Clemson University
School of Health Research

Fall Information Exchange featuring

Clemson Research at the Forefront of the COVID-19 Pandemic

October 21, 2020 3:30 PM – 5:00 PM
Agenda

• Welcome and Introductions
  • Windsor Westbrook Sherrill, PhD
    • CUSHR Team
    • Congratulations

• CUSHR Updates - Thomas Britt, PhD
  • Appointment Committee
  • Announcements: Funding Opportunity

• COVID Operations Snapshot-- Lisa Knox, Director of Strategy and Operations

• Testing Strategies to Minimize COVID-19 Outbreaks - Dr. Lior Rennert, Assistant Professor, Public Health Sciences

• Modeling Team Leadership Lessons - Dr. Corey Kalbaugh, Assistant Professor, Public Health Sciences

• Testing for COVID at Clemson
  • Dr. Delphine Dean, Ron and Jane Lindsay Family Innovation Professor, Bioengineering
  • Dr. Mark Blenner - McQueen-Quattlebaum Associate Professor, Chemical and Biomolecular Engineering

• Wastewater Monitoring of COVID-19 - Dr. David Freedman, Professor & Chair, Environmental Engineering and Earth Sciences

• Rapid Innovation Task Force: Masks - Dr. Chris Cole, Professor Emerita, Clemson Textiles/ Materials Science and Engineering

*BREAKOUT SESSIONS : (1) HSC Seed Grant Information Session    (2) Presenter Q and A
PLEASE PICK A SESSION NOW – BOTTOM OF YOUR ZOOM SCREEN
Welcome

Windsor Westbrook Sherrill, PhD
Associate Vice President for Health Research
Provost’s Distinguished Professor, Public Health Sciences
Chief Science Officer, Prisma Health-Upstate
CUSHR TEAM

Windsor Westbrook Sherrill, PhD
Associate VP for Health Research, Clemson
Chief Science Officer, Prisma

Janet H. Evatt
Program Manager

John K. Williams
IT Coordinator

Thomas W. Britt, PhD
Chair, CUSHR Appointment Committee
HSC Campus Research Dir.-CU

Frances Parrish
PR / Information Coordinator

CUSHR INTERNS 2020

Samuel Livingston
Bre Franklin
Morgan Davis
Leti Goto
Spring 2021 Faculty Fellow

Hugo Sanabria, PhD
Associate Professor,
Department of Physics and Astronomy

Research interests: Protein Misfolding Diseases, Synaptic Plasticity, Protein Structure, Protein Dynamics, Single-molecule Fluorescence Spectroscopy

Congratulations!
Researcher of the Year

Hai Xiao, PhD
Samuel Lewis Bell Distinguished Professor and Interim Department Chair, Electrical and Computer Engineering

Dr. Xiao has organized several multidisciplinary research projects at Clemson
  • Currently serves as the principal investigator of seven projects with nearly $8.5 million in funding.
  • Published 88 peer-reviewed articles
  • Six patents
  • Graduated 10 PhD students since 2013
  • Currently mentoring eight PhD students and two master’s students

Congratulations!
Announcements

Thomas W. Britt, PhD
Professor, Psychology
Research Director for Clemson, Prisma Health Sciences Center
CUSHR Appointments

Applications are accepted for
- **Clinical Faculty** in the Fall
- **Faculty Scholars** in the Spring

Renewal requests also accepted this year

Faculty Profiles are posted on the CUSHR Faculty page
[https://www.clemson.edu/health-research/faculty/]
CALL FOR APPLICATIONS
Transformative Research Seed Grant Award
2020-2021

Health Sciences Center (HSC) at Prisma Health
Research Seed Grant Program

Projects should focus on improvement of health system performance, population health, or biomedical science that translates to clinical practice and improved patient outcomes.

**Funding:** Applicants may request a funding amount up to $20,000. Up to 20 grants will be awarded.

**Eligibility:** All applications must include an investigative partnership between one or more Health Sciences Center primary partners (Clemson, University of South Carolina, and Furman) and a clinical collaborator from Prisma Health.

**Letter of Intent deadline:** Friday, October 23, 2020 at 5 PM (EST)
CUSHR listserv provides regular communication

Stay Connected to Research News

- CUSHR listserv - Email cushr@clemson.edu with subject line CUSHR news. Receive the CUSHR Announcements and Updates on the first of every month, as well as CUSHR Health Happenings with weekly event and/or funding opportunity notices

- Clemson Research Division newsletter/Research Roar listserv available here. [link is provided in each CUSHR Announcements and Updates]

- Prisma Health Research Update listserv- https://app.smartsheet.com/b/form/d2b6f3efed6a422eb01bfdccbe432b46
CUSHR Website – a resource for collaboration

Find Collaborators

Stay up-to-date on events – past, present and future

Health Research Spotlights/Features
Clemson Research at the Forefront of the COVID-19 Pandemic

The event will include CUSHR updates and feature an insider's view of Clemson's reopening operations. Come and hear firsthand from researchers who are helping Clemson handle the COVID-19 crisis. Speakers will represent the many Clemson health researchers standing at the forefront of the pandemic.
Snapshot: Clemson COVID Reopening Plans

Ms. Lisa Knox
Director of Strategy and Operations
Clemson University Finance and Operations Division
Sampling Strategy

Dr. Lior Rennert
Assistant Professor and Biostatistician
Public Health Sciences
Testing Strategies to Minimize COVID-19 Outbreaks

- Lior Rennert, Public Health Sciences
- Email: liorr@clemson.edu
- In collaboration with Clemson University Modeling Team: Christopher McMahan, Christopher Colenda, Lu Shi, and Corey Kalbaugh
Compartment-Based Models

<table>
<thead>
<tr>
<th>Compartment</th>
<th>Equation</th>
<th>Parameter</th>
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</thead>
<tbody>
<tr>
<td>Susceptible (S)</td>
<td>( dS(t) = -\beta \times (A + I) \times S / N )</td>
<td>( \beta: ) Contact Rate; dependent on ( R_0 )</td>
</tr>
<tr>
<td>Exposed (E)</td>
<td>( dE(t) = \beta \times (A + I) \times S / N - \sigma \times E )</td>
<td>( \sigma: ) Incubation time (3 days)</td>
</tr>
<tr>
<td>Asymptomatic (A)</td>
<td>( dA(t) = (1 - \alpha) \times \sigma \times E - \phi \times A )</td>
<td>( \alpha: ) Proportion of symptomatic exposures; ( \phi: ) Infectious period of asymptomatic: 14 days</td>
</tr>
<tr>
<td>Symptomatic (I)</td>
<td>( dI(t) = \alpha \times \sigma \times E - \gamma \times I )</td>
<td>( \gamma: ) Infectious period for symptomatic before presentation to health services (3 days)</td>
</tr>
<tr>
<td>Isolation (Q)</td>
<td>( dQ(t) = \gamma \times I - \rho \times Q )</td>
<td>( \rho: ) Isolation period after infection (11 days)</td>
</tr>
<tr>
<td>Recovered (R)</td>
<td>( dR(t) = \phi \times A + \rho \times Q )</td>
<td></td>
</tr>
</tbody>
</table>

The parameters \( \sigma, \phi, \gamma, \) & \( \rho \) are the inverse of the period: e.g., \( \sigma = 1 / \text{incubation time} \)
## Pre-Semester Testing

<table>
<thead>
<tr>
<th>% infectious at beginning of semester</th>
<th>% of student population infectious on campus for each testing strategy (expected number of active cases on campus for N=25,000)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No testing</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>1%</td>
<td>1% (225 cases)</td>
</tr>
<tr>
<td>2%</td>
<td>2% (450 cases)</td>
</tr>
<tr>
<td>5%</td>
<td>5% (1125 cases)</td>
</tr>
</tbody>
</table>

- Without pre-semester screening of all students, hundreds to thousands of infectious students will return to campus at the semester start!

Lior Rennert, Department of Public Health Sciences; email: liorr@clemson.edu
Impact of Pre-semester Testing on Active Infections Throughout Semester

- Days to trigger represents the time (days) until isolation bed capacity (500 beds) is reached.
- Assumes 50% of infected students on-campus students and 25% of infected off-campus students require isolation bed.

No testing (solid red line), 1 test per student (dashed blue line), 2 tests per student (dotted green line).
Impact of Phased Reopening on Active Infections Throughout Semester

- Model is on-campus population only
- Phased reopening returns one-third of student population to campus each month

Benefits of phased return:
- Minimizes size of the susceptible student population early semester
- Vacates a large portion of isolation beds
- Opportunity to ensure sufficient resources are in place
- Improve safety protocols and disease mitigation strategies before return of additional students to campus.

- No pre-semester interventions (solid red line)
- Pre-semester testing only (dashed blue line)
- Phased reopening + pre-semester testing (dotted green line)
Impact of Informative Testing on Active Infections Throughout Semester

- Model is on-campus population only

- **Random sampling:** Choose 700 random students every day

- **Targeted Sampling:**
  1. Randomly sample population on day \( t \)
  2. Identify dorms with COVID-19 cases
  3. Use portion (or all) of 700 tests on day \( t+1 \) to test every student in targeted dorm

- Repeat steps 1-3 on day \( t+2 \)
Between September 23rd and October 5th, our team alternated between random sampling and targeted sampling.

Red and purple dashed lines represent estimated prevalence on-campus.

The targeted sampling resulted in an 8.6% percent positive, compared to 5% in random sampling prior to October 6th.

On October 6th, we began sampling all on-campus students once per week.
Testing Strategy

Dr. Corey Kalbaugh
Assistant Professor and Epidemiologist
Public Health Sciences
Collaboration

Be a team player:
Say “yes” to collaboration more than you say “no”
Know Your Lane
Training the next generation of pandemic leaders

Brandon Lumsden
Banu Laksiva
Snehal Lopes
Yuan Yang
Stefanie Mokalled
Pick Your Battles Wisely

Which hills are worth dying on?
- Data acquisition
- Integrity of the scientific strategy
- Population health v clinical medicine
Testing Procedures

Dr. Delphine Dean
Ron and Jane Lindsay Family Innovation Professor
Bioengineering

Dr. Mark Blenner
McQueen-Quattlebaum Associate Professor
Chemical and Biomolecular Engineering
Testing for COVID at Clemson:
Our efforts so far

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How is COVID diagnosed?

Samples used:
- Nasopharyngeal (NP) swab (“scratching your brain” test)
- Nasal swab (just the inside of your nose)
- Saliva (spit)
- Few others: throat swab, sputum, cheek swab, etc.

Current FDA approved diagnostic test methods (do you currently have COVID-19?)
- RT-PCR: detects the genetic material of the virus
- Antigen: detects viral protein directly (this is the proteins on the virus itself)

Serological testing (did you have COVID-19 in the past?)
- Detects antibodies (IgG, IgM, IgA) to the virus. This is the proteins your body’s immune system makes in response to the virus.
Issues with NP swab testing

While NP swab with RT-PCR is the gold standard for diagnosis, it is problematic for large scale testing and screening:

- It’s expensive (tests cost $50-$100/test)
- It is difficult to do (need trained personnel for sample collection and running the test)
- It’s very uncomfortable and people hate them. It’s hard to convince asymptomatic people to have to go through this test (especially more than once)
- Time consuming (running the test take 1-4 hrs depending on the machine) Due to all the steps and sample handling, the tests usually come back in ~48hr but can take up to 7 days when there are backlogs
- There are supply chain issues with the specialized parts of the test:
  - NP swabs, viral transport media, PPE for collection, etc.
Development of saliva testing

Clemson University and University of South Carolina worked together to create rapid, low-cost, effective saliva based COVID-19 testing

- Saliva is easy to collect (anyone can spit! Even children)
  - No need for highly trained personnel for sample collection!
- Viral load in saliva is highly correlated to infectiousness of the individual
- Virus in saliva is very stable making it easy to handle the sample
- Does not require viral transport media, specialized swabs or collection device, which have been in shortage. Can use pretty much any container to collect spit and it will still work.
Saliva PCR

Measure the virus genetic material in saliva

- As sensitive as NP swab PCR test
- Worked to establish protocols for integration of this test into standard clinical lab practice
- Can screen more people who would otherwise not come in for testing
  - Asymptomatic people are not likely to come to get an NP swab because it’s so uncomfortable, but they are willing to spit in a tube!

- Only small “downside”:
  - Saliva is viscous thus requires a little bit of a different initial preprocessing step than NP swab samples to work with large scale highly automated robots. This is not expensive or any slower but does require small changes some of the lab standard lab protocol
Current Clemson Saliva Testing and Collection Research

Collaborated with MUSC COVID-19 biorepository to test and validate new protocols and test
- Biorepository is useful for getting specific types of patient samples (samples from in hospital patients)

Saliva testing of Pickens County with Representative Neal Collins
- Study led by Dr. Helmut Albrecht and Dr. Phil Buckhaults at U of SC
- Clemson and U of SC researchers are testing saliva from Pickens County
- Optimize saliva PCR protocols for large scale rapid testing cross-validated at different test sites
- Return test results with 24hrs or less
- All positive tests are confirmed by DHEC, counseling provided by clinicians
- The program has led to several business re-openings, stopping of micro-outbreaks in the community, catch completely asymptomatic “super spreaders” who would have otherwise not gotten tested.
- Presented to SC senate subcommittee: tasked with making a joint proposal to the committee. (video of Dr. Albrecht talking about this program is at ~1:54:00)
- Tuesday, August 4, 2020 1:00 pm; Senate Legislative Oversight Committee -- Testing and Tracing Subcommittee of Re-Open SC Select Committee
Clemson University Saliva Collection Research

Approved IRB protocol through Prisma Health (for FDA clearance)
Collected samples from mandatory employee screening tests
  ▪ Test results confirmed by MUSC NP swab
  ▪ July 22 collection: 100 samples all negative
  ▪ July 27-28 collections: 96 samples, 1 positive (confirmed by MUSC)
  ▪ Saliva PCR done and results returned within 1 day
Collect samples from Clemson Athletics screening program
  ▪ Initial collections from positive tests July 6- July 12
  ▪ Aug. 3 collection: 187 samples, 2 positives
  ▪ Results returned on same day (NP swab result returned ~3 days)
Overall by Sep. 15: nearly 2000 tests to validate different saliva testing protocols.
Set up a CLIA and start testing!

Sep. 25 ran our first official diagnostics tests with athletics 😊
Test costs 1/10th the cost of standard COVID diagnostics
Scaling up!
Currently, testing: athletics, band, employees, and symptomatic/contact traced people
CLIA lab stats and plans

Week 1: 271
Week 2: 224
Week 3: 1114
Week 4: 1128
Week 5: Ongoing (Est. 2000)

Total: 2648
Positives: 50 (1.94%)
Rerun/Inconclusive: 63 (2.61%)
Negatives: 2562

Currently running a single-plex lab developed assay.
Validating a multi-plex lab developed assay.
Wastewater Surveillance

Dr. David L. Freedman
Professor and Department Chair
Environmental Engineering and Earth Sciences
Wastewater Surveillance of SARS-CoV-2 in Three Clemson Area Sewersheds

Many thanks to:

- Chris McMahan (CU, Math Sci.)
- Stella Self (USC)
- Lior Rennert (CU, Public Health)
- Corey Kalbaugh (CU, Public Health)
- David Kriebel (U-Mass Lowell)
- Duane Graves (President, SiREM)
- Sudeep Popat, Jessica Deaver, Chris Coskrey, Tanju Karanfil (EEES)
- Many dedicated employees of Clemson University Facilities

Clemson University has funded the wastewater surveillance
Wastewater-Based Epidemiology

• WBE has been used for decades
  ❖ Monitor the effectiveness of polio vaccine: “Israel experienced an outbreak of wild poliovirus type 1 (WPV1) in 2013–2014, detected through environmental surveillance of the sewage system. . . As we approach global eradication, polio will increasingly be detected only through environmental surveillance.”
    Brouwer et al., 2018; PNAS
  ❖ Monitor the magnitude of opioid use at a community level; most drugs are only partly metabolized and are excreted at detectable levels in sewage
  ❖ Gauge spread of antibiotic-resistant microbes

• Wastewater is a mirror of important processes that occur within human populations, at the level of individual buildings, neighborhoods, or whole communities
WBE Applied to SARS-CoV-2

- Symptomatic and asymptomatic individuals who are infected with SARS-CoV-2 shed the virus in their feces.
- This creates an opportunity to monitor for the presence of the virus in sewage.
- Monitoring sewage can indicate at the community level if transmission of the virus is . . .
  - imminent, since people can shed virus ~1 to 2 weeks before they exhibit clinical symptoms (leading indicator);
  - underway, especially in the absence of extensive testing of individuals;
  - on the decline, in response to efforts to reduce transmission.
Results to Date

Concern Levels:
- IV
- III
- II
- I
- 0

Mask Ordinances (Clemson, Central)

Detection Limit

Virus Copies Per Liter of Wastewater
Valencia, Spain

Compare to Local Samples
$>10^5$ copies/L

- Cochran Rd: 18/21
- Pendleton/Clemson 18/19
- Campus
  - Pre 9/14: 0/25
  - Post 9/14: 9/10
Results from Other Cities:
Boston, MA

Graph showing SARS-CoV-2 (Copies/mL) over time from March 1, 2020, to October 1, 2020, with data points for Southern and Northern copies/mL.
Estimating Number of Cases

Formula is based on a mass balance:

\[ \text{# Infected} = \frac{AXB}{CxD} \]

- \( A \) = Flow rate (L/d)
- \( B \) = Virus copies/L
- \( C \) = Feces rate (~129 g/person/day)
- \( D \) = Virus density in feces (copies/g feces); max ~4.7E07 copies/g

- Use Monte Carlo simulations to factor in uncertainty in \( C \) and \( D \)
- Does not include decay in sewer system
- Don’t forget: DHEC reports cumulative cases; this formula gives infected individuals on any given day
Estimating Number of Cases: SEIR Model

**Figure 2.** SEIR model showing (Panel A) proportions of the population that are susceptible (black), exposed (red), infectious (green), and recovered (blue); model predictions for mass rate of SARS-CoV-2 RNA in wastewater over time (Panel B); and predictions of the number of infections versus RNA mass (Panel C). Individual gray points represent each simulation. The blue line represents the median, the green and red lines represent the 75% and 95% confidence intervals, respectively. Colored data points correspond to measured RNA mass rates (Table 1) and estimates of infected individuals based on equation 10 (blue) and estimated positive cases (320) assuming 2% of the population was infected (red). The green triangle represents the average RNA mass rates for July 16 to August 18 (Table 1) versus the ~320 positive cases.
## Manhole Results

<table>
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</tbody>
</table>

- Thornhill used for quarantine
- Likely at least one infected individual in all locations
- WBE has stopped since all on-campus residents being tested once per week
Summary

- WBE can serve as a leading indicator of COVID-19 infections
- WBE can inform public policy: mask ordinances (City of Clemson’s extended)
- Once transmission is active, virus in wastewater becomes a lagging indicator, but levels will come down when transmission is brought under control
- Virus levels in wastewater can be used to predict the number of infected individuals, taking uncertainty into account
- Modeling indicates ~12 infected individuals/reported case in 29631
- The virus has persisted in the Clemson area
- WBE will be an important tool for assessing the effectiveness of a vaccine
- *Poop doesn’t lie*
Masks

Dr. Chris Cole
Professor Emerita
Clemson Textiles/Materials Science and Engineering
Rapid Innovation Task

Force: Masks

Dr. Chris Cole
Professor Emerita
Clemson Textiles/Materials Science and Engineering
PROBLEM:

- PPE Availability
- Mismatch: Worldwide Supply vs Demand during a Pandemic

Prisma Health RITF Alternative Options:

- Reprocessing/Recycling Existing N95 masks
- Procuring Alternative Mask Products
- Developing new mask technologies
RITF Research Strategy

• N95 Mask Reprocessing Issues
  Question: What is the impact of reprocessing on mask materials and how can the impact be verified?

• Alternative Mask Performance Verification
  Question: What is the actual performance and how can we identify likely failure routes?

• Alternative Mask Designs and Technologies
  Questions: How can we identify mask and filter media performance characteristics? How can we measure appropriate properties, given the lack of access to rapid external testing?
Required Testing and Approvals for N95 Masks

N95 masks for medical applications are different than non-medical masks due to the need for liquid holdout.

All N95 masks require NIOSH approval for particle filtration.

Medical N95 masks cannot have exhalation valves to reduce pressure needed for exhalation (not to exceed 25 mm).

Not feasible to perform these tests on each batch of recycled N95 masks.
Mask Testing

- The US requires an annual Fit Test for all wearers of N95 masks.
- The Fit Test requires a minimum score of 100 using either a Qualitative Fit Test or a Quantitative Fit Test.
- The activities or exercises which the wearer performs are identical in the two tests. The differences are the chemical challenges and the sensors used.

The US fit test is stressing the filter media, the mask design, and the mask components as well as determining the match of the mask to the individual wearer.
Test Results

• All 3M 1860 dome masks, new and after Vapor Hydrogen Peroxide processing, meet the minimum 100 fit factor.
• No KN95s have passed
• Quantitative fit testing is useful as a development tool. The activity where failure occurs gives an indication of what specifically is causing the failure - edge of mouth, filter media, area around nose, etc.
Other Masks

- Thoughtful design and engineering
- Children’s masks
- Special purpose masks
- Work with industry partners
Contacts

Dr. Chris Cole
Clemson University
cwjrv@clemson.edu
Clemson Research at the Forefront of the COVID-19 Pandemic

The event will include CUSHR updates and feature an insider's view of Clemson's reopening operations. Come and hear firsthand from researchers who are helping Clemson handle the COVID-19 crisis. Speakers will represent the many Clemson health researchers standing at the forefront of the pandemic.
Select a breakout:

1. HSC Seed Grant Discussion
2. Presenter Q&A