SWINE HEALTH INFORMATION CENTER
FINAL RESEARCH GRANT REPORT FORMAT

Project Title and Project identification number: The Domestic Swine Disease Surveillance: improvement sustainability and providing monthly updates until May of 2021. # 20-103 SHIC.

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Industry Summary:

In 2017 SHIC funded the Domestic Swine Disease Surveillance project, currently housed under the Swine Disease Reporting System (SDRS) initiative. The purpose of this proposal was to keep the Domestic Swine Disease Surveillance program ongoing and further develop a capability to improve sustainability over time. The specific aims included a) keep updated the aggregated database with diagnostic data from the participating laboratories, and provide monthly PDF reports to SHIC as well as keep updated the online interactive dashboards; b) enhance the sustainability of the project by migrating the report-building mechanism to an automated R Markdown technology; c) improve data exchange capability between the Data warehouse project, the Domestic Swine Disease Surveillance program, and other SDRS programs by migrating the data visualization platform to Tableau.

During the time of this project, the database was consistently updated with data from participant laboratories. The database was continuously updated and now contains data from more than 950,000 distinct submissions tested by PCR for the five U.S. porcine endemic agents, i.e., porcine reproductive and respiratory syndrome virus (PRRSV), porcine epidemic diarrhea (PEDV), porcine deltacoronavirus (PDCoV), transmissible gastroenteritis (TGEV), and *Mycoplasma hyopneumoniae*. Interactive online dashboards with filtering capabilities, e.g., age category, specimen, geographic region, were kept alive, updated, and are available on the project website (https://www.fieldepi.org/sdrs). Monthly PDF reports have been consistently produced and releases every first Tuesday of the month. Monthly PDF reports are published at the project webpage, SHIC website (https://www.swinehealth.org/domestic-disease-surveillance-reports/), and distributed by email to more than 270 registered receivers from 129 organizations/institutions from 7 countries (US, Canada, Mexico, Brazil, Chile, Germany, and Spain).

In July 2020 (SDRS report # 29), monthly PDF reports started to be produced using the R Markdown technology and gained a new face. An R Markdown script has written and allowed the generation of reports in a standard and consistent format. The R Markdown script was codified to automate as much as possible the process of generating and update images, formatting, and description for the monthly detection changes under each agent page. As an ongoing real-time project, there is still the need for staff to interpret the finding, debugging, communicate results with the advisory group, gather feedback, and compile the final report, including the input and feedback from the Advisory group. The usage of an R Markdown script has enhanced SDRS sustainability by reducing the time needed and errors in compiling the final monthly PDF final report.

Interconnection between databases and different visualization and analytical tools are key elements for project sustainability. The need to efficiently process and interconnect the database with the R Markdown and visualization platforms like Power BI and Tableau requested a redesign of the SDRS database structure. The SDRS has been built using a building block approach. Initially, SDRS started reporting PRRSV detection from Iowa and Minnesota VDLs and later on added South Dakota and Kansas VDLs and additional data for the enteric coronavirus and *M. hyopneumoniae*. Initially, each agent's database was kept separated. A restructuring was done to compile, combine, and store all data into a single database. This redesign allowed the database interconnection with the R Markdown to generate PDF monthly reports, analytical tools like R and SAS, and business intelligence tools, like Power BI and Tableau, for data visualization.

Additionally to the proposed scope of this project, the SDRS team has consistently produced monthly audio and video reports distributed on the project website, Youtube Channel, Swine Cast platform, and LinkedIn. Also, during the last year, SDRS has been actively engaged in providing information and support to the U.S. swine industry when it went into a crisis due to the activity of contemporary and emergence of a new PRRSV strain threatening the U.S. swine health. Early detection is a key component for containing the spread of emerging or re-emerging animal health threats. More than 110 monitoring algorithms are currently implemented in the SDRS background to detect early changes in the pattern of agent detection.

This collaborative project funded by SHIC has real-time capabilities for data collection, analysis, and sharing of swine health data and information to protect and enhance the health status of the United States swine herd. SDRS is a real-time coordinated and largely representative national swine disease monitoring program that provides VDL information in efforts to minimize disease threats current and future impact. The SDRS is the only publicly available source of swine health information from U.S. VDLs. It is also the only source of information on pathogen activity in all age groups (from boar studs to grow-finish pigs). The sharing of information on endemic and endemic re-emerging diseases affecting the swine population in the U.S. has and continues to assist veterinarians and producers in making informed decisions on disease prevention, detection, and management.

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Scientific Abstract:

Submission information, reverse transcriptase-polymerase chain reaction (RT-PCR) or PCR test, and testing results data for 5 U.S. porcine endemic agents, i.e., porcine reproductive and respiratory syndrome virus (PRRSV), porcine epidemic diarrhea virus (PEDV), porcine deltacoronavirus (PDCoV), transmissible gastroenteritis virus (TGEV), and *M. hyopneumoniae* were retrieved from four U.S. swine-centric veterinary diagnostic laboratories (VDLs). These 4 VDLs account for > 94% of all porcine samples tested in U.S. National Animal Health Laboratory Network (NAHLN). Anonymized data were retrieved and organized at the submission level using SAS (SAS® Version 9.4, SAS Institute, Inc., Cary, NC) using PROC DATA, PROC MERGE, and PROC SQL scripts. Each agent-specific dataset was combined into a unique structured statistical and business intelligence tools compatible database. The

Microsoft Power BI - Business data analytics tool was connected to the database and programmed to perform daily updates on the online dashboards housed at the project website (www.fieldepi.org/SDRS). An R Markdown script was written to semi-automate the monthly PDF reports creation. A preliminary monthly PDF report has been distributed to the advisory group and VDLs collaborators to gather input and feedback. Received feedback and input were incorporated into 15 final PDF monthly reports (SDRS report #29 to #44), which were consistently released on the first Tuesday of the month. Monthly reports were uploaded to the SHIC website (https://www.swinehealth.org/domestic-disease-surveillance-reports), project page (www.fieldepi.org/SDRS), and distributed by email to 270 registered receivers from 129 organizations/institutions located in 7 countries (US, Canada, Mexico, Brazil, Chile, Germany, and Spain). Additionally to the proposed scope of this project, the SDRS team also produced monthly audio and video reports distributed on the project website, YouTube channel (https://www.youtube.com/channel/UCa4Y50BEtSc8G04-PnFQEMQ), Swine Cast platform (http://www.swinecast.com/), and LinkedIn (https://www.linkedin.com/in/fieldepi-field-epidemiology-46814a194).

The capabilities here implemented resulted in a single statistical and business intelligence tools compatible database. Additionally, the development of an R Markdown script has allowed for a consistent and standardized way of generating monthly PDF reports, reducing the time needed and errors for report compilations. All actions implemented during the last 15 months have significantly improved SDRS sustainability. The SDRS is the only publicly available source of swine health information from U.S. It is also the only source of information on pathogen activity in all age groups (from boar studs to grow-finish pigs). VDLs and has consistently provided information on endemic agents, helping to early detect emerging or re-emerging pathogens, manage, prevent, and control the spread of animal health threats.

Introduction:

In 2017 SHIC funded the Domestic Swine Disease Surveillance (https://www.swinehealth.org/domestic-disease-surveillance-reports), currently housed under the Swine Disease Reporting System (SDRS) initiative, to aggregate and report veterinary diagnostic data collected from VDLs (Trevisan et al., 2019). The initial program was developed in collaboration between the Iowa State University Veterinary Diagnostic Laboratory (ISU-VDL) and the University of Minnesota Veterinary Diagnostic Laboratory (UMN-VDL) to prove the concept that it is possible to aggregate standardized diagnostic results from multiple labs in the U.S. The project was successful and was expanded to incorporate additional data from South Dakota State University Animal Disease and Research Diagnostic Laboratory (SDSU-ADDL) and Kansas State University Veterinary Diagnostic Laboratory (KSU-VDL). Currently, this project is the only publicly available source of swine health information from U.S. VDLs. With a database containing information for five porcine endemic agents and more than 950 thousand cases, SDRS is also positioned as one of the largest U.S. and international databases for veterinary diagnostic information. The SDRS has been providing science-based spatiotemporal information on pathogen activity with great representativeness of the U.S. swine industry. SDRS offers an interactive free of charge interactive benchmarking tool and monthly reports containing the highlights for the most significant changes in the patterns of agent detection and the interpretation from a panel of producers and practitioners, i.e., the advisory group. The U.S. swine industry appreciation for this project really in its ability to provide real-time information on the macroepidemiological aspects of agent detection in the U.S. Due to its importance and significance in providing real-time analysis and information of swine health data to help in protecting North American swine population there was the need to keep SDRS alive and updated.

Objectives: The objectives of this proposal were to keep the Domestic Swine Disease Surveillance program ongoing and further develop a capability to improve sustainability over time. The specific aims included:

A.   Keep updated the aggregated database with diagnostic data from the participating laboratories, and provide monthly PDF reports to SHIC as well as keep updated the live interactive dashboards;

B.   Enhance the sustainability of the project: migrate the report-building mechanism to the automated R Markdown technology.

C.   Improve data exchange capability between the Datawarehouse project, the Domestic Swine Disease Surveillance program, and other Swine Disease Reporting System programs by migrating the data visualization platform to Tableau.

Materials & Methods:

Specific methods were used for each objective, which resulted in integration and sustainability improvement for the SDRS project.

Monthly PDF reports and dashboards updates: to keep updating the aggregated database with diagnostic data from the participating VDLs, keep updated the live interactive dashboards, and provide monthly PDF reports to SHIC and stakeholders similar procedures like the one implemented at the time of SDRS implementation were applied. Briefly, data were continuously received from the participating VDLs and collated into a standardized format. The online dashboards available at the project web page (www.fieldepi.org/SDRS) were synchronized with the database and updated daily for VDLs sharing daily HL7 updates and twice a month for VDLs sharing data using a CSV format. The project investigators consulted with the SDRS advisory group, consisting of veterinarians and producers distributed across different U.S. regions and representing independent and integrated production systems. The advisory group has provided their input and feedback on the most relevant findings and project improvement.

Additionally, an advisory group face-to-face meeting was held in Saint Paul, MN, to collect feedback about future directions of the SDRS program. Advisory group feedback led to further analysis in relevant points. For example, SDRS was requested to support stakeholders with information and data analysis during the emergence and national crisis caused by the PRRSV 1-4-4 L1C variant strain. The epidemiologic curve of detection of the PRRSV 1-4-4 L1C variant strain was discussed with the industry, incorporated into the bonus page, presented by the SDRS team in 2 SHIC webinars, and made public on the PRRSV page of the SDRS report.

Generation of the report on a semi-automated format: an R Markdown script (https://rmarkdown.rstudio.com/lesson-1.html) was written and maintained by one collaborator (Trevisan). The R Markdown is an open-source, i.e., no initial or future maintenance cost required, technology that allows consistent SDRS report build using a script. The product is a clean, high-resolution PDF report that allows updates of the report figures and content in an automated, standardized, and quick fashion.

Improve data exchange capability between the Datawarehouse project, the Domestic Swine Disease Surveillance program, and other SDRS programs by migrating the data visualization

platform to Tableau: the SDRS has been structured on a building block approach, i.e., first has collated data for PRRSV, followed by the enteric coronaviruses, and *M. hyopneumoniae*. All VDLs agent-specific collated database was initially stored on different datasets. Agent-specific datasets were combined into a single database and kept continuously updated with newly generated diagnostic data. The new database is compatible and allows data exchange between tools like R Markdown, statistical and data visualization tools. Also, it has enabled reproduction and dashboards visualization using different business intelligence tools like Power BI and Tableau.

Results:

The SDRS was kept ongoing, and further developments were applied. Monthly reports have been delivered using the new advancements proportioned by the R Markdown technology. For a report that is distributed online, the quality of the images has been tremendously improved. A high resolution is kept when zooming in on the images. Monthly PDF reports are made available at SHIC web page https://www.swinehealth.org/domestic-disease-surveillance-reports/, and together with online dashboards in the project website at https://www.fieldepi.org/SDRS. Currently, this project is the only publicly available source of swine health information from U.S. VDLs.

Table 1: Summary of proposed objectives for this project.

Proposed goal	Accomplishments
(a) Keep updated the aggregated database with diagnostic data from the participating laboratories, and provide monthly PDF reports to SHIC as well as keep updated the live interactive dashboards	Data from the four participants VDLs (ISU-VDL, UMN-VDL, SDSU-ADDL, and KSU-VDL) were kept up to date in the interactive dashboards and used to feed all monthly PDFs SDRS reports #29 to #44 released on the first Tuesday of each month.
(b) Enhance the sustainability of the project: migrate the report-building mechanism to the automated R Markdown technology.	Since July 2020 (SDRS report # 29), monthly PDF reports have been compiled using an R Markdown script.
(c) Improve data exchange capability between the Datawarehouse project, the Domestic Swine Disease Surveillance program, and other Swine Disease Reporting System programs by migrating the data visualization platform to Tableau.	A single standardized database that allows interconnection between different analytical, e.g., SAS and R, and visualization platforms, e.g., Power BI, Tableau, Shiny App, and report building (R Markdown) was created.

Discussion:

The Domestic Swine Disease Surveillance, housed under the SDRS initiative, supported by SHIC, has successfully provided real-time swine health data information for U.S. swine endemic agents.

SDRS is the only publicly available source of swine health information from U.S. VDLs that is continuously updated on a real-time basis. SDRS stands out on integration, monitoring, and sharing information regarding emerging and re-emerging animal health threats. The SDRS is well aligned with SHIC's mission *"to protect and enhance the health of the United States swine herd through coordinated global disease monitoring, targeted research investments that minimize the impact of future disease threats, and analysis of swine health data."*

The procedures implemented under this proposal allow not only the capture and integration of the data from the 4 VDLs in a structured format but also created a basis for sustainability. Data integration and monitoring capabilities allow in identifying meaningful information for changes in trends in the detection of endemic agents. Historical data generates valuable information, but the real value in protecting U.S. swine production lies in the ability to monitor diagnostic data in real-time and inform stakeholders of changes in detection patterns. Knowledgeable stakeholders can use this information and tools for many applications, including warning signals or indicators to reinforce or implement biosecurity and biocontainment practices to reduce the spread of agents and disease among farms and regions.

During the last year, SDRS had stood up, transforming data into information on a real-time basis to support stakeholders with information on emerging animal health threats. As an example, SDRS provided real-time epidemiological detection and regular analysis for genetic changes associated with the PRRSV 1-4-4 L1C variant strain that posed a high animal health threat to the U.S. swine industry. SDRS monitoring algorithms were key tools to detect and issue a warning for changes in the patterns of PRRSV detection that led to further investigation and identification, and reporting of this emerging threat.

Efforts have been made to communicate this project to a broad range of U.S. swine industry and also globally. Monthly reports are uploaded at SHIC website (https://www.swinehealth.org/domestic-disease-surveillance-reports), project page (www.fieldepi.org/SDRS), distributed by email to 270 registered receivers from 129 organizations/institutions located in 7 countries (US, Canada, Mexico, Brazil, Chile, Germany, and Spain). Additionally to the proposed scope of this project, the SDRS team also produced audio and video reports distributed on the project website, YouTube channel (https://www.youtube.com/channel/UCa4Y50BEtSc8G04-PnFQEMQ) having 35 subscribers, Swine Cast platform (http://www.swinecast.com) 2,124 downloads January-July 2021, and LinkedIn (https://www.linkedin.com/in/fieldepi-field-epidemiology-46814a194) 3,733 visualization and 2,452 minutes watched. Additionally, a peer-reviewed manuscript describing the macroepidemiological aspects of enteric coronavirus in the U.S. (Trevisan et al., 2021a) and another on data visualization and application for population health management (Trevisan et al., 2021b)have been published. The SHIC was acknowledged as the source of funding.

Even though lots of information has been provided by the SDRS project, the advisory group has been requesting improvements. Across priorities requested by the advisory group are

a) expand regional representativeness and data analysis for detection of emerging animal health threats;

b) data mining approaches to investigate agents co-detection and associations at an overall and at age categories levels;

c) explore the association between agent detection on diagnostic data and disease incidence in the field;

d) monitor counts of negative cases and testing results for an abnormal number of submissions as an effort of early detection of emerging animal health threats;

e) connecting Grow-Finish influenza A and PRRSV diagnostics results as a predictor of agent activity in this age category disease outbreaks.

The SDRS project will continue searching for stakeholders support to fulfill its goal in share information on endemic and emerging diseases affecting the swine population in the U.S., assisting veterinarians and producers in making informed decisions on disease prevention, detection, and management.

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