81st General Session World Assembly
World organisation for animal health Paris, 26-31 May 2013

81 SG/9

Original: English

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

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***Summary**: The continued development of new technologies in the sciences of animal health, veterinary public health and animal welfare has improved early warning detection and epidemiological response for disease control and eradication. As new technologies are developed and deployed for the control and eradication of aquatic and terrestrial animal diseases, approaches for integrating these methods into current standards and guidelines will be needed.*

A questionnaire was sent to the Delegates of all 178 OIE Member Countries to assess the impact new technologies would have on disease control and eradication in OIE Member Countries. The questionnaire also attempted to determine how these technologies will affect the OIE's role in ensuring that new methods and the best scientific practices are validated and incorporated to improve animal health and welfare and positively impact food security worldwide. Summarized questionnaire responses indicate that the vast majority of OIE Member Countries consider new technologies to be important for controlling and eradicating animal disease. OIE Member Countries have incorporated at least some new technologies into their current national veterinary programs. Among all countries, foot-and-mouth disease, animal influenza and rabies were identified as the priority diseases for developing or implementing new technologies. Diseases impacting aquaculture tended to have lower priority for implementation overall, but were geographically associated with aquaculture production. Lack of infrastructure, resources, and scientific evidence were identified as the most frequent barriers to implementing new technologies. Disease transmission modeling and risk assessments were the technologies that most countries would request assistance in technical capacity building. Vaccine technologies such as DIVA and high potency vaccines are not currently widely available or used, but over three fourths of the countries would support their use. However, prior to the implementation of new technologies, respondents believed there could be a need to update some current OIE standards and guidelines, and provide guidance to OIE Member Countries on their validation and use.

1. Introduction

Technologies now available to the global animal health community are changing the way animal diseases are detected, managed, controlled, and eradicated. These technologies have also provided opportunities to improve animal health and welfare and contribute to public health while reducing economic losses to the aquatic and terrestrial animal industries and enhancing food security. The OIE's philosophy of excellence in its scientific expertise is highlighted as a major objective under its Fifth Strategic Plan (2011-2015). This Plan provides for a continued commitment to strengthen technical capacities, management, legislation and good governance of Member Countries' Veterinary Services (VS) in collaboration with global partners with the support of donors.

Developments in science will continue to provide opportunities for improving methods for disease detection, control and eradication for the global community. The OIE is committed to working with key partners to assist in incorporating these tools into the overall animal health plans of OIE Member Countries as part of a strategic global scientific research and development agenda for high-impact infectious diseases. Through capacity building with the OIE Performance of Veterinary Services (PVS) Pathway Tool and twinning projects with its Reference Laboratories and Collaborating Centres, the OIE will continue to strengthen the ability of OIE Member Countries' VS to incorporate these technologies while improving their ability to participate in the development of international standards and guidelines.

2. Application of New Technologies

New technologies continue to be successfully implemented by many countries, which has led to improved animal disease control and eradication efforts worldwide. As examples, the use of differentiating infected from vaccinated animals (DIVA) vaccines and an accompanying diagnostic enzyme-linked immunosorbent assay (ELISA) contributed to the eradication of pseudorabies virus from the U.S. domestic swine population (Ma, *et al.*, 2008) and the DIVA strategy was successfully used by Italy for eradicating low pathogenic avian influenza from domestic poultry (Marangon, *et al.*, 2008; Marangon, *et al.*, 2003).

Since 2005, the OIE has supported a range of activities for the use of epidemiological models among its Member Countries, including sponsoring a Technical Item presentation at the 2007 General Session; developing general OIE guidelines for the development, verification, validation and use of epidemiological models; establishing an *ad hoc* Group on Epidemiological Modeling and Animal Disease Management, and hosting a meeting of this *ad hoc* Group in 2008. In 2011, the OIE published a *Scientific and Technical Review*, which included a series of manuscripts describing a variety of modeling strategies and their applications (OIE, 2011). Disease modeling techniques are also used by policymakers as aids for developing infection control strategies and to support policy and decision making at the national level. The sustained interest and importance of modeling to the international veterinary community is also evident, as these methods continue to be used to develop policies for control and planning of diseases of importance such as pseudorabies in Thailand (Ketusing, *et al.*, 2011) and classical swine fever in the European Union (Brosig, *et al.*, 2012). Modeling studies have been conducted to assess the effectiveness of control strategies and screening performance in making more science-based decisions and minimizing economic losses related to a vaccination-to-live strategy for FMD (Backer, *et al.*, 2012).

Examples of other new technologies that can improve surveillance and diagnosis of terrestrial and aquatic diseases include loop-mediated isothermal amplification (LAMP) methods. These polymerase chain reaction (PCR)-based tests do not require expensive laboratory equipment to obtain results, making these tests feasible for use under field conditions (Fu, *et al*., 2011), and are currently developed to detect diseases such as shrimp yellow head virus (Khunthong, *et al.*, 2013), Rift Valley fever virus (Le Roux, *et. al.*, 2009), and capripoxviruses (Das, *et al.*, 2012). Other technologies such as pooling samples for cost-effective surveillance are being explored. These include the use of PCR assays to identify foot and mouth (FMD) virus from bulk milk samples in dairy herds (Thurmond and Perez, 2006) and oral fluids of swine (Ramirez, *et al.*, 2012).

Although terrestrial animal diseases tend to be at the forefront for new technology development, these tools are also impacting the control of aquatic diseases. For example, the use of molecular epidemiology techniques has provided an improved understanding of natural distribution of viral diseases in salmonid fish, which in turn has improved the ability to trace sources of new disease outbreaks and disease transmission (Snow, 2011). Other methodologies of interest to the OIE Member Countries for future use include microarray and chip technologies for identification of animal pathogens, new whole-genome sequencing methods for use in molecular epidemiology and disease transmission, and nanotechnology applications.

Scientific advancements continue to produce new methods and improve existing tools for animal disease detection, control and eradication. The OIE and its Reference Laboratories and Collaborating Centres must look ahead to identify, assess and validate those technologies most appropriate for addressing the needs of the OIE Member Countries, including developing guidance for newly emerging diseases. This effort will ensure new technologies for use that are robust, are an improvement over current methods, are properly validated, and are incorporated into OIE standards and guidelines in a timely and transparent manner.

3. Questionnaire

The Technical Questionnaire for the 81st General Session M*odern 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* was comprised of 13 questions, including several multi-part questions, as well as opportunities to provide free-text responses. This questionnaire was distributed to 178 Delegates on November 26, 2012 in the three official languages of the OIE (English, French and Spanish). Responses were requested by January 28, 2013, but completed questionnaires submitted through February 19, 2013 were included in the analysis. An additional questionnaire was received after February 19, and was not included for data analysis. However, responses were reviewed, and were in line with overall and regional results.

The nine new technologies addressed in this questionnaire focused on three broad categories: disease analysis and trending, use of diagnostic testing techniques, and use of vaccine technologies. The specific technologies represented in the 2013 survey are listed below. Definitions used in the questionnaire for these technologies are found in Appendix 1.

- Disease transmission modeling
- Disease risk assessments
- Nucleic acid-based laboratory tests for screening and disease confirmation
- Pen-side or animal-side diagnostic tests
- Population testing
- DIVA vaccines
- High potency vaccines
- Molecular epidemiology techniques

The questions were designed to address how OIE Member Countries are currently implementing new technologies for eleven zoonotic and non-zoonotic diseases and the priority of their country's Veterinary Services (VS) for making use of new methodologies in the near future.

This questionnaire also requested information on practices employed by OIE Member Countries during both routine testing and outbreak situations, including outbreak situations where there could be consideration of slaughtering animals for human consumption. Respondents were asked questions regarding conditions for which new technologies would be implemented for future disease outbreaks, and potential limitations impacting these decisions. A specific question was posed regarding the adoption of DIVA or high potency vaccines for controlling outbreaks. Finally, OIE Member Countries were asked to provide input on changes in policies and guidance that should be considered by the OIE and Members' VS so that technologies such as DIVA vaccines could be utilized for international trade.

The need and interest for specific improved technologies varies between different regions and countries throughout the OIE membership, and is dependent on whether the final objective of implementation is for animal and human health, food security, and/or trade. However, by making improvements in these technologies, national authorities can focus resources and increase the likelihood of stopping disease from spreading to uninfected populations while working to protect public health and food security, and preventing the needless depopulation of uninfected animals.

4. Responses from OIE Member Countries

Of the 178 OIE Member Countries polled, responses were received from 109, for an overall response rate of 61.2%. Countries were assigned to one of five regions for data analysis and regional summarization based on OIE Regional Commissions. The five Regional Commissions are: Africa (52 countries), Americas (30 countries), Asia, Far East and Oceania (36 countries), Europe (53 countries), and the Middle East (20 countries). Not all countries within each region returned a completed form. Response rates for each region were: Africa – 48.1%, Americas – 72.4%, Asia, Far East and Oceania – 48.4%, Europe – 77.4% and the Middle East – 46.1%. A complete list of countries responding to this questionnaire is found in Appendix 2.

4.1. Current Utilization of New Technologies

Recently, several new technological developments have become available for disease control, and countries were asked to comment on those currently in use by their VS. Among all responding countries, **the most frequently utilized technologies were risk assessments (50.6%) and nucleic acid-based test for disease confirmation (43%).** In contrast, the technologies least likely to be used by OIE Member Countries were high potency and DIVA vaccines, at 13.0% and 8.2% respectively. This low percentage likely is due in large part to the lack of availability of DIVA vaccines and availability of high potency vaccines for the OIE listed diseases.

FMD (39.6%), classical swine fever (16.0%), brucellosis (14.6%) and animal influenza (11.8%) were indicated by OIE Member Countries as diseases in which DIVA vaccines were available for use in their countries. High potency vaccines were indicated to be available for use for rabies (37.2%), FMD (29.4%), classical swine fever (22.8%), peste des petits ruminants (20.4%) and brucellosis (18.6%).

There were differences in the application of specific technologies among regions (Table 1). In general, disease transmission modeling is not widely used, with affirmative response rates varying from 33.3% (Middle East) to 9.5% (Africa). A wide range in use among regions was also noted for nucleic acid-based tests utilized for screening or surveillance purposes, with regional responses varying from 54.5% (Asia) to 21.6% (Americas). Pen-side and population testing are also not currently used by the majority of countries, with an overall affirmative response rate of 19.8% to 29.9%. Another survey area with a wide range in utilization was in the application of molecular epidemiology techniques, with 52.5% use by Europe and 14.2% by Africa.

Table 1. Frequency of utilization of new technologies, by all responding countries and by OIE Regional Commission

Region	Disease transmission modeling	Disease risk assessments	Rapid nucleic-acid-based laboratory tests for screening samples	Rapid nucleic-acid-based laboratory tests for confirmation in diagnostic samples	Pen-side or animal-side diagnostic tests	Population testing	DIVA vaccines	High-potency vaccines	Molecular epidemiology techniques
All countries	19.4 %*	50.6 %	37.9 %	43.0 %	19.8 %	29.9 %	8.2 %	13.0 %	34.2 %
Africa	9.5 %	35.6 %	23.3 %	17.1 %	17.8 %	29.5 %	2.2 %	11.6 %	14.2 %
Americas	16.5 %	45.5 %	21.6 %	34.2 %	17.7 %	24.7 %	8.7 %	5.6 %	25.5 %
Asia, Far East, and Oceania	22.4 %	61.2 %	54.5 %	52.7 %	24.2 %	27.3 %	10.3 %	16.4 %	35.8 %
Europe	23.7 %	59.9 %	50.6 %	62.5 %	19.5 %	34.8 %	10.6 %	15.5 %	52.5 %
Middle East	33.3 %	40.9 %	27.3 %	24.2 %	25.8 %	22.7 %	10.6 %	19.7 %	18.2 %

* Values were summed over all diseases and represent percentage responding "Yes" to Questionnaire Item 1: "Indicate for each disease listed those technologies available for use in your country."

Animal influenza (48.5%) and FMD (44.7%) were the two most frequently identified diseases where all countries were presently using at least some of the technologies for disease control and eradication (Table 2). When evaluated at a regional level, responses for animal influenza ranged from 60.7% (Asia) to 38.7% (Africa). A similar range of responses was seen for FMD (57.4% to 28.4%). Diseases with the lowest frequency of application of the technologies overall were Rift Valley fever (12.0%) and infectious salmon anemia (13.4%).

Table 2. Utilization of new technologies for all diseases, by OIE Regional Commission

Disease	All Countries	Africa	Americas	Asia, Far East and Oceania	Europe	Middle East
Animal influenza	48.5 %*	38.7 %	45.0 %	60.7 %	51.5 %	50.0 %
Bovine TB	28.7 %	17.8 %	27.0 %	39.3 %	33.3 %	22.2 %
Brucellosis	36.9 %	28.4 %	37.6 %	37.8 %	40.9 %	40.7 %
Rabies	29.3 %	13.8 %	19.0 %	36.3 %	41.5 %	29.6 %
Rift Valley fever	12.0 %	15.1 %	5.8 %	9.6 %	14.4 %	11.1 %
African Swine fever	20.9 %	13.3 %	8.5 %	19.3 %	35.5 %	0.0 %
Bluetongue, orbiviruses	25.6 %	8.0 %	9.5 %	28.1 %	44.2 %	22.2 %
Classical swine fever	32.6 %	4.4 %	38.1 %	44.4 %	47.4 %	0.0 %
Foot-and-mouth disease	44.7 %	28.4 %	34.9 %	57.0 %	53.1 %	57.4 %
Infectious salmon anemia	13.4 %	0.4 %	13.8 %	14.8 %	22.5 %	0.0 %
Peste des petits ruminants	20.3 %	28.0 %	5.3 %	25.2 %	18.7 %	38.9 %

* Values represent percentage responding "Yes" to Questionnaire Item 1: "Indicate for each disease listed those technologies available for use in your country" for each disease.

Many respondents reported other diseases of importance that were not listed in the questionnaire. Most frequently mentioned were Newcastle disease (10 responses) and anthrax (8 responses), with Aujeszky's disease and contagious bovine pleuropneumonia tied for third place (4 responses each).

The usage of specific technologies was significantly different between zoonotic and non-zoonotic diseases. Pen-side or animal-side testing was used at a significantly higher rate for zoonotic diseases than for non-zoonotic diseases ($p<0.001$). Population testing for the zoonotic diseases was used much more frequently than for non-zoonotic diseases ($p<0.001$). Other technologies that differed significantly were use of disease risk assessments ($p=0.01$), and rapid nucleic-acid based tests for screening ($p=0.04$). Of these, only application of rapid nucleic acid based laboratory tests for screening samples was significantly higher for non-zoonotic diseases.

4.2. Priority for Development or Implementation of New Technologies

Key trends were observed in OIE Member Countries priorities for implementing new technologies, with the type of disease having a major impact (Table 3). **Among all countries, 61.2% rated foot-and-mouth disease as a "high" priority for implementing new technologies**; for four out of the five regions, FMD was the highest priority for implementing new technologies. **Animal influenza and rabies were the next two diseases of priority for OIE Member Countries**, with an average of 51.7% and 45.7%, respectively, of all countries ranking these as high priority for developing or implementing new technologies.

These observed region-specific differences may be related to disease prevalence and risk to livestock sectors and the public. For example, in the Asia, Far East and Oceania Regional Commission, animal influenza was 2nd highest priority (63.7%), whereas in Africa, the 2nd highest priority was peste des petits ruminants (56.9%). The Middle East also ranked animal influenza as their 2nd highest priority (57.4%), with peste des petits ruminants a close 3rd (55.6%). European countries' 2nd highest priority was rabies (50.7%), whereas the two highest priorities in the Americas were classical swine fever (55.6%) and animal influenza (52.4%). Again, other diseases mentioned by respondents as a priority for implementing new technologies were Newcastle disease (9 respondents), anthrax (7 respondents), and Aujeszky's disease (3 respondents).

Table 3. Priority for developing or implementing new technologies by disease and by OIE Regional Commission

Region	Response	Animal influenza	Bovine TB	Brucellosis	Rabies	Rift Valley fever	African swine fever	Bluetongue and other orbiviruses	Classical swine fever	Foot-and-mouth disease	Infectious salmon anemia	Peste des petits ruminants
All countries	Low	18.4%	34.0%	27.0%	23.0%	46.3%	36.0%	28.1%	29.6%	12.1%	45.5%	37.7%
	Medium	18.0%	24.7%	23.8%	16.2%	15.4%	9.6%	24.9%	17.2%	14.0%	10.6%	15.2%
	High	51.7%	28.2%	36.8%	45.7%	18.2%	33.5%	25.8%	38.2%	61.2%	12.4%	26.4%
	Don't know	5.2%	6.0%	6.3%	7.2%	8.4%	8.6%	9.9%	6.6%	5.5%	17.5%	8.5%
	No response	6.6%	7.2%	6.2%	7.9%	11.6%	12.2%	11.3%	8.4%	7.2%	14.0%	12.1%
AFRICA	Low	13.8%	25.8%	15.6%	13.8%	15.1%	27.6%	24.9%	45.8%	4.9%	38.7%	9.8%
	Medium	18.2%	20.4%	21.8%	9.8%	77.8%	4.9%	19.6%	8.4%	8.0%	2.7%	8.9%
	High	49.8%	29.3%	41.3%	51.6%	1.8%	37.8%	14.2%	12.9%	63.1%	6.7%	56.9%
	Don't know	10.7%	15.1%	12.4%	12.9%	5.3%	13.3%	25.3%	16.4%	12.9%	28.0%	12.0%
	No response	7.6%	9.3%	8.9%	12.0%	5.3%	16.4%	16.0%	16.4%	11.1%	24.0%	12.4%
AMERICAS	Low	22.2%	27.5%	28.0%	33.9%	5.8%	49.7%	46.6%	25.4%	22.2%	38.6%	68.8%
	Medium	18.0%	25.4%	28.0%	18.5%	76.2%	10.6%	16.9%	13.2%	15.9%	9.5%	0.5%
	High	52.4%	35.4%	38.1%	34.9%	0.0%	16.9%	15.9%	55.6%	50.8%	11.6%	1.6%
	Don't know	1.6%	3.7%	1.1%	3.2%	18.0%	4.8%	5.8%	0.5%	3.2%	24.3%	11.1%
	No response	5.8%	7.9%	4.8%	9.5%	18.0%	18.0%	14.8%	5.3%	7.9%	15.9%	18.0%
ASIA, FAR EAST, OCEANIA	Low	14.8%	37.0%	37.0%	22.2%	9.6%	41.5%	34.1%	15.6%	10.4%	50.4%	40.0%
	Medium	12.6%	24.4%	17.8%	21.5%	77.8%	9.6%	27.4%	33.3%	9.6%	9.6%	14.8%
	High	63.7%	32.6%	33.3%	43.0%	0.7%	27.4%	29.6%	44.4%	74.8%	13.3%	26.7%
	Don't know	8.9%	4.4%	5.2%	12.6%	11.9%	15.6%	5.2%	6.7%	4.4%	14.8%	5.9%
	No response	0.0%	1.5%	6.7%	0.7%	11.9%	5.9%	3.7%	0.0%	0.7%	11.9%	12.6%
EUROPE	Low	22.0%	40.9%	33.1%	26.0%	14.4%	29.5%	21.4%	23.6%	13.6%	53.1%	43.1%
	Medium	21.4%	27.6%	24.9%	16.3%	70.7%	12.5%	28.7%	21.1%	19.5%	15.4%	26.3%
	High	47.4%	23.8%	32.5%	50.7%	8.4%	46.6%	37.4%	48.0%	59.3%	17.9%	16.3%
	Don't know	3.0%	2.4%	6.0%	2.4%	6.5%	4.6%	4.9%	2.2%	3.3%	4.9%	7.3%
	No response	6.2%	5.1%	3.5%	4.6%	6.5%	6.8%	7.6%	5.1%	4.3%	8.7%	7.0%
MIDDLE EAST	Low	9.3%	35.2%	3.7%	5.6%	11.1%	53.7%	7.4%	53.7%	1.9%	33.3%	1.9%
	Medium	7.4%	20.4%	24.1%	20.4%	63.0%	5.6%	42.6%	0.0%	5.6%	16.7%	18.5%
	High	57.4%	16.7%	51.9%	31.5%	3.7%	0.0%	20.4%	0.0%	68.5%	0.0%	55.6%
	Don't know	1.9%	3.7%	3.7%	16.7%	22.2%	13.0%	5.6%	16.7%	0.0%	42.6%	0.0%
	No response	24.1%	24.1%	16.7%	25.9%	22.2%	27.8%	24.1%	29.6%	24.1%	7.4%	24.1%

Technologies with the highest priority for development and implementation were disease risk assessments (44.1%), rapid nucleic acid-based laboratory tests for disease confirmation (43.6%), and molecular epidemiologic techniques (41.8%).

Overall, zoonotic diseases were rated significantly higher for development and implementation of technologies. Pen- or animal-side testing ($p<0.001$), disease risk assessments ($p<0.001$), population testing ($p=0.003$) and disease transmission modeling ($p=0.01$) were all identified as high priorities.

4.3. Technologies for Advancing Animal Health and Welfare

Approximately 81% of all countries responded that they were planning on implementing one or more of these new technologies for future outbreak situations. The situations where new technologies were considered most important were disease risk assessments (99.1%), rapid nucleic-acid based laboratory tests (91.7%) and disease transmission modeling (90.7%). All of these technologies were identified by approximately 75% of all respondents as being important for advancing animal health and welfare.

Of note, there was increased interest in using disease risk assessments and pen-side testing for zoonotic diseases compared to non-zoonotic diseases.

Additional technologies that OIE Member Countries noted as important included improved forms of animal identification and traceability systems for animal movement, use of Geographic Information Systems (GIS) for risk assessments and risk mapping, vector surveillance, socio-economic assessments and various diagnostic testing platforms for disease identification and confirmation.

4.4. Use of New Technologies in Routine and Outbreak Situations

For routine testing, new technologies were most often used by countries for supporting policy decisions (93.5%), diagnostic testing (91.7%), and routine surveillance (90.7%). New technologies were least likely to be used by a country's VS for zoning or compartmentalization for routine animal movement. Other uses for new technologies reported by various countries were noted, including monitoring terrestrial and aquatic animals in quarantine for import/export, use in trade assurances, use in disease preparedness planning exercises, and development of health standards/certifications.

In the case of disease outbreaks, new technologies were most frequently used for disease confirmation (91.7%), to support VS policy decisions (89.8%), and disease screening (88.9%). Other uses provided by survey respondents included import/export decisions, epidemiological investigations, and estimating resources needed for an outbreak response such as personnel and vaccines.

As noted previously, the value of using new technologies for disease control and eradication is apparent to the OIE membership, as the majority of countries indicated their plans to implement one or more of these new technologies in future outbreak situations. Circumstances cited where new technologies could be used were disease monitoring and confirmation, rapid diagnosis of disease during either endemic or emerging/foreign animal disease outbreaks, and demonstrating disease freedom after an outbreak is contained. Disease transmission modeling and risk assessments were also cited by several respondents as tools requiring implementation during outbreak situations. Less frequently cited was utilization of new vaccination strategies such as DIVA or high potency vaccines. Again this low use likely reflects the lack of availability of DIVA strategies and high potency vaccines for the range of diseases included on the survey.

Responses from this questionnaire indicate that 75.9% of countries supported the use of DIVA or high potency vaccination strategies during a disease outbreak. Support varied by region, with a high of 85% in the Americas and 82.9% in Europe, and a low of 66.7% for both the Middle East and Asia, Far East and Oceania Regional Commissions.

4.5. Impact of Outbreaks on Use of Animals for Human Consumption

A major criticism of the "stamping out" disease policy for the eradication of FMD is public concern for animal welfare and impact on food security. This approach can result in the destruction of large numbers of uninfected animals that could potentially be used for human food consumption.

In general, OIE Member Countries were more likely to consider allowing animals to be slaughtered for human consumption in outbreaks involving non-zoonotic diseases. VS would be most likely to consider allowing slaughter of animals for human consumption for non-clinically ill, test negative, vaccinated animals from control areas with non-zoonotic diseases (80.6%). Non-vaccinated animals that had recovered from disease or non-clinically ill, test positive animals by a nucleic acid-based test method had the least likelihood of being allowed for human consumption if the outbreak involved a non-zoonotic disease (42.6%, and 29.6%, respectively). For zoonotic diseases, VS were much less likely to consider allowing slaughter for human consumption, with only 7.4% responding that they would consider allowing animals for human consumption if they were test positive. Many respondents noted that these decisions were disease- and product-specific, and would need to be made on a case by case basis. **Other factors, including relative risk to public health including the animal and human component, public perception, and relevant international and domestic requirements and guidance were also cited as important factors impacting a country's decision for allowing animals to be slaughtered for human food consumption during an outbreak.**

4.6. Limitations to Implementation of New Technologies

The lack of scientific evidence and the lack of infrastructure or resources to support new technologies were equally identified by OIE Member Countries as the two most common limitations for implementing new technologies. When the response rates for "impacts" and "strongly impacts" were combined for these two answers, 70.4% and 70.3% of OIE Member Countries, respectively, responded affirmatively.

When "somewhat impacts" responses were included into the affirmative response category, the affirmative response rate range for all limitations was between 81.4% and 96.2%, indicating that the limitations listed had at least some influence on a country's ability to implement these new technologies. Combined affirmative response rates including "somewhat impacts", "impacts" and "strongly impacts" for each limitation are as follows; lack of resources/infrastructure, 96.2%, lack of scientific evidence to support the use of this technology, 88.0%, techniques not validated in country, 82.5%, and technique not recognized by the OIE, 81.4%.

Other limitations mentioned by respondents included the difficulty in obtaining positive/negative controls and reference reagents for implementation of new laboratory tests, the acceptance or approval of the use of these technologies by regional multi-national regulatory bodies, limited availability of technical specialists in fields such as bioinformatics, molecular epidemiology, immunologists and biostatisticians to implement these technologies, and the acceptability of these new technologies to consumers.

4.7. Technical Capacity Building Needs for New Technologies

Among all countries, respondents' reported needs for technical capacity building for new technologies were highest for disease risk assessments (74.1%), disease transmission modeling (73.1%), molecular epidemiology techniques (63.9%) and DIVA vaccines (62.0%). The lowest affirmative response rate for any of the technologies listed was 53.7%, indicating a need among the OIE Member Countries for all of these technologies.

Additional suggestions for capacity building included the development of an international classification system for aquatic animal diseases, metagenomics, and socioeconomic impact studies. Improved support for testing and validation of technologies through better access to positive controls and animal specimens from OIE Collaborating Centres or Reference Laboratories, and development of OIE twinning projects were also mentioned as needed assistance.

4.8. Changes Needed to Recognize or Implement New Technologies

Slightly over half of all respondent countries (55.6%) reported that a change in international standards for trade would be necessary should DIVA or high potency vaccines or other technologies be adopted by the OIE. Approximately one-fourth of countries were not sure if a change would be needed (23.1% responded "Don't Know"), and 19.4% responded "No" (1.9% did not respond to the specific question). **Respondents noted that provisions for more traditional methods of disease control must remain,** as it cannot be assumed that all countries will have the capacity to rapidly adopt these new technologies and equivalency standards and/or transition times would be needed.

Recommendations for changes to international trade standards included items such as clarifying the guidelines for movement or export of vaccinated animals and animal products, incorporating guidance for countries utilizing a "vaccinate-to-live" policy, developing standardized criteria for determining the status of vaccinated animals, and understanding the impact of vaccine on controlling disease vs. infection. The impact on timeframes needed to re-initiate trade for countries using high potency vaccines was noted as well as harmonization of diagnostic tests methods and test interpretation to ensure scientific consensus. In addition, consultation with human health officials was noted as important with respect to zoonoses.

Slightly over half of the countries (51.9%) responded that a change in current OIE definitions, *Codes* or *Manuals* would be needed when new technologies such as DIVA or high potency vaccines and corresponding diagnostic tests are adopted, however, 25.9% were not sure if changes would be needed. In their comments, OIE Member Countries noted that the changes would need to be specific for individual diseases and must be science-based. Again, clarification on the use and interpretation of DIVA vaccines and test results was requested, including details on DIVA vaccine production. Respondents indicated they continued to have questions regarding the determination of the status of vaccinated animals and surveillance requirements regarding absence of infection and absence of virus circulation. Recently, Caporale, *et al.*, 2012 addressed this topic noting that surveillance strategies must be based on a solid VS infrastructure.

Slightly less than half of responding countries (46.2%) said that additional processes should be considered by the OIE to allow for rapid incorporation of these new technologies into its *Manuals* and *Codes,* but 29.6% indicated that they were not sure if changes would be needed. There were also many comments related to maintaining current processes that provide for a transparent and thorough evaluation. Responding countries indicated that under certain situations a more rapid and flexible process might be valuable. Suggestions from the respondents for improving the current process included convening specialized *ad hoc* Groups to evaluate new technologies, holding more frequent meetings of current *ad hoc* Groups, organizing regional meetings or conferences for discussions and possible trainings with case studies, and inviting the specialized Commissions of the OIE to develop and submit proposals to the World Assembly.

5. Discussion

The OIE has a strong history of ensuring that new methods and the best scientific practices are incorporated into its standards and guidelines–. The OIE also developed a procedure for Validation and Certification of Diagnostic Kits to assist its Member Countries to adopt new diagnostic technologies certified fit for a specific purpose. The OIE Fifth Strategic Plan acknowledged the importance of new technologies which can improve animal health and welfare through enhanced success in disease prediction, detection, control and eradication.

In order to ensure that new technologies are appropriately integrated into animal health standards and guidelines, the OIE sent the Member Countries a questionnaire to assess their current and envisaged use of new technologies. The results of the questionnaire used for this Technical Item confirmed the continued importance and value of OIE standards and guidelines and identified opportunities for additional contributions by the OIE and its scientific structures.

The OIE has dedicated efforts to the detection and control of animal influenza and FMD including collaborations with other international organizations. Responses from the questionnaire indicated that these efforts have been well-placed. These two diseases were the top diseases for which countries were utilizing some new technologies and also were listed in the responses as high priorities for continued implementation of new technologies.

Delegates did identify challenges to implementing new technologies. These challenges included the lack of sufficient scientific evidence to support their use, their lack of infrastructure or resources, techniques not being validated in their country, and techniques not being recognized by the OIE. Responses from OIE Member Countries also identified a strong need for technical capacity building related to new technologies especially with regard to disease risk assessments, disease transmission modeling, molecular epidemiology techniques and DIVA compatible vaccines. Respondents also noted the implementation of new technologies was limited by the difficulty in obtaining positive/negative controls and reference reagents as well as the limited availability of technical specialists in fields such as bioinformatics and molecular epidemiology.

Surveillance is critical to protecting animal health but continually evolving aquatic and terrestrial animal pathogens make it essential to frequently improve and validate the sensitivity and specificity of diagnostic tests used to detect and confirm important terrestrial and aquatic diseases. The questionnaire results indicated that a high priority for OIE Member Countries is the development and implementation of rapid nucleic acid-based laboratory tests for disease confirmation in diagnostic samples. Another high priority is the development of molecular epidemiologic techniques. Validation of new technologies including "fitness for purpose" for diagnostic testing continues to be a challenge for VS. In addition, it is recognized that technologies such as nucleic acid detection systems may be more sensitive and specific than existing "gold standard" methods which creates challenges in assay evaluations.

While there was much agreement in the responses to the questionnaire, one area would require further study and evaluation. Almost half of the OIE Member Countries indicated that additional processes should be considered by the OIE to allow for more rapid validation and incorporation of these new technologies into standards and guidelines. However, other respondents indicated that either they were not sure any changes were needed or that current processes should be maintained to continue to provide for a thorough evaluation in a transparent manner. It is clear from the questionnaire responses that validation and recognition by the OIE are important for implementation of new technologies. The challenge for the OIE and its Member Countries will be to develop a proposal that can accommodate these seemingly contradictory responses wanting sufficient rapidity and responsiveness while maintaining scientific rigour and transparency. It was also noted that provisions for traditional methods of disease control must remain as all countries would not have similar capacities or timelines to adopt technologies.

Continued support for "One Health" approaches, the subject of a Technical Item in the OIE 80th General Session, was demonstrated in responses to this questionnaire. Respondents indicated the importance their VS' place on veterinary public health, as affirmative responses regarding the priority for development and implementation of new technologies was significantly higher for zoonotic diseases than for non-zoonotic diseases. With the use of new technologies, additional challenges may arise from identification of animal pathogens with zoonotic potential that traditional detection methods wouldn't have been able to detect. In questionnaire responses, OIE Member Countries identified the need for further guidance regarding the use of animals for human consumption in zoonotic disease situations. The OIE should therefore continue to work closely with public health authorities to develop disease-specific guidance.

Clearly, based on OIE Member Countries responses collected in support of this Technical Item, the OIE should further continue and expand its critical scientific and technical capacity building role in the development and implementation of new technologies. Guidance on the appropriate use of these technologies for decision-making processes, in particular in situations involving public health is also needed. Considering the often rapid evolution of aquatic and terrestrial animal pathogens, the respondents identified the need to evaluate opportunities for a more rapid validation and incorporation of new technologies into OIE animal health standards and guidelines. By addressing these key areas, the OIE can greatly assist its Member Countries to optimally employ appropriate new technologies essential to combat current and future disease challenges and enhance food security.

6. Acknowledgements

The authors would like to thank USDA-APHIS-VS staff: Judith M. Rodriguez and Kathy Foster for database development, data entry and analysis of free-text responses; Christine A. Kopral for data management and analyses; Jerome E. Freier for geospatial analyses; and Anne Berry for report formatting.

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…/Appendices

APPENDIX 1

Definition of new technologies used in the Technical Questionnaire for the 81st General Session.

TERM	DEFINITION
Disease risk assessments	[OIE Definition of Risk Assessment] The evaluation of the likelihood and the biological and economic consequences of entry, establishment and spread of a hazard within the territory of an importing country.
Disease transmission modeling	Mathematical model of infectious disease transmission to investigate outcomes of an epidemic under management intervention scenarios.
DIVA vaccines	Differentiating infected from vaccinated animals.
High potency vaccines	Vaccines formulated at a targeted potency that is well above the minimum immunizing dose to provide early onset of immunity, greater cross protection, and longer duration of immunity.
Molecular epidemiology techniques	The use of molecular biology techniques such as sequencing to characterize nucleic acid or amino acid-based content of an infectious agent in order to facilitate epidemiological activities, including disease surveillance, outbreak investigations, and identifying transmission patterns and risk factors among cases.
New technologies	Contemporary advances, technical innovations or new applications of previously available tools in the fields of diagnostics, vaccinology, epidemiology, and risk assessment which improve animal health and welfare by providing increased options for detection, management, control or eradication strategies.
Outbreak [of disease]	The occurrence of one or more cases (an individual animal infected by a pathogenic agent, with or without clinical signs) in an epidemiological unit.
Outbreak testing	A test or group of tests performed on diagnostic samples from animal sources to confirm the presence of disease or infection, determine the extent of disease spread during an outbreak, and confirm absence of disease after outbreak is contained.
Pen-side or animal-side diagnostic tests	A rapid assay that can be conducted and assessed at the site where the animals being tested are located, with limited to no processing of samples required.
Population testing	A technique where many animals are screened using a single sample, and the epidemiological unit tested is the group of animals contributing to the sample. Example: testing a milk storage tank that received milk from several animals.
Rapid nucleic-acid based laboratory tests	Laboratory tests that directly detect the genetic material of an infecting organism or virus, such as PCR or sequencing, and are used to confirm the presence of infection in less time than is normally required for seroconversion or antibody production to occur in an infected animal.
Routine testing	A test or group of tests performed on diagnostic samples from established surveillance sources to identify specific diseases of interest. Example: testing of blood samples collected from a slaughter facility for Brucellosis.

APPENDIX 2

List of OIE Member Countries responding to the questionnaire

Afghanistan, Algeria, Argentina, Armenia, Australia, Austria, Azerbaijan, Barbados, Belgium, Benin, Bhutan, Bolivia, Bosnia and Herzegovina, Brazil, Bulgaria, Burkina Faso, Canada, Cape Verde, Chad, Chile, China (People's Republic of), Colombia, Congo (Democratic Republic of the), Costa Rica, Cote D'Ivoire, Croatia, Cyprus, Czech Republic, Denmark, Dominican (Republic), Ecuador, Egypt, Equatorial Guinea, Estonia, Finland, France, Georgia, Germany, Ghana, Greece, Guatemala, Guinea, Guinea-Bissau, Haiti, Honduras, Hungary, India, Ireland, Israel, Italy, Japan, Jordan, Kazakhstan, Korea (Republic of), Kuwait, Latvia, Lebanon, Lesotho, Liechtenstein, Lithuania, Luxembourg, Malaysia, Mali, Malta, Mauritania, Mauritius, Mexico, Moldova, Morocco, Nepal, Netherlands, New Caledonia, New Zealand, Nicaragua, Niger, Nigeria, Norway, Panama, Paraguay, Peru, Philippines, Poland, Portugal, Romania, Russia, Rwanda, Saudi Arabia, Serbia, Seychelles, Singapore, Slovakia, Slovenia, Spain, Sri Lanka, Sweden, Switzerland, Chinese Taipei, Tanzania, Thailand, Togo, Tunisia, Turkey, Uganda, United Arab Emirates, United Kingdom, United States of America, Uruguay, Venezuela, Zimbabwe.