SWINE HEALTH INFORMATION CENTER
FINAL RESEARCH GRANT REPORT FORMAT

Project Identification Number: #16-262 SHIC
Project Title: Enhancing universally recognized diagnostic data standards and systems of electronic messaging necessary for transcending inter-laboratory connectivity and the next generation of web-based swine health information management tools for both non-program disease and program disease applications.

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Industry Summary (Abstract):

Seamless integration of diagnostic data from any number of veterinary diagnostic laboratories (VDLs) into third-party database applications for further analytical and reporting purposes has long been recognized as a critical element necessary for proficient detection, monitoring, response, and/or management of significant diseases across a region, state, or nation. Establishing and adopting the use of universally recognized diagnostic data standards and a common electronic messaging schema are foundational elements necessary for the development of sustainable and scalable systems of connectivity and web-based analytical tools necessary to support the current needs and future demands of the US Pork Industry.

This highly collaborative initiative served to further develop the core infrastructure and diagnostic data standards necessary for US Pork Industry stakeholders to effectively harness the capabilities that any number of existing or yet to be developed (web-based) animal health information management technologies aim to provide. Primary deliverables included the development of a more comprehensive electronic message schema; a greatly expanded formulary of now more than 700 standardized test result codes covering the full-spectrum of diagnostic tests commonly conducted on swine case submissions to veterinary diagnostic labs (VDLs); an intuitive, web-based search engine that enables users (e.g., VDL information technology personnel) to readily identify the appropriate diagnostic test result code(s) (i.e., Logical Observation Identifier Names and Codes, or LOINC®) to use for each of the specific assays conducted and reported from their laboratory; and a web-based electronic message validator that allows VDLs to test, trouble-shoot, and validate their electronic messaging capabilities.

Each of the VDLs collaborating on this infrastructure development project demonstrated their ability to electronically synthesize and successfully deliver results from diagnostic case submissions utilizing the updated electronic messaging schema and expanded formulary of diagnostic test result codes. To ensure national level scalability, the updated electronic messaging schema derived from this project is consistent and fits within the overarching architecture of the Health Level Seven® (HL7) messaging schema adopted by the United States Department of Agriculture National Animal Health Laboratory Network (USDA NAHLN). The expanded formulary of standardized codes for diagnostic test results (LOINCs); the updated

and more comprehensive HL7 electronic messaging schema; the standardized diagnostic test result code (LOINC®) search engine; and the HL7 electronic message validator application developed as a result of this project will be made available for use by VDLs across the USDA NAHLN.

The infrastructure developed in accordance with the primary deliverables of this initiative will provide a lasting foundation for enhancing the adoption and use of universally recognized diagnostic data standards and HL7 electronic messaging capabilities in swine interest VDLs in the USDA NAHLN. Furthering the establishment and use of such standards are critical building blocks for enhancing the connectivity and interoperability of diagnostic information across VDLs and for broadly transcending swine diagnostic information management into the digital era. Albeit these developments centered at the four VDLs collaborating on this project and were specifically focused on diagnostic tests conducted on US swine, this precedent-setting work could readily be expanded and emulated for use across any number of animal species and VDLs.

Keywords: include at least 5 keywords
Data
Diagnostic
HL7
LOINC
NAHLN
Standard
Swine
VDL

Scientific Abstract:

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architecture of the Health Level Seven® (HL7) messaging schema adopted by the United States Department of Agriculture National Animal Health Laboratory Network (USDA NAHLN). The expanded formulary of standardized codes for diagnostic test results (LOINCs); the updated and more comprehensive HL7 electronic messaging schema; the standardized diagnostic test result code (LOINC®) search engine; and the HL7 electronic message validator application developed as a result of this project will be made available for use by VDLs across the USDA NAHLN.

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Introduction:

Diagnostic test result nomenclature, format, and structure of otherwise equivocal data being stored and reported varies widely across veterinary diagnostic labs (VDLs) and laboratory information management systems. Similarly, the submission, premises, and animal level identifiers captured and reported in VDL records vary. Thus, establishing and adopting the use of universally recognized veterinary diagnostic data standards and a fully capable electronic Health Level Seven® (HL7) messaging schema are necessary to create sustainable and scalable systems of seamless connectivity across VDLs in the United States Department of Agriculture National Animal Health Laboratory Network (USDA NAHLN).

While the need for enhancing the connectivity and interoperability of veterinary diagnostic records from VDLs across the US has long been recognized for program disease monitoring and response purposes, there has been recent growing interest within the private sector for using next generation animal health information management technologies for non-program disease applications. These include aggregating data from VDLs for any number of enterprise specific or aggregate data summary purposes. Irrespective of the specific purpose for data aggregation, laboratory information management systems utilized, or third-party database applications being used to integrate, analyze, summarize, and report the information of interest; establishing and adopting the use of universally recognized data standards and message schema are foundational elements necessary for transcending veterinary diagnostic information management into the digital and/or big-data era. Heretofore, the development and use of universally recognized diagnostic data standards and electronic messaging has been largely limited to a finite number of reportable disease applications within the USDA NAHLN.

Objectives:

This paper serves to describe a highly collaborative and precedent setting initiative whose primary aims were to enhance the expanse and utility of universally recognized veterinary diagnostic data standards and systems of electronic messaging necessary for transcending inter-laboratory connectivity and the next generation of web-based swine health information management tools. Specific outcomes aimed to establish the ability of four swine interest veterinary diagnostic laboratories in the USDA NAHLN to electronically generate and message the full complement of routinely reported swine diagnostic test results to third-party, web-based, database applications using standardized diagnostic test result codes (i.e., Logical Observation Identifier Names and Codes, or LOINCs) and Health Level Seven® (HL7) messaging. These aims included efforts to update the existing USDA NAHLN HL7 electronic messaging schema to ensure the information contained within the message was comprehensive enough to fully meet the anticipated needs of the US Pork Industry for both program and non-program disease monitoring, management, and reporting applications.

Materials & Methods:

Initial efforts focused on developing the necessary updates to the HL7 message schema. We started by formulating a more comprehensive list of submission, premises, animal, and sample level identifiers that are necessary for the veterinary diagnostic record and the HL7 electronic message that is used to transmit the resulting diagnostic records from the VDLs' laboratory information management systems to any number of third-party database applications. The resulting list of identifiers are illustrated in **Figure 1**.

We then proceeded to determine the necessary information (i.e., data elements of the results) for each of the various types of quantitative and qualitative diagnostic assays routinely conducted on swine samples. Examples of the types of assays included polymerase chain reaction, immunohistochemistry, fluorescent antibody, indirect immune-fluorescent antibody, enzyme-linked immunosorbent assay, fluorescent focus neutralization, serum neutralization, virus neutralization, hemagglutination inhibition, fluorescent multiplexed bead-based immunoassay, bacterial and fungal culture, virus isolation, gene specific sequencing, whole genome sequencing, antimicrobial susceptibility testing, blood chemistry analyses, and an array of analytical chemistry based methods used to quantify minerals, vitamins, drugs, and toxins in biological specimens, animal feeds, or water. Additionally, we determined the granularity of diagnostic (assay) result identity needed by end users to collate and differentiate amongst diagnostic result information received from VDLs. These accomplishments provided the direction necessary to determine the content of the multitude of standardized diagnostic result codes (LOINCs) to be obtained and to ensure the updated HL7 message schema readily accommodates the result content needing to be reported.

A comprehensive list of the diagnostic assays routinely conducted on swine diagnostic case submissions were compiled across the four VDLs collaborating on this initiative. This inquiry included obtaining information about the respective analyte, test method, scale, unit, and specimens for each of the assays. After obtaining the complete list of tests conducted on swine case submissions from each VDL, it was determined which tests could be grouped together into single LOINCs, and which tests would need distinct or separate LOINCs. This now consolidated list of tests from all the VDLs was then analyzed to determine if each test could be mapped to an existing LOINC, or if new LOINCs were needed. The compilation of this work identified more than 700 standardized LOINCs necessary to report the results from the diagnostic testing and analyses routinely conducted on swine submissions.

Regenstrief LOINC Mapping Assistant (RELMA®) was used to map the results for each test to the appropriate LOINC. For each test for which a suitable LOINC did not exist, a dossier of information for that particular assay was prepared and submitted to the official LOINC® Committee for their review, approval (if granted), and assignment of the corresponding new LOINC. The much expanded formulary LOINCs relevant to swine diagnostic medicine created over the course of this project were then mapped by each VDL to the appropriate test and result within their respective laboratory information management system.

To enable the VDLs to test, trouble-shoot, and demonstrate proficiency in HL7 electronic messaging; a web-based, HL7 messaging validator application was developed. A series of dummy cases were created and distributed to each of the collaborating VDLs such that each VDL could test and demonstrate their proficiencies in generating and electronically messaging these case results using the aforementioned standardized LOINCs and updated HL7 message schema. As an additional tool, a web-based LOINC search engine was created to allow VDL information technology specialists to readily identify the correct LOINCs to use when mapping and reporting the results for each of the tests conducted on swine case submissions in their respective laboratories.

Results:

An updated version of the HL7 schema previously adopted and used across the USDA NAHLN was developed as a result of this initiative. Careful attention was paid to ensure that the additional information capable of being incorporated into the electronic message was done in a way that fit well within the overall structure of the existing USDA NAHLN HL7 message schema. The USDA NAHLN has since agreed in principle to accept and adopt this more capable and comprehensive HL7 message schema as their standard for use across the USDA NAHLN in the future.

This compilation of work identified approximately 706 standardized LOINCs needed to report results for swine submissions. Of the 706 LOINCs reviewed, 319 could be assigned to existing LOINCs, and 387 applications for new LOINCs were prepared and submitted to the LOINC committee. Each application for a new LOINC included a dossier of necessary information specific for each test (request), as well as an explanation and a justification for a new LOINC. The LOINC Committee works diligently to avoid the creation of redundant or unnecessary LOINCs. All of the applications (n≈ 387) for new LOINCs submitted over the course of this project were approved by the LOINC® Committee and assigned officially recognized LOINCs.

A very intuitive (web-based) LOINC search engine was developed and has been used extensively over the course of this project. This application enables VDLs to easily identify the appropriate LOINC to use for when they are mapping and reporting results from their respective veterinary diagnostic laboratory information management system.

An HL7 messaging validator application was created to allow for collaborating VDLs to test and demonstrate their electronic messaging capabilities. This permissioned access application allows VDLs to send their message to an HTTP server where it is run through an XML validation process. If the message has errors, an error message is returned to the user. If the message is confirmed as valid, it is then uploaded to a database which parses the data out and inserts into the portal tables. Users can then view the results on the Veterinary Message Portal, compare the data they sent, and fix any errors or inconsistencies. Users (VDLs) can only access and view the messages and corresponding data of which they have permissioned credentials to view. Each of the four VDLs collaborating on this project successfully demonstrated their abilities to electronically generate and transmit veterinary diagnostic case records using the much-expanded formulary of standardized diagnostic test result codes (LOINCs) and the updated and more comprehensive HL7 schema developed over the course of this project.

Discussion:

This precedent-setting veterinary diagnostic information infrastructure development effort furthered the establishment and use of the diagnostic data standards and electronic messaging capabilities that are needed to create sustainable and stepwise improvements in the US swine industry stakeholder's ability to harness the capabilities of any number of existing or yet to be developed (web-based) animal information management technologies. The digital age of which we now live continues to enable new and ever improving ways of aggregating and summarizing information. The adoption and use of universally recognized veterinary diagnostic data standards is a critical element for enabling data within any number of VDLs' laboratory information management systems to be more seamlessly aggregated and summarized for any number of private enterprise specific, aggregate level summary, or program disease response purposes. The significant learnings, developments, and capabilities furthered over the course of this project holds significant promise for helping advance the systems of connectivity across all VDLs in the USDA NAHLN. As mentioned previously, the expanded formulary of LOINCs, LOINC search engine, HL7 message validator, and the updated HL7 schema will be made available for use by VDLs across the USDA NAHLN. Globalization and the associated increased movement of people, animals, products, and disease causing agents throughout the world as well as US Food Animal Agriculture's ever increasing dependence on export markets are having a very real-world impact on the demand and need for a highly capable and seamlessly connected veterinary diagnostic laboratory infrastructure and network in the US. The advancements and developments derived from this highly collaborative initiative represent critical building blocks in furthering the connectivity of veterinary diagnostic information needed to support the current and future needs of the US Pork Industry. Such developments also most certainly have direct application and can be readily expanded for use and benefit across all the various species groups, sectors of food animal agriculture, and VDLs in the USDA NAHLN.

Figure 1. List of submission and sample level identifiers capable of being incorporated into the proposed updated version of the USDA NAHLN HL7 Message.