHIS], FAO [Empress] and WHO) and from these central sources/databases back to the field. As is currently being seen in public health[6-8], there is also potential in animal health for social media to serve as a complement to data obtained by more traditional methods and allow this communication to reach a broader audience. Disease alerts and information flow to veterinarians, CAHWs, and animal owners/producers will be an integral part of future surveillance and disease reporting programs and allow for enhanced situational awareness and informed decision-making to occur at the local level. Key to accomplishing a multi-directional flow of information and sustaining the use of these technologies will be the identification and implementation of incentives that encourage participation. The OIE should work to identify and implement incentives that encourage early reporting from both formal and informal data sources. Methods for incentivizing, incorporating and analyzing "informal" animal health reports within the WAHIS system should be enhanced with input including verification from OIE Member Countries.

Results of the survey indicate that OIE Member Countries are keen to take advantage of existing and emerging technologies to support animal health for data management, disease outbreak reporting, active and passive surveillance, and emergency response. Information technologies offer substantial opportunities for enhancing animal, public and ecosystem health across the globe. OIE's support and/or involvement to promote the development, implementation, and integration of these technologies will be critical for establishing capacity for adoption and utilization.

5. Acknowledgements

The authors would like to thank IIAD staff, Ms. Sarah Caffey and Dr. Kelly Soltysiak, for data entry, and the U.S. Department of Agriculture Animal and Plant Health Inspection Service Veterinary Services (USDA-APHIS-VS), Dr. Terry McElwain, Associate Director and Regents Professor, Paul G. Allen School for Global Animal Health, College of Veterinary Medicine, Washington State University, and Dr. Keith Biggers, Director, Computing and Information Technology, Texas Center for Applied Technology, Texas A&M University for their review and input into the development of the questionnaire.

6. References

1 Lautner, Elizabeth A., Bjork, Kathe E., Wagner, Bruce, and Harris, Beth. 2013. Modern Approaches and the Use of New Technologies for the Control and Eradication of Aquatic and Terrestrial Animal Diseases that Fully Consider Animal Welfare and Minimize the Impact on Food Security. World Organisation for Animal Health (OIE) 81st General Session, World Assembly, OIE, Paris 26-31st, May 2013.

2 WHO. 2011. mHealth: New horizons for health through mobile technologies Global Observatory for eHealth Series [Online], Volume 3. Available: http://www.who.int/goe/publications/goe_mhealth_web.pdf [Last Accessed 13 March 2015].

3 OIE. 2010. Fifth Strategic Plan, 2011-2015.
Available: http://www.oie.int/fileadmin/Home/eng/About_us/docs/pdf/5th_StratPlan_EN_2010_LAST.pdf
[Last Accessed 13 March 2015].

4 WHO-OIE. 2010. WHO-OIE Operational Framework for Good governance at the human-animal interface: Bridging WHO and OIE tools for the assessment of national capacities. Available: http://www.oie.int/fileadmin/Home/fr/Media_Center/docs/pdf/WHO_OIE_Operational_Framework_Final2.pdf [Last Accessed 17 March 2015].

5 UK 2005. Ministry of Defence Interim DStan 00-79. "Technology Insertion" Part 1, Issue 1, 25th February 2005.

6 Schmidt, Charles W. 2012. Trending Now: Using Social Media to Predict and Track Disease Outbreaks. *Environmental Health Perspectives* 120.1 (2012): a30–a33.

7 Browstein, John S., Freifeld, Clark C., Madoff, Lawrence C. 2009. Digital disease detection – harnessing the web for public health surveillance. *N. Engl. J. Med.*, **360**:2153-2157.

8 HealthMap. HealthMap: Global, Local Information. www.healthmap.org [Accessed 21 March 2015].

APPENDIX 1

Definition of current and new information technologies and animal health settings used in the Technical Questionnaire for the 83rd General Session

TERM	DEFINITION
Active Surveillance	Investigator-initiated collection of animal health related data using a defined protocol to perform actions that are scheduled in advance. Decisions about whether information is collected, and what information should be collected from which animals is made by the investigator.
Animal Health and Data Management Software	Software, either open source or proprietary, with primary purposes to store, process, and organize data while maintaining data security and integrity.
Biosensors	A biological sensor that serves as an analytical device to provide real-time monitoring and measuring of various animal metrics, such as body temperature, movement, heart rate, and/or changes in body analytes (e.g. protein or enzyme levels).
Health Information Systems	Any system that captures, stores, manages or transmits information related to the health of individuals or the activities of organisations that work within the health sector.
Information Technology	The comprehensive management of animal health information across computerized systems and its secure exchange between consumers, providers, government and other entities. Technology systems allow data and information to be stored, processed, shared, and analyzed.
Laboratory Information Management System	Software-based laboratory and information management system that offers a set of features that support day-to-day operations of a laboratory.
mHealth	The use of mobile devices in collecting aggregate and animal level health data, providing healthcare information to animal owners, community animal health workers, veterinary practitioners, researchers, and animal health officials, real-time monitoring of animal health status, and direct provision of care (via mobile telemedicine/tele-diagnostics).
Mobile Technology	Technology used for cellular communication. Includes the use of mobile devices (e.g., smartphones, tablets) to support animal health activities such as remote data collection and reporting.
Passive Surveillance	Observer-initiated provision of animal health related data (e.g. voluntary notification of suspect disease) or the use of existing data for surveillance. Decisions about whether information is provided, and what information is provided from which animals is made by the data provider.
Remote Sensing	The science and art of obtaining information about an object, area, or phenomenon through the analysis of data acquired by a device that is not in contact with the object, area, or phenomenon under investigation.
RFID	Radio-frequency identification technology that can be attached on the outside of an animal or injected; the technology provides an automated method to support activities such as animal identification and traceability.
Tele-diagnostics	Diagnostic medicine that is based on the evaluation of data transmitted from instruments that are monitoring and/or testing an animal at a remote location.

APPENDIX 2

List of OIE Member Countries responding to the questionnaire

Afghanistan, Algeria, Andorra, Angola, Argentina, Armenia, Australia, Austria, Azerbaijan, Bahamas, Bahrain, Bangladesh, Barbados, Belgium, Belize, Benin, Bolivia, Bosnia and Herzegovina, Botswana, Brazil, Brunei, Bulgaria, Burkina Faso, Cambodia, Cameroon, Canada, Cape Verde, Chad, Chile, China (People's Republic of), Colombia, Congo (Democratic Republic of the), Costa Rica, Croatia, Cuba, Cyprus, Czech Republic, Denmark, Djibouti, Dominican (Republic), Ecuador, Egypt, El Salvador, Estonia, Ethiopia, Finland, France, Germany, Greece, Guatemala, Guinea, Guinea Bissau, Haiti, Honduras, Hungary, India, Indonesia, Iran, Iraq, Ireland, Israel, Italy, Jamaica, Japan, Jordan, Kazakhstan, Kenya, Korea (Republic of), Kuwait, Latvia, Lebanon, Lesotho, Liechtenstein, Lithuania, Luxembourg, Madagascar, Malawi, Malaysia, Maldives, Malta, Mauritania, Mauritius, Mexico, Micronesia (Federated States of), Moldova, Mongolia, Morocco, Mozambique, Myanmar, Namibia, Nepal, Netherlands, New Caledonia, New Zealand, Nicaragua, Niger, Nigeria, Norway, Oman, Pakistan, Panama, Paraguay, Peru, Philippines, Poland, Portugal, Republic of Macedonia, Romania, Russia, Rwanda, Saudi Arabia, Senegal, Serbia, Seychelles, Singapore, Slovakia, Slovenia, South Africa, Spain, Sri Lanka, Sudan, Suriname, Swaziland, Sweden, Switzerland, Syria, Taipei (Chinese), Tajikistan, Tanzania, Thailand, Trinidad and Tobago, Tunisia, Turkey, Uganda, United Arab Emirates, United Kingdom, United States of America, Uruguay, Uzbekistan, Venezuela, Vietnam, Yemen, Zambia, Zimbabwe.