CS486C –Senior Capstone Design in Computer Science
Project Description

Project Title: VirusWatch: A platform for hosting community surveillance activities	
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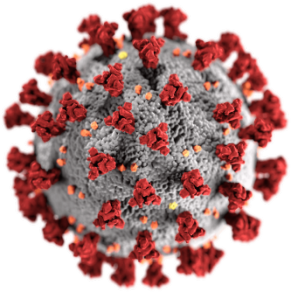
Project Overview:



Since SARS-CoV-2 was first detected in the United States, more than five million people have been confirmed positive for infection and nearly 164,000 have died. The U.S. has been battling this outbreak since Spring 2020 and we are now entering a new “season” where educational institutions are deciding whether to hold classes in-person or strictly online. In-person classes will result in more densely situated learning, and in some cases, living settings.

Although Arizona has recently observed a decline in state-wide cases, the three major universities, including Northern Arizona University (NAU) in Flagstaff, started moving students into dormitories the week of August 3rd, with in-person classes beginning August 31st. As with previous academic years, new students may import new strains of pathogens, including SARS-CoV-2, to university towns.

As educational institutions reopen, one significant concern is that congregating students in high density educational and sometimes living settings may facilitate transmission of SARS-CoV-2. This could be particularly true if certain student populations are non-compliant with wearing facial coverings and physical distancing. With a lack of resources to carry out continuous universal testing, we hypothesize that wastewater-based testing surveillance could be a solution for community monitoring to identify spikes of SARS-CoV-2 and other viruses prior to outbreaks occurring, providing public health officials and other policy-makers with information needed to take strategic, mitigating actions. We have been taking samples from outside of NAU dormitories, and

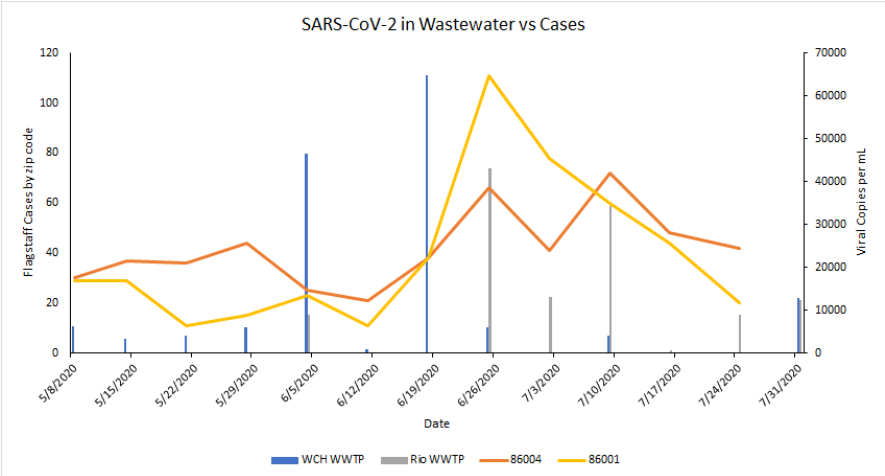


Figure 1. The orange and yellow lines represent the number of human cases each week, by zip code, and the y axis on the left side is for cases. Bars represent the "wastewater signal" from Wildcat Hill WWTP (blue bars) and Rio de Flag WWTP (grey bars).

wastewater treatment plants from the City of Flagstaff, City of Sedona, Village of Oak Creek, Munds Park, and Kachina Village. We plan to expand to specific neighborhoods within these locations, so a way for different policy makers to access these data is greatly needed.

What can technology do to help? presently, we are collaborating with the City of Flagstaff, City of Sedona, Village of Oak Creek, Munds Park, Kachina Village, and Northern Arizona University to test their wastewater at various geographic scales to monitor the SARS-CoV-2 outbreak magnitude. However, the reports we submit to them are simple excel spreadsheets and charts that we recreate each week and submit. We would like to host a secure website, and possibly a mobile application, that would allow the different agencies we work with to login to see their own results as well as a few basic analyses that would allow them to compare (for example) case counts or percent seropositivity to a quantitative wastewater signal.

Although the major focus of attention is currently on SARS-CoV-2, it is important to point out that tracking the spread of infectious viruses more generally has always been an important public health issue, and will remain so indefinitely, long after SARS-CoV-2 has faded from the headlines. For instance, our lab has also been very active in developing new techniques and technologies for monitoring seasonal spread of the West Nile Virus (WNV); informatics tools like the one described here would greatly streamline such efforts as well. In short, the product proposed here has been lacking for a long time and will greatly help with monitoring SARS-CoV-2, but also all other viral infectious diseases of public health concern going forward. It is therefore important that the product be designed to allow addition of new pathogens and support the tracking of multiple pathogens.

The Envisioned Product

We envision a website (secure web app) that can host and compare any type of surveillance data (e.g. case counts, % positive, wastewater signal, viral copies per sample) so that we can determine how far in advance wastewater surveillance can “alert” stakeholders of an upcoming outbreak. We would additionally generate an automated basic caption that would tell stakeholders what the data means overall and for the most recent epidemiological week. Finally, we would like policy-makers to have the ability to provide date-labelled annotations to describe interventions they are implementing, which would help explain the wastewater signal over time. Detailed requirements will be developed by the Capstone team, but some key features that will need to be supported by the product include:

The Basics: minimal viable product

- Provides a secure web application, including user authentication and roles-based permission architecture.
- Supports ingestion of various pathogen monitoring data; saves to a database architecture to support flexible searching and constitution of various datasets across time and space.
- Provides a basic web-based GUI for all operations, including data uploading, browsing/searching data, graphical data analysis, and data export.
- Provides a variety of graphical data summaries (e.g. like the figure above) that can allow program administrators to monitor surveillance activities so they can rapidly implement intervention strategies.
- Safe and private. Stakeholders from one agency cannot access data from another agency.
- Supports sending emails and text messages to sample-associated stakeholders immediately after results are available.

Unique and Key features to make it truly usable

- Provides many GUI enhancements and upgrades to move from basic functionality to fully-featured, elegant, and deployment-ready.

- Provides more powerful search tools: authorized users can not only retrieve datasets uploaded but can specify various criteria develop new datasets from data points drawn from the entire database. Allows export of any dataset for further analysis.
- Advanced analysis and visualization. For a selected dataset, can send into a fully functional graphical viewer; users can zoom in/out the time scale, can juxtapose various time-series data, etc.
- Provides for easy monitoring of multiple pathogens and addition of new pathogens to monitor. Ideally, system administrators would have a "new pathogen" function where they provide some basic info about the new pathogen; the system then "clones" an additional "sub-page" of the site devoted to that pathogen
- Supports secure data storage and presentation for users with appropriate access credentials.
- Ability for information content to be organized based on epidemiological week and location
- Can support input from Client Hepp as well as from public health stakeholders

Stretch goals: Cool ideas for an exceptional app

- Provides users with a personal "lab book" where they can save searches and datasets, group their work into "analysis A", "Analysis B", etc.; and annotate these with their notes.
- Allows controlled sharing of analyses, e.g., user can invite certain other users to share and comment on certain analyses they have done/saved.
- Provide researchers the ability to deploy surveys to policy-makers and gather other metrics (e.g. usage patterns and intervention responses), downloading these datasets for further analysis with permissions.
- Other features, as discovered during requirements acquisition. We are inventing new technology here; the creative input of the team is strongly encouraged!

Knowledge, skills, and expertise required for this project:

- Knowledge of web-based application programming frameworks, with particular emphasis on cross-platform frameworks like Ionic and React Native.
- Knowledge of modern Web2.0 programming techniques required to develop the administrative web app
- Knowledge of back-end server and database technologies, with emphasis on configuration and deployment of cloud-based server resources.

Equipment Requirements:

- There should be no equipment or software required other than a development platform and software/tools freely available online.
- An NAU-based server will be required as a deployment platform.

Deliverables:

- The software applications as described above, deployed and tested successfully with real data. Must include a complete and clear User Manual for configuring and operating the software.
- A strong as-built report detailing the design and implementation of the product in a complete, clear and professional manner. This document should provide a strong basis for future development of the product.
- Complete professionally-documented codebase, delivered both as a repository in GitHub, BitBucket, or some other version control repository; and as a physical archive on a USB drive.