CARES Funding Supports FSU CARES (Covid-19 Assessment, Research & Emerging Science)

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Executive Summary

A one million dollar NC Collaboratory Funding opportunity allowed Fayetteville State University to establish a comprehensive program that used a multi-disciplinary approach to contribute to the body of knowledge of COVID 19 and its impact. These multi-disciplinary projects were led by teams of faculty and students, who sought to develop and implement assessment strategies of COVID-19, conduct exploratory research to understand its impact and tap into the potential of novel retinal research. The specific activities for the project were as follows:

1. COVID-19 viral testing to FSU students and the Cumberland County Community. (Nursing) (Faculty team: Arhin, A., PhD., Gallagher, S., DNP, Nunez, R. MSN (**Undergraduate Student: Dilma Lopez)**
2. Social Vulnerability Index Research. (Psychology) (Faculty Team: Nyutu, P. PhD, Coyle, L. PhD ,Tran, K. PhD Fu, C. PhD, & Wall, W. PhD.
   Graduate Students: Olivia Boyd, Orutanu Ra, Shakeyra Foust, Zenia Washington
3. Developing the capacity of serological testing. (Biology) (Faculty Team: Haddad, E. PhD, Jiazhang, Y. PhD & Washington, E., MS. **Undergraduate Students: Jasmine Daniels, Crystal Graham, Emily Vilchis and 9 other students enrolled in Capstone Course.**
4. Retinal Net Prototype Pilot. (Multi-disciplinary). Faculty Team: Bhattacharya, S. PhD., Gammons, R. & Adivar, M. **Graduate Student: Catherine Spooner**

Results of Projects and Implications for Future Research.

COVID-19 PCR viral testing to FSU students and the Cumberland County Community

Fayetteville State University (FSU) met its original goal to provide COVID-19 testing and education to the underserved population of Cumberland and Harnett Counties, North Carolina. The underserved population the project focused on were those with social vulnerabilities, including poverty, homelessness, the elderly, racial or ethnic minorities, rural communities, and those with chronic diseases.

Results

Testing and education was offered on FSU's campus and in the surrounding community. A total of 2865 PCR viral tests were completed with 2500 being usable. 197 of those tests were SARS COV2 RNA positive, an overall positivity rate of 6.9%. Data was collected on several variables including gender, age, race, employment, household status, education, self -reported health behaviors, plans to receive COVID-19 vaccine when it becomes available. Data was analyzed and the only variable that was statistically significant to COVID-19 status was gender.

In this population, males were twice as likely to test positive for SARS COV2 RNA (18.4%) than females who tested positive for SARS COV2 RNA (7.9%) with a p value $p < 0.035$. Another important finding is 65.3% of individuals we surveyed planned to receive the vaccine when it

becomes available. Implications for further research includes examination of antibody testing among our population.

Social Vulnerability Index Research

This project was designed to add to the body of Social Vulnerability Index research, mental health research, and health behaviors research by examining the COVID-19 impacts on disadvantaged populations in the Cumberland County region. After obtaining IRB approval, individuals who presented for COVID-19 resting were recruited for the study. The research employed the Social Vulnerability Index (SVI) as a framework to examine COVID-19 impacts on disadvantaged populations in the Cumberland County region. The effects of COVID-19 to these groups were examined as it relates to mental and behavioral health. Additionally, the research examined the impact on accessibility to and provision of care by seeking the input of health providers who serve this population. The goal was to provide both individual and socio-cultural perspectives of the challenges emerging as a result of the impact of COVID-19 pandemic and provide recommendations.

Research Questions:

1. Is there a correlation between health behaviors and the presence of COVID-19?
2. Is there a correlation between the Social Vulnerability Index (SVI) and the presence of COVID-19?
3. How has the coronavirus/COVID-19 pandemic influenced the population's mental health?
4. What are the perceived barriers to provision and access of care to socially vulnerable populations due to the COVID-19 pandemic?

Research Activities

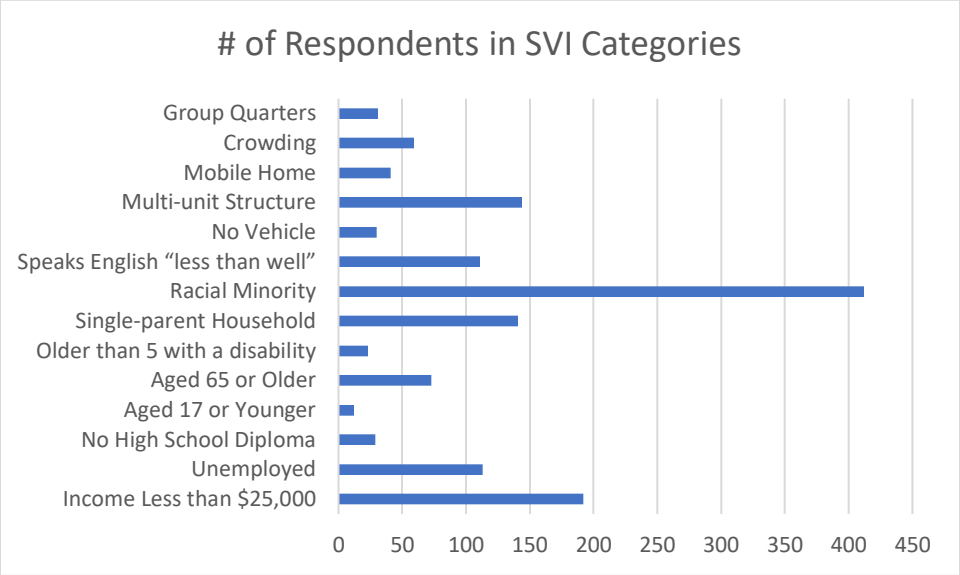
Participants

Subjects were recruited from volunteers who presented at the FSU CARES COVID-19 testing sites. The testing sites were located at the grounds of the Fayetteville State University, and at various community resource locations in Cumberland County. 596 participants volunteered for the study with their demographics distributed as follows:

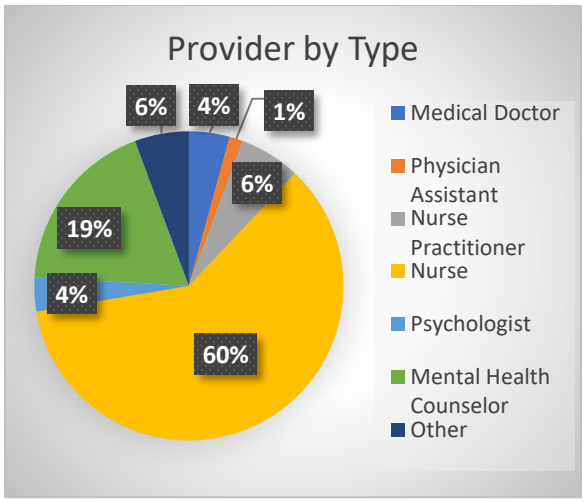
- Gender: 217 Male; 356 Female; 2 Other
- Age: 12 (17 and younger); 481 (18-64); 73 (65 and Older)
- Living with a disability: 23
- Race: 326 Black/African American; 148 White; 36 Hispanic; 31 Biracial/Multiracial; 10 Asian; 9 American Indian/Alaska Native; 8 Others
- Employment: 268 Full-time; 83 Part-time; 83 Retired; 113 Unemployed
- Annual Income ($): 192 Less than 25,000; 147 25,000-49,999; 122 50,000-99,999; 32

100,000 and above.

- Housing and Transportation: 59 Crowded; 31 Group quarters; 41 Mobile home; 144 Multi-unit structure; 30 No Vehicle
- Respondents who fall within the Social Vulnerability Index (SVI)



Participants for the provider part of the study consisted of 141 providers drawn from lists of medical doctors, physician assistants, nurse practitioners, nurses, psychologists, counselors, and other health providers in Cumberland County. The vast majority of our sample were female (87%). The race/ethnicity of the sample was as follows: Non-Hispanic White/Caucasian (53%), Black/African American (35%), Hispanic Latino (4%), Asian American (3%), and Other (5%). More than half of the sample identifies as a nurse (63%). Other categories are displayed below.



Procedures

Approval for the study was acquired from the Fayetteville State University Institutional Review Board. Information about the COVID-19 testing sites was disseminated through the North Carolina Department of Public Health website, through broadcast stations, flyers posted at the community resource centers, and announcements at FSU News. Participants were then approached at the testing sites while waiting in queue and explained about the study by trained research assistants. Those who volunteered were asked to provide informed consent before completing the research instruments. The signed consents were separated from the questionnaires and a de-identified code was entered on the completed questionnaire for matching with COVID-19 test results after they became available. All the research materials are maintained in a secure place by the lead researchers. Data from the completed questionnaires were then entered into encrypted excel files in readiness for statistical analyses.

The COVID-19 provider survey was distributed by e-mail to providers residing in Cumberland County licensed by the North Carolina Board of Nursing (n=5192), the North Carolina Medical Board (n=498), the North Carolina Psychology Board (n=74), and the North Carolina Social Work Certification and Licensure Board (n=251), and the North Carolina Board of Licensed Mental Health Counselors (n=279). Those who volunteered for the study by clicking the link to the online survey platform, Survey Monkey, were first provided with an explanation of the study and asked to provide informed consent. They then completed the self-reported survey instrument and reviewed a debriefing statement at the end. Data collected were stored within a secure server that was only be accessible to the researchers.

Measures

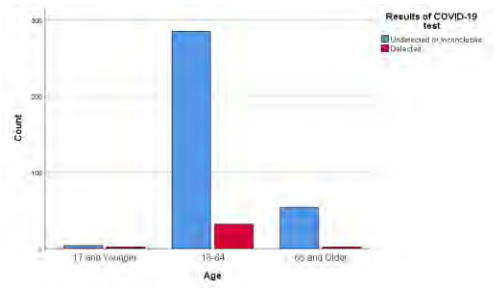
The COVID-19 Testing Questionnaire. A 42-item instrument that was developed by the researchers for the purpose of the study. The instrument asked for demographic information based on the CDC SVI themes and social factors (Flanagan, Hallisey, Adams, & Lavery, 2018), chronic health conditions, behavior changes, and mental health concerns as result of COVID-19 pandemic, as well as the impact that COVID-19 has had on finances, employment, and general health.

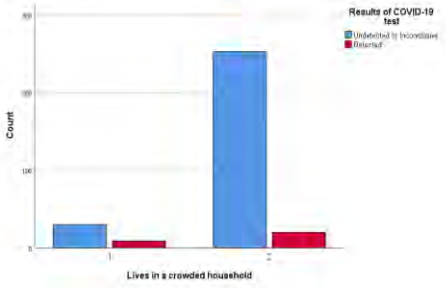
Provider Survey of COVID-19 Impact on Care to Socially Vulnerable Populations. This instrument was developed by the researchers for the purpose of this study. The instrument consisted of 49 items, including: (1) demographic data (e.g., race, ethnicity, provider type, years of experience), (2) frequency of treating SVI populations during the COVID-19 pandemic, (3) perceived impact of SVI statuses on access to care during the COVID-19 pandemic, (4) adjustments made to enable care to SVI populations during the COVID-19 pandemic, (5) needs in order to provide better care to SVI populations during COVID-19 pandemic, (6) use of SAMHSA's Recommendations for First Responders (SAMHSA 2018), and (7) two qualitative data prompts.

Results

Relationship Between SVI and the Presence of COVID-19

Among the SVI factors examined, there were significant correlations between the results of COVID-19 and age (r = .112) and living in a crowded household (r = -179). Percentages of those whose results were positive in age groups 17 and younger and 65 and older were higher as compared to percentage of those positive within the age range 18-64. Similarly, the rate of positives in those who live in crowded households were higher as compared the rates among those not living in crowded households.





When the distribution of rates of COVID-19 detected were examined within groups of SVI factors, higher rates were present among the SVI populations who live in crowded households, group quarters, multi-unit structures, mobile homes, single-parent household, and speak English less than well, as compared to the general population. The rates of COVID-19 detection were highest among those less than 18 years old as compared to other ages, Hispanic/Latino as compared to other races, and those employed part-time. The rates of detection were second highest among those with an annual income of less than $25,000. A complete list of percentages is presented in the table below.

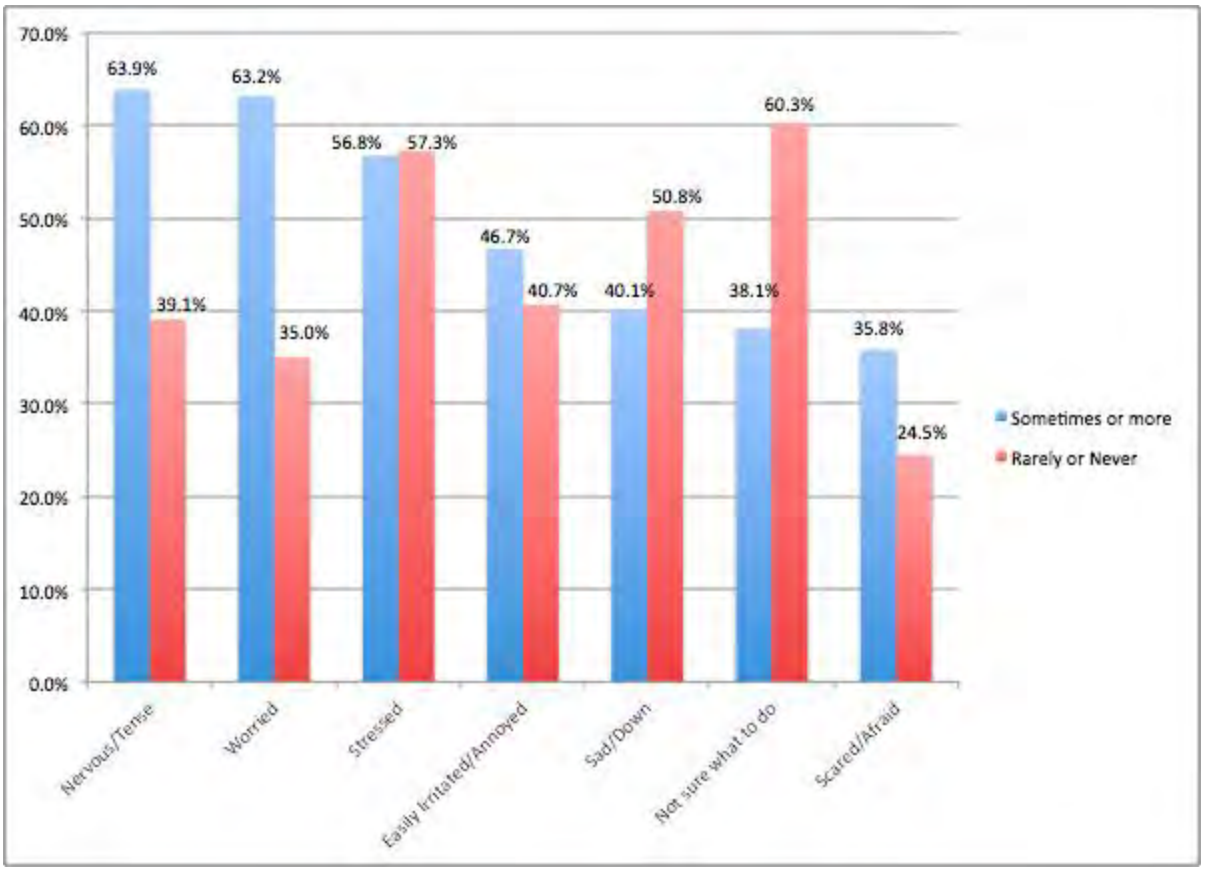
Percentages of COVID-19 Detected Cases within Groups of SVI Factors

SVI Factor	**Group**	**% Detected within Group**	**% Detected within Factor**
Age	17 and Younger	33.3	5.6
	18 - 64	10.1	88.9
	65 and Older	3.6	5.6
Lives with a Child with Disability	Yes	0	0
	No	8.5	100
Race	American Indian/ Alaska Native	0	0
	Asian	11.1	2.8
	Black/ African American	9.6	55.6
	Hispanic/Latino	14.3	11.1
	White/Caucasian	8.2	25.0
	Biracial/Multiracial	9.5	5.6
	Other	0	0
Employment	Full-Time	9.3	50.0
	Part-Time	15.8	26.5
	Unemployed	9.2	17.6
	Retired	3.3	5.9
Single-Parent Household	Yes	10.1	37.0
	No	7.8	63.0

High School Diploma/ GED	Yes	9.1	93.9
	No	11.8	6.1
Speaks English Less than Well	Yes	11.3	34.8
	No	6.9	65.2
Income	Less than $25,000	10.2	43.8
	$25,000-49,999	12.4	37.5
	$50,000-99,000	4.7	12.5
	$100,000 and above	10.0	6.3
Lives in Multi-Unit Structure	Yes	13.3	40.0
	No	7.6	60.0
Lives in Mobile Home	Yes	10.7	11.5
	No	8.2	88.5
Lives in Group Quarters	Yes	13.3	7.7
	No	8.5	92.3
Lives in a Crowded Household	Yes	23.1	31.0
	No	7.3	69.0
Has Access to a Vehicle	Yes	9.5	97.1
	No	5.0	2.9

Impact of Coronavirus/COVID-19 Pandemic on the SVI Population's Mental Health

Participants were asked to indicate how often they experienced mental health symptoms (nervous or tense, worried, sad or down, stressed, easily irritated or annoyed, scared or afraid, and not sure what to do) due to concerns about coronavirus/COVID-19. Over 64% of participants reported experiencing some concerns of mental health, with 25% reporting as experiencing concerns many times or always. Worry and feeling nervous/tense were the most reported concerns.



When examining the relationship between SVI factors and reports of mental health concerns as a result of COVID-19 pandemic, significant effects were found in age $F(2, 376) = 3.09$, $p = .047$, race $F(6, 464) = 2.80$, $p = .011$, and living in a mobile home $F(1, 401) = 5.632$, $p = .018$. Among the age groups, those younger than 18 years reported higher mental health concerns, while those aged 65 and older had lowest concerns. Among the racial groups, Hispanic/Latino reported higher mental health concerns than other groups followed by American Indian/Alaska Native, and those of Biracial/Multiracial origin. People living in mobile homes reported higher mental health concerns than the others.

When examining the relationship between SVI factors and concerns about welfare (finances, employment, and general health together) as a result of COVID-19 pandemic, significant effects were found in income $F(3, 459) = 2.107$, $p = .000$, living in crowded household $F(1, 395) = 5.172$, $p = .023$, and in the interaction between living in a crowded household and access to a vehicle $F(1, 395) = 5.674$, $p = .018$. With regard to concerns of welfare, the less the income the less the concerns of welfare reported, and similarly, those living in crowded households reported less welfare concerns than others. Those who live in a crowded household and had no access to a

vehicle reported higher concerns of welfare (M = 8.06) than those who had access to a vehicle (M = 7.57).

Means and Standard Deviations for SVI Factors with Significant Effects

SVI Factors	Group	N	Mean	SD
Age	17 and Younger	8	18.63	8.93
	18 - 64	342	18.36	6.70
	65 and Older	53	14.77	5.72
Race	American Indian/ Alaska Native	7	19.71	7.65
	Asian	10	16.70	7.39
	Black/ African American	285	16.82	6.72
	Hispanic/Latino	29	21.31	6.55
	White/Caucasian	125	17.41	5.91
	Biracial/Multiracial	25	18.48	6.67
	Other	5	14.40	6.69
Lives in Mobile Home	Yes	26	19.77	7.57
	No	393	17.38	6.75
Income	Less than $25,000	186	7.59	1.90
	$25,000-49,999	146	7.69	1.80
	$50,000-99,000	118	8.71	1.08
	$100,000 and above	31	8.84	1.51
Lives in a Crowded Household	Yes	42	7.36	2.08
	No	371	8.11	1.76

Multivariate analyses were conducted to examine the relationship between SVI factors and specific welfare concerns (finances, employment, and general health) as a result of COVID-19 pandemic. Wilks' Lambda test indicated a significant effect for income level, living in crowded household, having access to a vehicle, and an interaction effect between gender and age, and between living in a crowded household and having access to a vehicle. The effect of income was on finances (p=.001), with those who had an annual income of more $50,000 and more reporting higher concerns. The effect of living in a crowded household was on impact to employment (p=.027), and to general health (p=.003), while the effect of not having access to a vehicle was on general health only (p=.004), and interaction effect between the two was on general health (p=.000). The interaction effect between gender and age was on impact to employment with males aged 65 and older indicating higher concerns.

Perceived Barriers to Provision and Access of Care on SVI Populations due to the COVID-19 Pandemic

Providers were asked to rate the frequency at which the following SVI factors have affected the ability of patients to access care during the COVID-19 pandemic: being in a racial minority group, elderly age (65+), living with a disability, unemployment, no high school diploma/GED, poor housing/homelessness, without reliable transportation, and living in a rural area. The most commonly reported factors identified as frequently/always affecting the ability of patients to access care during the COVID-19 pandemic were lack of reliable transportation, elderly age, and poor housing/homelessness, while the factors with low impact were having no high school diploma/GED, being a racial minority, and being unemployed. See the table below for complete data.

Factors affecting access to care during COVID-19, reported by providers

Patient Factor	**Frequency**		
	Rarely/Never	**Sometimes**	**Frequently/Always**
Being a racial minority	40 (38%)	34 (38%)	26 (25%)
Elderly age (65 and above)	24 (23%)	36 (35%)	43 (42%)
Living with a disability	31 (29%)	39 (37%)	36 (34%)
Being unemployed	36 (34%)	35 (33%)	35 (33%)
Having no high school diploma or GED	47 (45%)	37 (36%)	20 (19%)
Poor housing or Homelessness	36 (35%)	26 (25%)	42 (40%)
Being without reliable transportation	28 (26%)	31 (30%)	47 (44%)
Living in a rural area	35 (33%)	40 (38%)	31 (29%)

When looking at data trends by provider variables, race seemed to have the most influence on how providers indicated SVI factors that affected patients' access to care. Most notably, Non-Hispanic-White/Caucasian providers were more likely to report that being a racial minority rarely/never impacts access to care (n=26; 53%) when compared to Black/African American providers (n=5; 17%). Furthermore, only 47% of non-Hispanic white/Caucasian respondents reported that being a racial minority sometimes, frequently, or always impacted access to care

compared to 83% of Black/African American providers. Linear regression was used to further investigate this trend. There was a significant relationship between provider race and provider's report that being a racial minority impacts access to care ($t = 2.616$, $p = .01$); provider race explained 12% of the variance in providers' report that being a racial minority impacts access to care.

Qualitative data were collected to identify adjustments that providers had made in providing care to SVI populations due to COVID-19 pandemic. The most commonly reported adjustments were:

- implementation of virtual appointments (e.g., telehealth, videoconferencing, and phone calls),
- increased use of PPE,
- decreased cost of services,
- increased testing,
- increased patient education,
- increased referrals to community resources,
- increased overall flexibility.

Additionally, providers reported that they needed the following to provide better care to SVI populations due to COVID-19 pandemic: more staff/space, more/better PPE for providers and patients, community resources, patient-education resources, improved technology/technical capabilities for patients to enable telehealth, transportation for patients, improved patient insurance, interns, training, and financial support.

Regarding the use of SAMHSA guidelines for first responders, the most frequently used tips by the providers to cope with COVID-19 pandemic were: (1) train hard and know your job well (M = 4.42, SD= .71), (2) know your personal signs of stress (M=4.31, SD= .91), and (3) safeguard yourself (M = 4.21, SD = 1.07). The tips least frequently employed by our sample were (1) take breaks regularly (M = 3.31, SD =1.27), set your personal disaster plan in motion (M = 3.30, SD = 1.36), limit time spent working in very high-intensity settings (M=3.25, SD=1.29), and keep freshly stocked go-kit (M=3.08, SD=1.45). Interestingly, healthcare professionals reporting 25 years or more of professional experience reported a higher frequency of engagement in stress management practices when compared to healthcare professionals reporting less than 25 years of professional experience. See the table below for complete list of the tips and rate of their use.

Implications

1. COVID-19 pandemic seems to affect most people who are younger (under 18) and those who are elderly (65 and above) in Cumberland County.
2. COVID-19 also has had a higher effect on those who leave in crowded households in Cumberland County

3. Regardless of SVI status, participants in this catchment area reported a high presence of negative emotions related to the pandemic. This is consistent with national findings (https://jamanetwork.com/journals/jamanetworkopen/fullarticle/2770146). How ever, it's worth noting that participants in this sample demonstrated a nuanced emotional response to the pandemic wherein feelings of stress/worry/tension appear to predominate feelings associated with depression and/or PTSD.
4. Health care providers have observed an impact on access to care by SVI population since the start of COVID-19 pandemic. The highest negative impact on access to care has been to patients who lack reliable transport, those who are elderly, and those who are homeless. Providers have tried to make adjustments by increasing use of aspects that may be relevant for the SVI population such as telehealth, patient education, and referral to community services.

Developing the Capacity of Serological Testing

The Biology faculty have modified the curriculum of the capstone course for seniors to include training on commercial ELISA kit using mock/artificial human serum/plasma samples; ELISA-based serological assay; Cell culture and embryo-based assay and RT PCR for virus detection in unknown/environmental samples. In the last semester, despite all the related COVID-19 challenges,12 students were introduced or trained on an ELISA serological assay.

Finally, equipment was ordered for the design of a Biosafety Level 2 (BSL2) University laboratory, the first at FSU with Serology/PCR, Research, & Teaching capabilities.

Retinal Net Prototype Pilot

In collaboration with Fortem Genus, a local biomedical company, FSU piloted the development of RetinalNet .05, a prototype medical artificially intelligent system to detect COVID -19 through both retinal and iris eye imaging. We know that COVID-19 does have an effect on the eye; however, the specific COVID-19 signature/pattern in the eye is not yet known to the medical profession. There is mounting evidence that Artificial Intelligence (AI) can help the clinician in all aspects of medicine, from formulating a diagnosis to making therapeutic decisions and predicting patient outcomes. Within AI, Deep Learning (DL) is a set of computational methods that allow an algorithm to program itself by learning from a large set of examples that demonstrate the desired behavior, removing the need to specify rules explicitly. In this project a DL algorithm was created to automatically detect Covid-19 in eye images. A specific type of artificial neural network (a large mathematical function with millions of parameters) optimized for image classification called a deep Convolutional Neural Network (CNN) was trained to classify eye images into one of two classes (also known as labels). The function computes Covid-19 positive class or Covid-19 negative class from the intensities of the pixels in an eye image.

Findings:

Data preprocessing protocols, hyperparameter search, neural network training protocols, and results are described here in narrative form with quantitative information presented in the attachments. A specific CNN named the Inception Resnet is used in this research. Data preprocessing was performed to address the problems of class imbalance (less images of COVID-19 positive than negative), small dataset and biased learning (the CNN predicts everything as COVID-19 negative). Data augmentation was used to balance the datasets, with more augmentations applied to the class with less data. Geometric rotation, injection of Gaussian noise and focal loss were used as augmentation techniques, with focal loss providing additional control on the problem of bias. In AI, a hyperparameter is a parameter whose value is used to control the learning process. By contrast, the values of other parameters are derived via training. One of the most important part of neural network modeling is selection of quality hyperparameters, or more simply: the selection of parameters that the model is unable to change and optimize on its own, such as learning rate and momentum. The difficulty with making a quality selection of hyperparameters is the breadth of the search space, which is nearly infinite. This important part of the research was carried out using the Bayesian hyperparameter optimization algorithm to find the best set of hyperparameter values. Bayesian techniques differ from other, less efficient techniques like random and grid searches in that they use past evaluation results to choose the next values to evaluate. In practice, this allows the Bayesian technique to find better values of hyperparameters in less time. Another important contribution of this research is the interpretation of the results of the CNN. In general, to develop trust in an AI technique with explaining the predictions of the model, it is important to understand the underlying mechanics of that technique, and any potential pitfalls associated with it. The Local Interpretable Model- agnostic Explanations (LIME) method was used to interpret the inner workings of the CNN when predicting the label of an image. The LIME method essentially produces a graphical overlay of a heatmap on the original image to highlight portions of the image that influence its decision in labeling that image as either COVID-19 positive or negative

Results and Further Research

Convolutional Neural Network (CNN), an artificially intelligent system was trained to classify eye images into Covid-19 positive class or Covid-19 negative class from the intensities of the pixels in an eye image. It was found that the CNN had high accuracy, precision and sensitivity in learning to detect the pattern of COVID-19 in the human eye. These quantitative results are very encouraging, and they strongly suggest that further research is warranted to determine the feasibility of applying this algorithm in the clinical setting and to determine whether use of the algorithm could lead to improved care and outcomes compared with current methods of COVID19 assessment.

Dr. Richard Gammons, a Co-PI of this project recently submitted a National Institute of Health grant proposal of $1.25 million to replicate and further study the findings. That proposal is currently under review.