The story behind the race to test for COVID-19 at the University of Illinois

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University of Illinois

The logo for the University of Illinois's COVID-19 SHIELD saliva-based testing.

It was late the evening of April 22, 2020 when Martin Burke, a then 44-year-old professor of chemistry, received a phone call from the university provost. The provost, Andreas Cangellaris, requested that Burke develop a COVID-19 testing program for the University of Illinois at Urbana-Champaign campus.

Burke received his undergraduate degree from Johns Hopkins University, his M.D. from Harvard Medical School and the Massachusetts Institute of Technology, and his Ph.D. from Harvard University. According to his profile (https://experts.illinois.edu/en/persons/martin-burke) on the university website, Burke's research group focuses on "the synthesis and study of small molecules with the capacity to perform protein-like functions."

YouTube (https://home/citizenaccess/public_html.youtube.com/watch?v=JCugr1EyUgE)

Martin Burke in the University of Illinois at Urbana-Champaign's COVID-19 Innovation video.

Burke was excited to receive the call from the provost as he had already been working on COVID-related issues such as lack of protective equipment for healthcare workers.

In March 2020, Burke had been strongly shaken when he first learned about the equipment shortage and said "many of us were trying to figure out what we could do to try to be helpful."

At the local Carle hospital, he tried to help resolve the lack of personal protective equipment (PPE) for health workers there dealing with COVID cases. As a result, Burke worked with the existing Health Maker Lab (https://healthmakerlab.medicine.illinois.edu/), based at the Carle Illinois College of Medicine, to create necessary protective equipment. His work at the lab involved leading teams to create gowns, masks, and face shields.

After the April phone call with the provost, Burke immediately called two of his colleagues, Paul Hergenrother (https://chemistry.illinois.edu/hergenro) and Tim Fan (https://experts.illinois.edu/en/persons/timothy-m-fan), who found the much needed lab

space for the requested campus-wide testing project. Burke, Hergenrother and Fan had all collaborated together in the past, and the team would all go on to create the campus's crucial saliva test.

Over the next week, Burke gathered eight more team members, forming the founding members of what was known as the SHIELD team. The first SHIELD meeting was held on April 30, 2020, just eight days after the Provost's call.

May 2020 – 488 cases in county

"They call it the brain swab," Burke said about the traditional COVID-19 testing method. The swab test involves sticking a swab all the way through to the end of the patients' nasal cavity until it reaches the upper part of the nasopharynx. This testing method was being regularly used around the world, and therefore, the related equipment was in high demand, almost impossible to acquire.

Instead, Burke and Hergenrother decided to pursue a saliva-based test, having heard of promising data on sensitively detecting SARS-CoV-2 in saliva at Rutgers and Yale universities. The problem with the Rutgers and Yale methods, however, was that they still required RNA isolation, which is a slow, expensive and supply-chain limited process.

Hergenrother, a professor of chemistry with research interests in chemical biology and deputy director of the Cancer Center at Illinois, proposed that it may be possible to skip this RNA isolation step. The team decided to pursue this route. That way, the team could perform fast, cheap and scalable COVID-19 testing without facing challenging supply chain issues.

Rutgers had been granted Emergency Use Authorization for its saliva test on April 13, 2020. This Emergency Use Authorization was granted by the FDA due to the extreme circumstances of the pandemic. Although it had not passed all the required FDA tests, it did pass most critical tests. Similar saliva testing research was being conducted at Yale — Yale scientists published an article about "SalivaDirect" on August 4, 2020.

A week after the call with Provost Cangellaris, Burke and his colleagues Hergenrother, Fan and Microbiology Professor Chris Brooke (https://experts.illinois.edu/en/persons/christopher-byron-brooke) launched a "discovery team" with the goal of developing a new saliva test, which eventually received the FDA emergency approval on March 1, 2021. Burke said the FDA authorization benefited a lot from key contributions from Jay Walsh (https://vpedi.uillinois.edu/people/staff/jay-walsh), vice president for economic development and innovation for the University..

June 2020 – 235 cases in county

The four principal investigators and five students and research assistants on this discovery team succeeded in coming up with the test in only six weeks' time, and the preprint (https://doi.org/10.1101/2020.06.18.159434) for it was published on June 18, 2020 in bioRxiv (https://home/citizenaccess/public_html.biorxiv.org/about-biorxiv).

July – 568 cases in county

In July, after consulting with the epidemiologist team members Nigel Goldenfeld and Rebecca Smith, SHIELD decided that to have an effective testing system, there would need to be twice weekly testing.

"We knew we were targeting 20,000 tests per day roughly as a maximum capacity, or, you know, greater than 100,000 tests per week," Burke said.

At that point, the team faced three main issues: acquiring lab technicians, obtaining the necessary equipment and finding a lab to conduct the saliva analyses. There was no time to build a lab from the ground up.

The team immediately started searching for lab equipment. The newly-developed saliva test required use of a PCR machine. This Polymerase Chain Reaction machine is used to take bits of DNA and multiply them, making it more detectable.

Unfortunately, these machines were also highly in demand at the time and the team only had two.

“We realized we needed six,” Burke said. “We leveraged a lot of our previous relationships with Thermo Fisher and… they helped us get access to more of those instruments. We were still short, so we borrowed two from great colleagues on campus, one from Gene Robinson at the IGB and one from Bruce Fouke at the Carver Biotechnology Center.”

The SHIELD team discovered that the “safest and most streamlined protocol” was to collect the saliva samples, heat them, then add the necessary follow-up ingredients. Each sample/ingredient mixture was inserted into its own well of a 96-well plate to be run through a qRT-PCR machine.

qRT-PCR machines work by multiplying the amount of a certain length of DNA, which is initially created from viral RNA. In this case, a primer, or gene targeter, was added to specifically convert several genes encoded in SARS-CoV-2 RNA into DNA. Copying the corresponding DNA multiple times and increasing their quantity in the sample makes it easier to detect. The COVID-19 genetic information is contained in the viruses, not the genome of the person infected.

In June, Tim Fan, who Burke describes as an “extraordinary outside-the-box thinker,” and member of the Veterinary Diagnostics department had the idea of turning the Veterinary Diagnostic lab into a COVID-19 testing facility.

Fan had completed his undergraduate veterinary degree at Virginia-Maryland Regional College of Veterinary Medicine. Then, at Cornell, he pursued a small animal internal medicine residency. He later underwent advanced clinical training in medical oncology at the University of Illinois. Among his research interests are evaluating novel drugs and drug delivery strategies, and Pharmacology is in his course rotation.

At last, the team had a testing method and a lab space. They even had machinery and equipment for the lab. What they needed was enough people to analyze 100,000 COVID-19 tests weekly and get the results back in a timely manner.

“We had, like, what, five or six [technicians] and we realized we needed 30,” Burke said.

The SHIELD team incorporated lab-trained grad students and went on a hiring spree for more.

August 2020 – 1,007 cases at UIUC

A tent and signs indicate a Covid-19 testing site at the University of Illinois Urbana-Champaign's Alice Campbell Alumni Center on Friday, July 31, 2020.

By the time students returned on August 15, the team was ready.

Keeping track of each plate-well and coordinating those wells with the corresponding person being tested was a complex matter. Robin Holland and Diana Ranoa, graduate students at the university, invented a matrix-based recording system that, according to Burke, was eventually "rendered more robust with electronic tube/plate/well tracking technology that was introduced throughout the Fall 2020 semester."

The department struggling at this point in time was Information Technology in regards to COVID testing. The IT team started off with basic spreadsheets of the participants, marking those who tested positive. The team also had to accommodate the spreadsheet for past cases — someone who tested positive one day and again two days later would not qualify as a "new" case.

At the beginning of testing, all of this work was done manually. The team was also responsible for getting the results to McKinley, which aimed to distribute the results to the UIUC community via a new app, called Safer Illinois. The app was discontinued for use after the fall 2021 semester.

The app was created by Bill Sullivan (https://landarch.illinois.edu/faculty/william-sullivan/) and his team at Rokwire and it allowed testing results to be directly sent to people's phones. This would allow people with positive tests to be quickly and safely isolated, thus curbing disease spread. But seamlessly linking the McKinley database to the new app was another big challenge.

Remarkably, and largely due to Greg Gulick, interim chief information officer at the University, these IT challenges were overcome. Now, those who take the saliva test receive their results in less than a day.

It was a huge loss for the SHIELD team and the University community when Gulick died at the age of 56 on February 16, 2021 of COVID-19.

While Burke emphasized the importance of his team members and the ability to delegate tasks, he was the head of the SHIELD team and was most responsible for keeping the project focused and productive.

Burke described dealing with the constant challenges as playing “whack-a-mole,” saying “as soon as you got something taken care of, like another thing would pop up.”

An average day for Burke would vary, but it might consist of several Zoom meetings and phone calls, visits to various sites such as engineering or the Institute for Genomic Biology, and assisting in the Veterinary Diagnostics lab.

“I’ll be honest…it was one of those invigorating times in my life, right?” Burke said. “I mean, because you, you genuinely felt this sense of purposefulness… felt the sense of history.”

A large part of his time was spent simply finding equipment to use in the lab. For instance, pipette tips were scarce during this time period.

“I spent a lot of time on Amazon trying to find tips… we could at least get some for, like, tomorrow,” Burke said. “I mean… we were trying to ship overnight, just to make sure we didn’t run out on a day-to-day basis.”

Burke praised his colleague Fan for his motivation as well. Reminiscing, he described receiving texts from Fan at 3 a.m. saying “only a few thousand more to go.” Fan was spending nights in the Veterinary Diagnostics lab, helping the technicians pipette samples just to stay caught up and get the results distributed.

September 2020 – 1,376 cases at UIUC

Nigel Goldenfeld was another key member of the SHIELD team. A professor of physics at UIUC, he was primarily the one in charge of predicting numbers of COVID-19 cases under various circumstances and mitigation.

But students who went to parties knowing they were positive (https://cu-citizenaccess.web.illinois.edu/2020/12/university-of-illinois-covid-19-complaints-and-social-media-reveal-how-widespread-violations-were/) and avoided quarantine made predictions difficult. The SHIELD team cooperated consistently with the Champaign-Urbana County Public Health Department to perform contact tracing; however, the department found students dodging the calls. Some students were even alleged to be selling negative saliva samples (https://cu-citizenaccess.web.illinois.edu/2021/03/additional-campus-covid-complaints-show-more-unsafe-unhealthy-and-outlandish-behavior/) to their COVID-positive peers.

October 2020 – 635 cases at UIUC

When cases spiked at the beginning of the fall 2020 semester, the university administration blamed those students in a mass email and there were numerous social media videos and photos showing students' partying.

Goldenfeld predicted a total of 700 cases over the course of the fall 2020 semester, but a surge of cases in late August had already propelled the numbers to 700 on August 28.

The team continued testing and monitoring to identify clusters of infections. Some psychologists had predicted the students' noncompliant behavior, such as holding large parties, and University of Illinois scientists attempted to consider it as well. The scientists "always modeled partying so we did not need to change that: 7k students partying without masks in spaces with poor ventilation 3 times a week," according to Goldenfeld. However, by the end of the month on August 31, the campus community had a total of 1,106 cases.

The SHIELD team had decided early on to not hold any in-person classes after fall break from November 21-29 and to continue online for the remainder of the semester and finals.

But the SHIELD team was already thinking about how to approach the spring 2021 semester. The team decided that the semester would continue to be a hybrid semester — partially online and partially socially-distanced in person.

January 2021 – 532 cases at UIUC

SHIELD planned a number of new approaches to the spring semester. The students would come back in scheduled stages according to class level. Furthermore, two negative COVID-19 tests were required before students could attend class in person or enter campus buildings.

In contrast to fall, spring 2021 did not bring a massive spike in cases at the beginning of the semester as the fall had. There was an increase of cases in February with 664 cases for the first 15 days, but nothing like the massive rush of cases during the last 15 days of August 2020, which saw 1,007 cases.

But the team was concerned about the highly contagious B.1.1.7 variant of COVID-19, later renamed the Alpha variant. The SHIELD team performed some gene sequencing of a few COVID-19 positive samples and discovered that the Alpha variant samples had one thing in common – a missing piece of DNA, known as "S-gene drop-out."

The lab began testing every sample for S-gene drop-out in order to identify the number of Alpha variant cases in the community.

February 2021 – 949 cases at UIUC

Also in February, vaccines began to be offered in the community. If vaccines were indeed working — and people took them — this had the potential to greatly reduce COVID-19 and its spread, as Burke said one of the SHIELD goals was to, "get everybody vaccinated before B.1.1.7 becomes a dominant strain.

The SHIELD team was "excited to have a chance to win that race against time," Burke said. "That'll be a huge accomplishment and we will — we will save a lot of morbidity and mortality if we can accomplish that."

After February, the number of weekly cases began to decrease and the team began to plan for the next semester, making decisions on how to hold classes.

On March 4, 2021 the university announced it would continue a form of hybrid courses (online and in-person) in fall 2021, but would expand the number of in-person classes.

June 2021 – 10 cases at UIUC

During the summer, the campus gave several updates regarding vaccination requirements. In June, the university allowed users to upload their vaccination records to the Safer Illinois app. In addition to keeping track of the user's saliva results and COVID-19 positivity standing, functionality improved and allowed uploading vaccination records, which served as a substitute for saliva testing and permitted regular building access.

In July, the university began requiring all students, faculty and staff to be vaccinated for COVID-19 unless they qualified for an exemption for health or religious reasons.

But during the spring and summer semesters, variants (mutations) of COVID-19 such as Delta and Lambda became increasingly major concerns around the globe.

At the beginning of fall 2021, between August 17 and Sept 17, there were only 651 recorded campus cases, compared with 1,982 cases in the same time period the year before. Also as of Aug 29, 52.77% of the Champaign County population was fully vaccinated and by mid-semester more than 90% of students and faculty had been vaccinated.

Early in the semester Burke said that while the vaccination rate was high on campus, the team was "very nervous" about the Delta variant, but so far the case numbers remained low.

Burke said it's been a "Herculean challenge" and "we're excited about where we are, but we really have to stay vigilant and continue to stay strong as a community. And that's going to be really important for us all to stay safe."