JUMP ARCHES
COVID-19 PRIORITY CALL 2020

ILLINOIS
Health Care Engineering Systems Center
GRAINGER COLLEGE OF ENGINEERING

AN OSF HEALTHCARE, UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN, AND UNIVERSITY OF ILLINOIS COLLEGE OF MEDICINE PEORIA COLLABORATION
Jump Applied Research in Community Health through Engineering and Simulation (ARCHES)

Jump ARCHES is a partnership between Jump Simulation and Education Center at OSF HealthCare and HCESC in The Grainger College of Engineering at the University of Illinois.

• Established in 2014 by a $62.5 million gift to provide direct access and competitive grants to engineers and physicians working together to combat problems in the realm of healthcare.

• Expanded in 2019 with a new commitment of $50 million

• Funded 40+ proposals with over $2 million since 2014
COVID-19 Priority Call 2020

Announced March 13, 2020, to address COVID-19, pandemics, and other public health crises through smart health, AI, data analytics, and other technologies.

Projects funded: 16
Total budget: $792,262
Sterilization & PPE
Research Goal: to use a microwave, wire, coffee cup, and hydrogen peroxide to decontaminate an N95 respirator in 30 seconds by creating a plasma

Methods: $3-4 \log_{10}$ of Tulane virus inactivation, maintain filtration efficiency and pressure drop
Testing the Filtration Efficiency of N95 Respirators for Health Care Employees and Protecting Public Health in Pandemic Flu Emergencies

Vishal Verma - Civil and Environmental Engineering, University of Illinois at Urbana-Champaign
Matthew T. Bramlet - University of Illinois College of Medicine at Peoria

Research Goal: to develop a robust testing protocol for N95 respirators

Methods: replicating NIOSH protocol using a suite of state-of-the-art aerosol measurement instruments

Results/Outcomes: rapid testing of various N95 respirators thus helping the healthcare and local community in times of pandemic emergencies such as COVID-19
Optimal Pooled COVID-19 Diagnostic Testing for Community Screening: Phase I Feasibility Study

Hadi Meidani - Civil and Environmental Engineering, University of Illinois at Urbana-Champaign
Co-PIs: John Farrell (OSF HealthCare), Daniel Lakeland (Lakeland Applied Sciences LLC)

Research Goal: to investigate a pooled community testing approach which optimally estimates the prevalence of COVID-19 in a community, leading to more informed planning for treatment and mitigation

Methods:
• Design different pooling strategies for PCR tests where a well with samples from multiple patients is tested and assess the feasibility and advantage of community testing by simulating different testing and spread scenarios
• Evaluate the effectiveness and accuracy of pooling strategies by conducting pilot pooled PCR tests at OSF and evaluate the capacity of pooling strategies for subsequent identification of infected patients

Phase I Results/Outcomes:
• Validation of pooled PCR testing
• Identification of important pooling parameters in accurate community screening
• Preparing framework for major community screening implementation and validation

Design more pooled tests
+ Identify infected cases
Healthier Homes: Reducing Risk of Infections Disease Transmission at Home (Proof of Concept)

Paul Francisco – University of Illinois at Urbana-Champaign
Dr. Beth Houser – OSF HealthCare

Research Goal: to determine potential for creating and maintaining an isolation zone at home

Methods:
• Isolate room or suite from rest of the home through air sealing and taping of heating vents
• Add ventilation to exhaust room
• Monitor pressures
• Test family members for infection

Results: to collect pilot data to support concept

Long-term success implications:
• People can recover at home to ease hospital burden
• Families can be less burdened with illness, care, and travel
Rapid, Contactless Vital Signs Collection Using Computer Vision and Consumer Technologies

Ramavarapu “RS” Sreenivas - Industrial and Enterprise Systems Engineering, University of Illinois at Urbana-Champaign
Co-PIs: Roopa Foulger, Brent Cross (OSF HealthCare)
Support: Stefan Malmberg, Taha Khan (Detectivio, Sweden)

Research Goal: to develop a platform equipped with a non-contact temperature sensor, RBG camera with software that runs on Raspberry Pi to log temperature, respiratory, and pulse of authenticated user using Rokwire API. User data is incorporated into OSF’s Pandemic Health Worker system which can be used for contact tracing and other remedial activities. Data made available to user at any time.

Methods: Eulerian Video Magnification, Artificial Neural Networks, IoT, Rokwire API
Development of a Reusable N95 Respirator
Jeremy Guest, Helen Nguyen, and Lisa Bievenue – University of Illinois at Urbana-Champaign
Brent Cross, Sister M. Pieta, John Kreckman, and Jared Rogers - OSF HealthCare

Phase I - Prototyping and Fit Testing: Develop and fit test a prototype N95 respirator (“Standard” size) that can accept existing medical respiratory filters, pass a N95 respirator fit test, and be sterilized or sanitized by readily available procedures. Evaluate filter supply chains and supply chain resilience.

Phase II - Prototyping and NIOSH Compliance Testing: Fabricate prototypes and have them tested for usability (by OSF) and N95 NIOSH compliance (by a certified laboratory). Design, prototype, and demonstrate a filter cartridge that can plug into the N95 respirator, achieve >95% particle removal efficiency, and be sterilized or sanitized by readily available procedures. Post designs open-access online.

- **Respirator** - made of PETG with polyethylene closed cell foam seal
- **Elastic and holder** - 3D printed elastic holder that pulls onto the front of the respirator
- **Filters** - N95 is designed to accept standard fittings for respiratory filters
- **End cap** - to protect the bottom of the filter from bodily fluids
Diagnostic & Testing
A single-step 10-minute point of care COVID-19 diagnostic test using Activate Cleave & Count (ACC) technology

Brian Cunningham - Electrical and Computer Engineering, University of Illinois at Urbana-Champaign
John Farrell - University of Illinois at Chicago

Research Goal:

• Derive and validate specific CRISPR Cas12a and Cas13a assays from multiple regions of the SARS-CoV-2 genome.

• Preparation of a point of care photonic resonator absorption microscope (PRAM) imaging instrument and design/testing of CRISPR Cas assay for detecting SARS-CoV-2 on platform.

• System characterization involving swab extract spiked with RNA, inactivated virus, and comparing assay against a CDC-certified RT-PCR assay for the determination of limit of detection, selectivity against non-target pathogen, and time to result.

Project Outcomes:

• Isothermal, room-temperature, nucleic acid test for viral pathogen going from sample to answer in 10 minutes

• Inexpensive and simple detection instrument suitable for usage in point of care scenarios such as clinics and hospitals with cost per test of ~$1
Development of a blood analysis technology for artificial intelligence-assisted, point of care decisions

Rohit Bhargava - Bioengineering and Cancer Center at Illinois, University of Illinois at Urbana-Champaign
James McGee - OSF HealthCare, Radiation Oncology, OSF Saint Francis Medical Center,
Tulika Chatterjee - Internal Medicine, OSF Saint Francis Medical Center

Project Concept (Phase I Goal): to develop methodology and validate concept for spectral-spatial analysis of blood

Methods:
• Develop IR imaging instrument
• Test on blood samples
• Develop AI methods for spectral data

Preliminary Results & Progress:
• Ensure rapid low noise scanning of instruments
• Develop sampling strategy for consistent results
• IRB paperwork and sample handling
• Preliminary data and validation
Rapid SARS-CoV-2 Detection from Nasal Swab Extracts

Rashid Bashir - University of Illinois at Urbana-Champaign
Enrique Valera - University of Illinois at Urbana-Champaign
Anurup Ganguli - University of Illinois at Urbana-Champaign
Sarah Stewart de Ramirez - OSF Innovation, OSF HealthCare

Project Aims:

• SARS-CoV-2 RT-LAMP validation using non-bi-phasic reactions and commercial thermocyclers

• Very-low SARS-CoV-2 detection from nasal samples using the bi-phasic technique

• Portable and inexpensive instrumentation development
**A rapid and affordable virus test for early warning of a pandemic**

*Joseph Irudayaraj* – Bioengineering, University of Illinois at Urbana-Champaign  
*Wen Ren* - Research Staff Bioengineering, University of Illinois at Urbana-Champaign  
*Co-PI: Dr. William Bond* - OSF HealthCare

**Research Goal:** to establish a simple, highly-sensitive, rapid virus test relevant to a pandemic threatening public health and safety.  
- Develop an integrated system with loop-mediated isothermal amplification (LAMP) and magnetic enhanced lateral flow (mLFA) to detect specific RNA from target pathogenic agents  
- Calibrate and test the system utilizing fabricated probes and RNA from known model organisms  
- Validate the assay utilizing RNA extracted from 2019-nCoV from clinical samples

**Outcomes:**  
- Establish the LAMP-mLFA test method with model nucleic acid sequences with sensitivity to 1000 copies/mL or less  
- Develop a calibration utilizing synthetic RNA targets for COVID and establish the limit of detection and limit of quantification  
- Validate the virus test with clinical samples or inactivated virus in synthetic nasal solution
AI, Data, & Supply
COVID-19 Keeping Safe Program

Brent W. Roberts - Center for Social and Behavioral Science, University of Illinois at Urbana-Champaign
Sarah Stewart de Ramirez - OSF Innovation, OSF HealthCare
Co-PIs: Nick Allen, Sanjay Patel (UIUC), John Paul, William Sullivan (Rokwire), John Vozelenilek (OSF HealthCare), Andrew Miller

Research Goal:
• Merge state-of-the-art COVID-19 exposure detection, real-time documentation of COVID-19 status, the OSF Pandemic Health Worker System with PatientSense, and mental health and social functioning support all in one package.
• Create a comprehensive, supportive program to manage COVID-19 for students, faculty, staff, and community members in Champaign County

Participating Organizations:
• The Grainger College of Engineering, OSF HealthCare, Rokwire, CSBS, and Oregon University
Supply-driven Hospital Resource Planning and Community Engagement for COVID-19 Treatment

Lavanya Marla - Industrial and Enterprise Systems Engineering, University of Illinois at Urbana-Champaign
Co-PIs: Qiong Wang (UIUC), Dr. Kurt A. Bloomstrand (OSF HealthCare), Dr. Benjamin Davis (Carle)

Research Goal: integrated supply planning and demand management

Methods: reinforcement learning for integrated queueing theory and inventory management, structural estimation of human response to announcements with game-theoretic network congestion models

Results/Outcomes: inventory and workforce management policies, streamlined congestion-mitigating community announcements

Supply Planning
- Inventory of one-time resources (masks, tests)
- Workforce optimization and scheduling

Demand Management
- Community response to announcements
- Manage network congestion at Emergency Depts
Data-driven modeling, analysis, and simulation of epidemic processes: Controlling COVID-19

Carolyn Beck - Industrial and Enterprise Systems Engineering, University of Illinois at Urbana-Champaign
Co-PIs: Tamer Basar (UIUC), Dr. Joseph Kim (OSF HealthCare & UIC)

Research Goal:
- Data-informed modeling of epidemic processes evolving over spatially and temporally-varying networks (human-contact, nearest-neighbor, transportation, etc.)
- Analysis and design of control policies for local, national, and global implementation

Methods: data estimation approaches applied in combination with nonlinear and distributed system analysis, control and implementation techniques

Results/Outcomes: analysis-derived insights and control policies to improve our understanding and enact suppression of COVID-19 locally and globally
Data Driven Analytics to Predict the Dynamics of the COVID-19 Outbreak & Impact on Healthcare Providers, Resources, and Communities

Ravishankar K. Iyer – Electrical and Computer Engineering, University of Illinois at Urbana-Champaign
Roy Campbell – Computer Science, University of Illinois at Urbana-Champaign
Sarah Stewart de Ramirez – OSF Innovation, OSF HealthCare

Research Goal: to enable hospitals to respond faster and with greater precision to the COVID-19 crisis by providing data needed and dynamically trained models. Aims to project infections and severity at hospital scale, develop novel analytics approaches based on domain-guided machine learning using Bayesian augmented deep learning, and address impact of the readmission severity.

Methods:

• Continuously improve prediction results by retraining model as more data is available
• Data stratification aligned with conditions existent in patient capture areas

- Chicago data, highest positive + presumed positive COVID19 cases
- CAPriCORN - Chicago Area Patient-Centered Outcomes Research Network
- Rush University
- UIC Health
- Illinois Department of Public Health (IDPH) (if available)
- OSF HealthCare (if available)
Secure Federated Learning for Collaborative Diagnosis

Sanmi Koyejo - Computer Science, University of Illinois at Urbana-Champaign
Co-PIs: Dakshita Khurana, George Heintz (UIUC), William Bond (Jump Simulation Center), Roopa Foulger (OSF HealthCare)

Research Vision: to improve healthcare quality and patient safety through technology to enable private training of highly accurate diagnostic models on datasets pooled by two or more medical providers. The long-term goal is to open-source techniques for privacy-preserving collaboration to other aspects of diagnostics and to enable medical breakthroughs via privacy-adhering computation on large-scale clinical data.

Impact: Enabling healthcare providers to respond faster and with greater precision to pandemics by providing advanced machine learning that adapts to rapidly evolving clinical data.

Novelty: Developing a computational protocol for securely training machine learning models, while data are distributed over several medical establishments.
Connect with HCESC:

- Health Care Engineering Systems Center
- @ILHealthEng
- healtheng.illinois.edu

COVID-19 Priority Call Phase 2 will be announced in August!

Thank you!