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Sustaining University Operations During the COVID-19 Pandemic

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Abstract

Colleges and universities around the world engaged diverse strategies during the COVID-19 pandemic. Baylor University, a community of ˜22,700 individuals, was 1 of the institutions which resumed and sustained operations. The key strategy was establishment of multidisciplinary teams to develop mitigation strategies and priority areas for action. This population-based team approach along with implementation of a "Swiss Cheese" risk mitigation model allowed small clusters to be rapidly addressed through testing, surveillance, tracing, isolation, and quarantine. These efforts were supported by health protocols including face coverings, social distancing, and compliance monitoring. As a result, activities were sustained from August 1 to December 8, 2020. There were 62,970 COVID-19 tests conducted with 1435 people testing positive for a positivity rate of 2.28%. A total of 1670 COVID-19 cases were identified with 235 self-reports. The mean number of tests per week was 3500 with approximately 80 of these positive (11/d). More than 60 student tracers were trained with over 120 personnel available to contact trace, at a ratio of 1 per 400 university members. The successes and lessons learned provide a framework and pathway for similar institutions to mitigate the ongoing impacts of COVID-19 and sustain operations during a global pandemic.

To provide a framework and pathway for colleges and similar institutions to mitigate the impact of novel coronavirus disease 2019 (COVID-19) and sustain operations, here we reflect on our experience operating during a pandemic. The severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) virus, which is driving the COVID-19 pandemic, is unique and particularly challenging for institutions to manage and control. This reality is the result of a combination of SARS-CoV-2 virus biology and epidemiology, as well as the behaviors of college students. The virus has a short latency period and is effectively spread by means of both asymptomatic and symptomatic transmission. Enabling spread among large groups of socially interacting individuals, sometimes in relatively confined spaces. COVID-19 is both similar and different from the recent Middle East respiratory syndrome (MERS) and severe acute respiratory syndrome (SARS) outbreaks.[1]

The global challenge posed by COVID-19 was recognized by the World Health Organization (WHO) when the outbreak was declared a Public Health Emergency of International Concern (PHEIC) on January 30, 2020, and then a pandemic on March 11, 2020.[2,3] A national emergency

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was declared in the United States on March 13, 2020.[4] Before this, Baylor University actively began addressing COVID-19 risks in January 2020 by postponing University-sponsored travel to China and then South Korea in February 2020. This was soon followed by travel restrictions to other countries and across the United States. Baylor University formally moved to online instruction on March 16 until commencement of the Fall semester on August 24, 2020.[5]

To resume and sustain operations during the COVID-19 pandemic, Baylor University established multidisciplinary teams to develop, guide, and support implementation of public health measures. Baylor University, chartered in 1845 in Waco, Texas, United States, is a private nonprofit Christian university. As of Fall 2020, Baylor had 19,297 students (14,399 undergraduates and 4898 students in graduate and professional programs) with 4736 living on campus. Overall, the in-session Baylor community of students, faculty, and staff was approximately 22,700 individuals. Baylor University is considered 1 of the major employers in the city of Waco and McLennan County, which has an estimated 256,600 residents.[6] There was recognition soon after going online in March that the university needed to find a way to safely reopen for the Fall 2020 semester to help students, staff, faculty, contractors, and the Waco community navigate the challenges presented by COVID-19.

In appreciation of these challenges, a "Swiss Cheese" risk mitigation model was applied.[7] This type of model accounts for the complexities associated with reducing inherent risks by applying multiple layers of protection to mitigate or eliminate hazards.[8] For example, the presence of any weakness or hole in any layer (face covering noncompliance) is offset by the strengths of another layer of intervention (social distancing).[8] Also embedded in the method we used was the principle of population-based management.[9] This multidisciplinary approach recognizes no one authority or organization possesses all the resources and expertise required to mitigate COVID-19 risks, sustain operations, and address the unprecedented lateral communications and decision-making processes required to succeed.[9,10]

Planning for the semester commenced with development of strategic priorities using a multisectoral team. Sub-teams were subsequently established, which included representatives with expertise in public health, infectious disease, epidemiology, critical care and clinical medicine, environmental health, emergency management, education, employment, sociology, law, procurement, laboratory management, toxicology, student support services, facilities management, information technology, wastewater, and residential accommodation. This approach was complemented by tabletop exercises, scenario planning, and ongoing engagement with city and county representatives at operational and leadership levels. Our teams focused on analyzing data and trends, contact tracing, testing, support services, and compliance, and evaluating public health measures, alternative strategies, and proposed campus events.

Baylor University applied a hybrid instruction model, with students having the options to attend class on campus (with face-to-face or hybrid instruction) or remain remote (with complete online instruction). Approximately 1600 course sections (39% of total offerings) were held in-person with face covering and social distancing requirements. Of all offered sections, 25% were taught in a hybrid format and 36% were fully online. Crowd capacities were limited to 25% for athletic events.[11] To mitigate transmission, there were limitations on nonuniversity events.

At the center of the mitigation measures were health protocols. This included face coverings and social distancing supported by universal entry screening, testing before arrival on campus, randomized testing (surveillance), testing of symptomatic and exposed individuals, and wastewater (sewage) monitoring for SARS-CoV-2 viral RNA. The overall strategy was selected because transmission risks in colleges are complex and unique. For example, transmission could occur in college classroom settings if there was no mandatory face coverings, insufficient physical distancing, or inadequate hand hygiene; residential and social settings also posed a significant risk.[12] Further information about the methodology is provided here.

Methods

All descriptive data presented were available to the Baylor teams overseeing strategies to mitigate the impact of COVID-19. Most of the data (except isolation, quarantine, and sewage data) were publicly available on Baylor's external website. Microsoft Power BI and Microsoft Excel were used to collect, collate, and display these data, which were de-identified and actively analyzed to inform decision making and situational awareness throughout the Fall 2020 semester. These activities, as part of public health surveillance, met exclusion criteria for institutional review board approval per 45 CFR 46.102(e) & (l).

Baylor University used a multisectoral systems approach to mitigate COVID-19 risks and sustain operations (Figure 1). This included teams focused on governance, health protocols, sewage surveillance, testing (surveillance, symptomatic, and contact), contact tracing, data analysis and trends, support services, and communications. Further detail about the methodology used to mitigate COVID-19 risks and sustain operations (teams and the roles) is described in the following.

Governance

Baylor's Board of Regents (BOR) has fiduciary responsibility for the university. Because of the potential impact of the COVID-19 pandemic, the Chair of the BOR convened the Executive Committee of the BOR weekly and the full BOR monthly throughout the summer of 2020. This allowed the President and the President's Council (PC) to update and inform the BOR of planning for the Fall 2020 semester and provided an opportunity to address any concerns. The PC is led by the President and consists of senior university leadership including the Provost, General Counsel, Chief Business Officer, Special Advisor to the President for Equity and Campus Engagement, and Vice Presidents for Advancement, Athletics, Human Resources, Marketing, and Student Life. This continued with less frequency throughout the Fall semester. Externally, the President and nominated representatives from Baylor attended the Waco and McLennan County COVID-19 health briefings, which were held 3 times weekly.

Throughout the pandemic, the President convened her council at least 3 times weekly to learn about campus conditions and to review and act on proposals across the university. PC was responsible for all final approvals of decisions that had campus-wide impact, such as the testing plan and large on-campus events, as well as budgetary reductions; PC functioned similar to a local board of health. Project 8.24 was formed, which involved a campus-wide team that worked with the Provost's Office, Division of Student Life, and other groups to develop and evaluate plans and decision

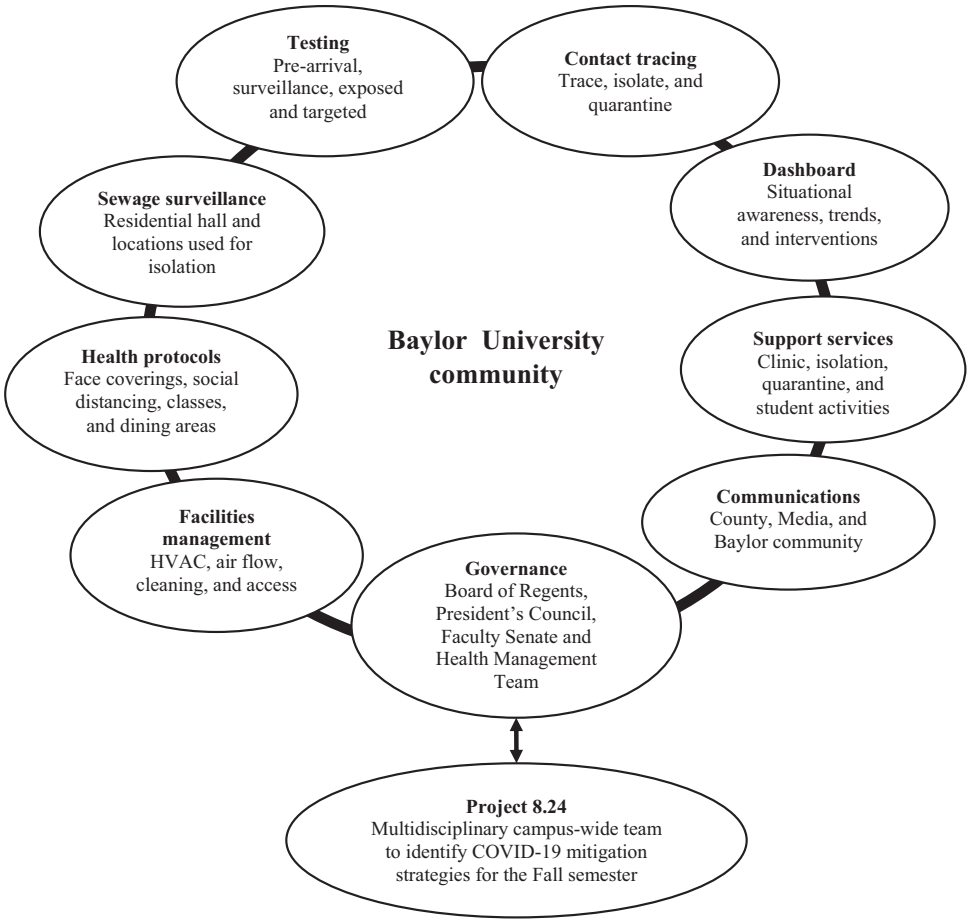

Figure 1. Multisectoral systems approach to sustaining operations.

timelines for the Fall semester.[13] This was co-chaired by the Provost and General Counsel. After Project 8.24, this work was completed, and implementation became the focus.

A Dashboard task force was formed, reviewed data daily, and provided a daily summary of conditions to the Provost, highlighting notable changes. The Provost convened weekly with academic leadership of the university, including Vice Provosts, Deans, Associate Deans, Registrar, and Faculty Senate Chair to create a schedule of classes meeting social distancing requirements, address technology and professional development needs for online teaching modalities, create and evaluate academic policies on issues such as attendance and face coverings, and communicate decisions made by the PC. As the semester commenced, a multidisciplinary health management team was formed and met daily to work through emerging policy issues, recommend intervention strategies, and review proposed events. The recommendations from this group were presented to PC for decision.

Facilities Management

An extensive analysis of heating, ventilation, and air conditioning (HVAC) of all buildings was conducted by Baylor's facility management team. Many HVAC systems were upgraded with an ultraviolet (UV) light and increased minimum efficiency reporting value (MERV) filtration, and all were modified to maximize external air flow intake and circulation. Cleaning protocols were reviewed for each facility and were increased in terms in both intensity and frequency. Particular attention was paid to residence halls and other higher-density communal areas. This was complemented by multiple external tents for study, approved small events and testing, disinfection supplies in all classrooms, and installation of 600 hand sanitizer stations campus wide with 12 million doses available.

Health Protocols

As recommended by the CDC and others, face coverings and social distancing were central to our implemented health protocols. Faculty, students, and staff were required to wear face coverings (prohibiting coverings like bandanas, neck gaiters, or masks with valves; and enforcing proper usage with a secure fit over both the mouth and nose) inside, at events, and wherever social distancing was not possible outdoors. Electrostatic sprayers were procured and used to disinfect high traffic areas in buildings twice daily. Residence hall rooms, classrooms, and offices were disinfected on the same day positive COVID-19 tests were reported from occupants in each room. Dining facilities were disinfected after every meal.

A Campus Safety Ambassador Program was used to rally 2 dozen volunteers at key high traffic locations across campus in the first few weeks of the Fall semester. The volunteers modeled safe distancing practices, assisted with questions, and positively reinforced a clean campus as students returned. This effort included directing students to resources and information as well as offering hand sanitizer and masks as needed. A private company was contracted to support monitoring of compliance with the

safety protocols throughout the semester. This was complemented by providing students, faculty, and staff with hygiene kits (including 2 face coverings, hand sanitizer, thermometer, and COVID-19 disease information), campus wide signage, and ongoing information about safety measures.

Sewage Surveillance

Sewage (or wastewater-based) epidemiology represents an established, integrative, and equitable population health surveillance approach. Spatially resolved examination of "sewersheds" supports population understanding of drugs of abuse consumption,[14] disease burdens (eg, polio[15,16]), and socioeconomics.[17] Because SARS-CoV-2 is shed in feces[18] before presentation of clinical symptoms,[19] sewage surveillance systems may provide lead indicators of COVID-19 emergence within a community, inform effectiveness of public health interventions, and examine implications of phased reopening of businesses or on campus activities.[20-22]

During Fall 2020 semester, there was weekly sewage sampling of campus student residence halls and an isolation facility (hotel) using time composited auto-sampling. Initially, wastewater collection systems were reviewed. Through this process, sampling locations were identified, and weekly collection of 24-h composite sampling was implemented. Sewage samples, along with duplicates and field blanks, were examined for SARS-CoV-2 viral RNA, which was normalized to respective hall occupancy.

Because sewage detection of SARS-CoV-2 RNA precedes clinical symptoms, this data stream was integrated within our internal COVID-19 dashboard and supported decisions for targeted testing of specific on-campus locations. During Spring semester 2021, we continued sewage surveillance efforts parallel to our externally supported research examining sewersheds and COVID-19 epidemiology in local communities.

Testing

Pre-arrival

Commercially available test kits were shipped to students, staff, and faculty before returning to campus. The university contracted with a company to provide an at home-sample kit, which was mailed to a laboratory after collection. The pretesting involved a self-administered nasal swab followed by quantitative polymerase chain reaction (qPCR) analysis (with US FDA emergency use authorization) for the SARS-CoV-2 virus. A negative test result was required before coming to campus and attending in-person classes.

Symptomatic and Exposed

Symptomatic individuals and those who had been exposed to someone confirmed positive with COVID-19 were tested onsite through university provided services. This was generally coordinated through the university health center with testing at the respiratory clinic, which was at a separate location. This strategy used a rapid antigen test (with US FDA emergency use authorization) with results in approximately 1 h.

Surveillance

A surveillance testing program was used through a contracted provider to determine infection incidence and to, therefore, implement targeted intervention strategies. Incentives were provided for students to complete surveillance testing. All students who completed surveillance testing received an $8 voucher to a local eating establishment. In addition to increasing compliance, this was a way to invest in local businesses impacted by COVID-19. Tests were available every weekday and participants were notified by means of email to make an appointment. The test involved a nasal swab with qPCR to determine SARS-CoV-2 presence. Students, faculty, and staff were randomly selected with replacement (eg, testing in 1 wk did not change their likelihood of being selected in the following week).

Several surveillance strategies were originally considered, including required weekly sampling of all Baylor community members. However, due to limited access to testing locally and nationwide the Fall 2020 semester began with 5% (random sample) of off-campus residence students sampled weekly and 10% of on-campus residence students, faculty, and staff sampled weekly. All tests used an external provider located on campus with results normally provided between 24 and 72 h after sample collection. Testing of off-campus student tests was increased to 10% following a campus visit from Dr. Deborah Birx, then-White House Coronavirus Response Coordinator, on September 24, 2020. Contractors working on campus were tested on a bi-weekly basis (50% each week) through the same testing provider.

Surge Testing

An opportunity presented to collaborate with the federal, state, and local governments to conduct "surge" testing on campus. The university was allocated 5000 tests for use within a 2-wk period (October 19-30, 2020). This testing capability was sponsored by the federal government in conjunction with the Texas Department of Emergency Management (TDEM) and the City of Waco. It was implemented by the National Guard and a government contracted nursing service, who also oversaw administration of cheek and saliva swabs for qPCR testing.

Targeted

Targeted testing was used after continuously observing data from the respiratory clinic, surge testing, surveillance testing, and sewage results. This option allowed the health management team to identify specific locations where viral transmission was thought to occur. Examples include residence halls, intramural sports teams, students attending athletic events, and specific student organizations/groups. Targeted testing frequently included health center staff testing residence halls on site using the rapid antigen tests for quick results, providing us the opportunity to identify viral transmission and take appropriate isolation and quarantine actions as needed.

Athletics

Testing within the intercollegiate athletics department was conducted in accordance with NCAA and Big 12 Conference requirements. The tests were provided by both the health center by means of the respiratory clinic and external providers. The university health center was primarily used for symptomatic or exposed individuals.

Contact Tracing

Our contact tracing program mirrored that used by the Waco-McLennan County Public Health District. Tracers were required to complete online training from Johns Hopkins University as well as the Health Insurance Portability and Accountability Act (HIPAA) training from the university. Tracers were instructed to complete their investigations and tracing on the same day a positive case was identified. If the positive case identified a close

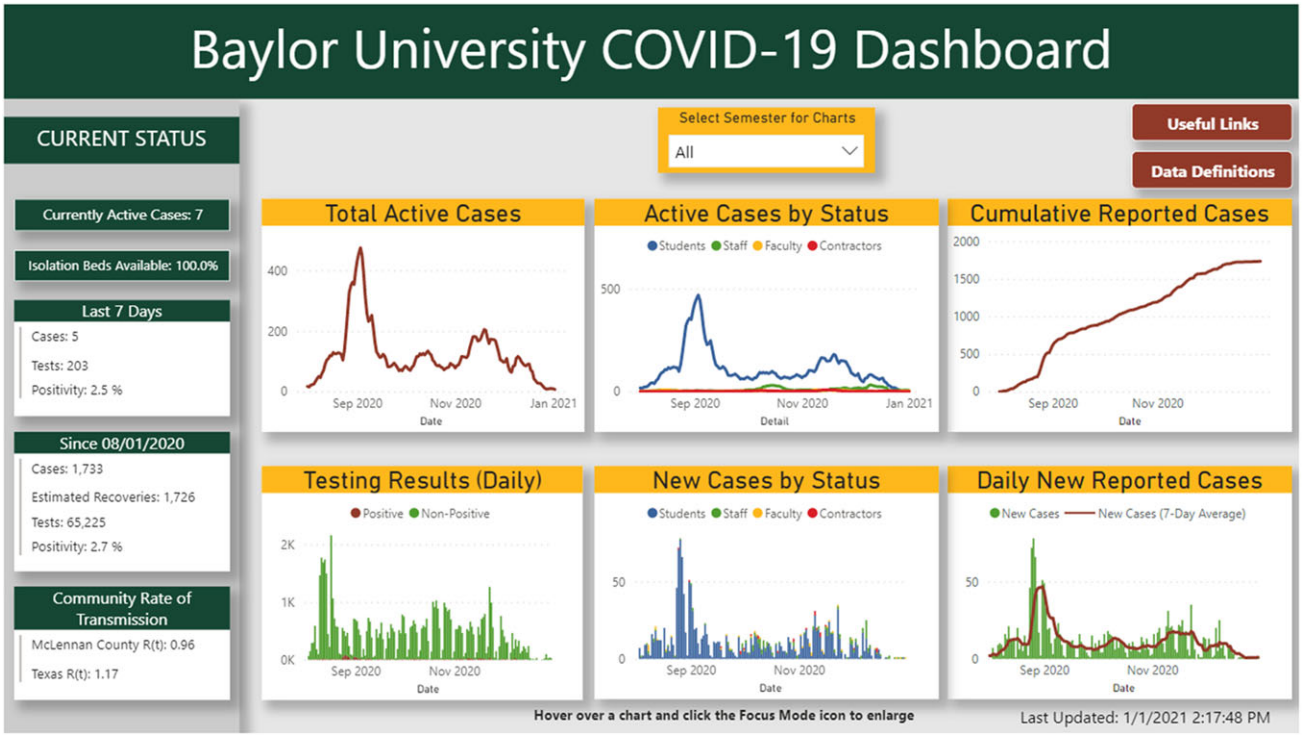

Figure 2. Example of the external Baylor COVID-19 Dashboard.

contact (defined as anyone who was within 6 ft of a contact for 15 min or more [cumulatively]), then the tracer called the contact and requested they quarantine for 14 d. The tracers additionally determined which rooms and facilities on campus had been visited by positive cases. All identified spaces were subsequently cleaned and disinfected by a rapid response team. More than 60 student tracers were trained with over 120 personnel available to trace, at a ratio of 1 tracer per 400 university members. This ratio was achieved through rapid recruitment of personnel and training of graduate students from social work and public health with their contact tracing activities counting as internships, a major part of their experience.

Tracers were instructed to be empathetic and assist the person with their needs while in isolation (for positive cases) or quarantine (for contacts). Those in isolation or quarantine typically requested assistance with retrieving materials such as books, contacting professors and financial aid, and delivery of groceries, medicine, and other supplies. In September 2020, the contact tracing team established a follow-up process calling people in isolation and quarantine; positive cases were called daily and contacts in quarantine were called every other day. Contact tracing was expanded to include a wellness team specifically tasked to contact all cases of students, faculty, and staff in isolation to monitor their health (signs and symptoms) and to provide assistance required to maintain isolation, groceries, textbooks, medication, etc. An anonymous survey was sent to all positive and close contact cases to document their experience of isolation and quarantine.

A Microsoft Teams page was established for contact tracing, which allowed multiple tracers to compile and update tracing information in a single, accessible site. The site grew to include dedicated pages for tracking isolation cases, quarantine cases and follow-up wellness checks. The site also served as a valuable resource for documenting and resourcing requests for assistance and tracking response.

Dashboard

The dashboard team daily reviewed de-identified data and provided a summary of conditions to the Provost. This was complemented by a weekly report. Data from each team were entered into Microsoft Excel and collated, analyzed, and presented using Microsoft Power BI. An external dashboard (Figure 2) was created for public viewing while an internal dashboard was used by the team to guide recommendations and strategies. This included information on case numbers, active cases, isolation availability, testing details by providers, outbreak, and cluster monitoring for both on- and off-campus housing and university facilities, and teaching availability of faculty members.

All data points were important for successful and safe operations, however, instructional continuity throughout the semester was vital. Departments were asked to identify back up instructors for all courses in case of faculty member illness, quarantine, or isolation. This was complemented by establishment of a survey to collect data directly from each department related to instructional capacity. Departments daily reported the number of individual instructors (faculty as well as staff scheduled to teach) who fell into each of the following categories: teaching at least 1 section face-to-face; teaching fully online and not in quarantine or isolation; teaching fully online and in quarantine or isolation; or unavailable to teach.

Support Services

A respiratory clinic was established on campus for students who were either experiencing COVID-19 signs and symptoms or were

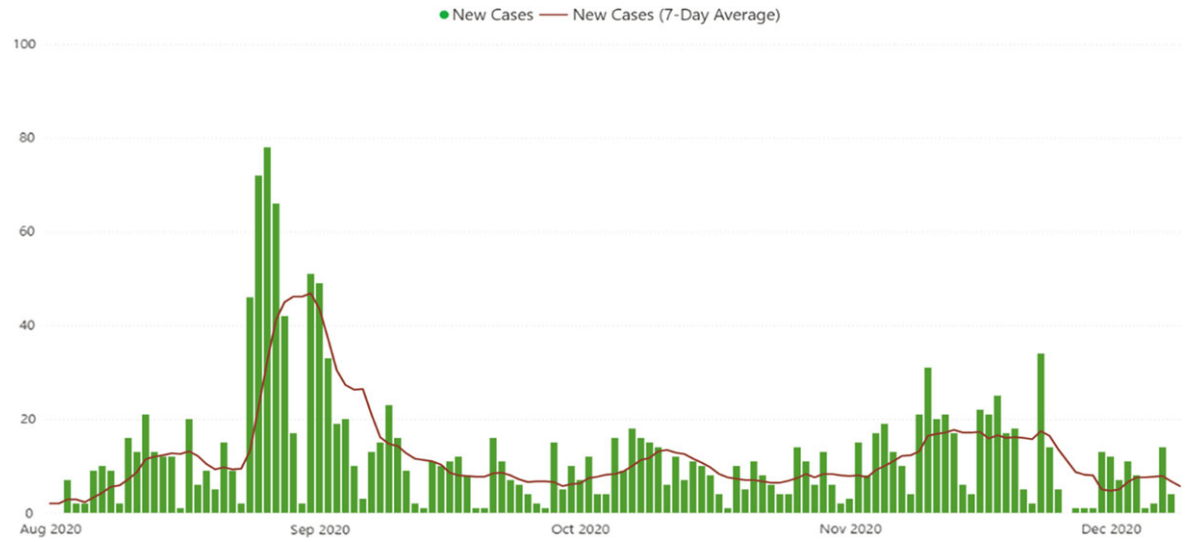

Figure 3. COVID-19 new cases by day.

in close contact with an individual who tested positive for the virus. This clinic primarily used a nasal swab with a rapid antigen test, yielding results within 30 min. As the semester progressed and processes strengthened, testing was extended beyond students to also include faculty and staff. Shortly before Thanksgiving, this testing was offered to all students, faculty, and staff, and this continued until December 18, 2020 (before the holiday break).

Baylor Student Life provided support services for students in isolation or quarantine, including advice, encouragement, exercise, mental health services, meal delivery, spiritual guidance, and a comprehensive set of programs and experiences to help students learn, grow, and develop.[23] Examples of these experiences included new student orientation, move in support, welcome week and Homecoming. Isolation for cases was offered at serviced hotels that we secured (in excess capacity) for on-campus residents. It was recommended that students avoid returning home to isolate to prevent the spread of COVID-19 to family, guardians, and friends. Off-campus students isolated at their place of residence, however, were offered a serviced hotel room if they lived with a housemate who was at increased risk of severe COVID-19 disease. Students in isolation or quarantine received meals, laundry services, and other needed care.

Communication

In preparation for and throughout the Fall 2020 semester, multiple communication methodologies were used. This included weekly communiques from the President, complemented by detailed emails/communication from the Provost, other leadership, and public health experts. There were panel discussions with faculty, staff, students, and parents. Targeted discussions occurred when groups of students were asked to reside in place for 3 d to allow contact tracing and rapid testing to be completed. Social media and traditional media were used to communicate messages, answer questions, and share information. A specialized telephone hotline team was created to support emerging COVID-19 challenges and issues (eg, pre-arrival testing and queries about students asked to reside in place).

Results

From August 1 to December 8, 2020, there were 62,970 COVID-19 (SARS-CoV-2) tests conducted among Baylor faculty, staff, students, and contractors. This is presented in Figure 3, which includes daily cases reported and a smoothed line representing the 7-d average. Within this group, 1435 people tested positive, with a positivity rate of 2.28%. Overall, there were 1670 cases, including 235 self-reports. The following tested positive for COVID-19: 1416 students, 107 staff, 90 athletes, 33 faculty, 22 contractors, and 2 others. This included 235 self-reports (155 students, 58 staff, and 22 faculty). This date range was bounded by start of activities to prepare for the semester commenced (August 1) and conclusion of the semester (December 8). This timeframe included pre-arrival testing, faculty preparation for the semester (began August 24, 2020), and students progressively returning to campus and Waco. The mean number of tests per week was 3500 with approximately 80 of these positive, or 11 positive cases per day.

As can be seen in Figures 3 and 4, when students, faculty, staff, and contactors returned to campus, there was an increase in positive cases, with a particular increase between August 9 and 22. During this period, there were 154 cases reported (mean of 11/d). This was followed by the first of 3 clusters. The first cluster was characterized by an increase in cases (507 cases averaging 36 per day) between August 23 and September 5 (associated with students returning to campus). The peak number of active cases during this cluster was 475 on September 3. This was followed by a decline of cases (135 cases) from September 6 to 19, dropping to 81 active cases by September 20. The lowest number of active cases on any day throughout the semester was 64 on December 6 (including students, staff, faculty, contractors, and athletics).

The second cluster occurred between October 4 and 15, including 142 cases with a mean of 12 cases per day. The peak number of cases was 134. This cluster was attributed to a combination of athletic-related travel and increased cases among staff. The third cluster occurred between November 3 and 19, including 282 cases with a mean of 17 cases per day. The peak number of active cases was 205. This cluster was attributed to social gatherings associated with Halloween.

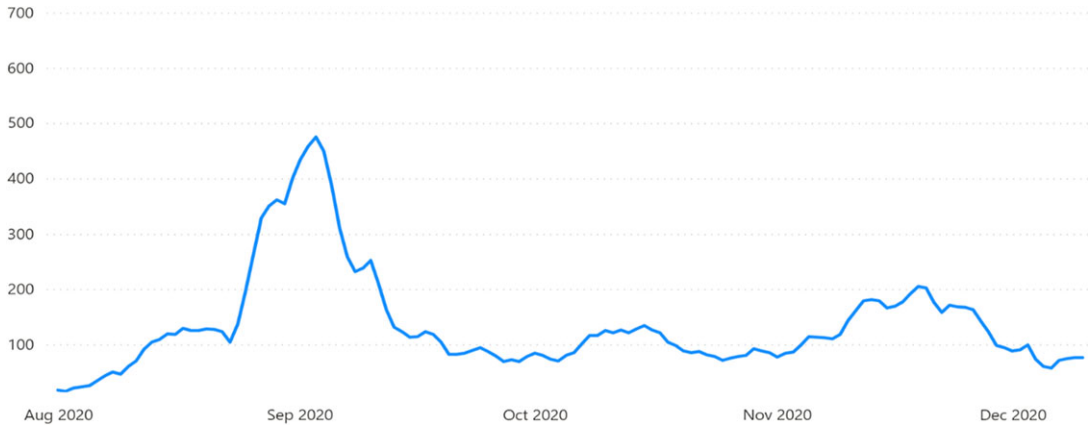

Figure 4. Active COVID-19 cases.

As described above, several testing and reporting mechanisms were used for identifying positive cases including pre-arrival, respiratory clinic, surveillance, surge, athletics, and contractors (Table 1). There were 13,621 pre-arrival tests completed (positivity rate of 0.99%). The decision to test before campus arrival identified 135 cases who were required to isolate at home before returning to campus. At the respiratory clinic, 11,188 rapid antigen tests were administered for symptomatic individuals and potential close contacts, with 798 people positive (positivity rate of 7.13%). Surveillance resulted in 21,435 tests of faculty members (1024), staff (4395), students (15,726), and other people (290), with 360 testing positive (positivity rate of 1.68%). Among Athletics students and staff, 8901 tests identified 91 positive cases (90 student athletes and 1 staff member) (positivity rate of 1.02%; 1.14% for student athletes and for 0.15% staff). The 4362 surge tests identified 29 positive cases (positivity rate of 0.66%). For contractors, there were 22 positive cases from the 3463 tests conducted (positivity rate of 0.64%). There were 235 self-reported positive cases (155 students, 58 staff, and 22 faculty members).

The number of tests conducted per week was dependent on need and availability. For example, from August 13 to 26, there were 10,646 tests (including pre-arrival and testing shortly after arrival). In contrast, 12,466 tests were conducted from October 19 to 30, when surge testing was available. Targeted testing occurred in residence halls, intramural sports teams, students attending athletic events, and specific student organizations/groups. The number ranged from groups as small as 4 to as large as 91 students. At the end of the semester, 19 student groups were tested, with 1741 tests identifying 33 positive cases. Within these groups, 2 were advised to quarantine for 3 d to allow contact tracing and testing to be completed. The targeted testing was conducted by the respiratory clinic and is included in the overall numbers provided in Table 1.

Most student cases were off campus (76%). In comparison approximately 66% of students lived off campus. Of the 1416 students who tested positive, 246 used our isolation facilities, with the highest number at any time being 52 on September 3 (approximately 30% of our isolation capacity). Of the 1766 contacts that quarantined, at least 277 (15.7%) eventually tested positive for COVID-19. Analyses of the isolation and quarantine data are ongoing.

Contract tracing identified all offsite sources of infection for faculty members, staff, and contractors (with no suspected transmission to these groups happening on campus). In terms of instructional continuity, no classes were canceled. However, 43 of 62 total departments reported 1 or more instructors who were in quarantine or isolation but still teaching online at some stage during the semester. Thirteen departments also reported 1 or more instructors who were unavailable to teach. In most cases, other faculty members would teach those courses because preparations for replacement instructors were made before the semester began. Transmission among students was traced back primarily to social gatherings or residences.

SARS-CoV-2 viral RNA appeared to increase in effluent sewage 1 to 2 wk before a cluster of cases. This progressively decreased as interventions (eg, isolation and quarantine) were implemented. As expected, there was a decline in the amount of SARS-CoV-2 viral RNA in sewage 3 to 5 wk following a reduction in cases. Data analysis for sewage effluent is ongoing.

Discussion

The establishment of multidisciplinary teams combined with direct engagement and visible support of the President and Provost was vital to resume and sustain Baylor University operations during the COVID-19 pandemic. This allowed teams to work seamlessly with leadership to develop, guide, and support implementation of public health measures. This was demonstrated by the rapid detection and control of clusters of cases within the Baylor community. For example, each of the 3 clusters lasted approximately 11 d between the first spike in cases until the rapid decline. Also, the team developed a targeted strategy of 3 d reside in place orders for clusters on campus (rather than building or campus wide). This allowed the university to safely continue operations while contact tracing and testing was completed. Resources were never stretched beyond capacity, and this was only possible due to the measured preparations in the summer, which included numerous tabletop exercises and scenario planning activities, surveillance tests, health protocols, and the rapid contact tracing, isolation, and quarantine processes.

A major consideration before reopening was the potential for spillover of COVID-19 cases into the Waco community. This was discussed among leadership, the health management team, and representatives of the Waco-McLennan County Public Health Department (health department) before the Fall semester. We were collectively confident the strategies in-place would mitigate impacts on the Waco community. Throughout the semester there was no evidence of a link between Baylor University

Table 1. COVID-19 testing data within the Baylor University community

Test type	Tests	Positive	Positivity rate
Pre-arrival (24 August 2020)	13,621	135	0.99%
Respiratory clinic	11,188	798	7.13%
Surveillance	21,435	360	1.68%
Surge	4,362	29	0.66%
Athletics (athletes and staff)	8,901	91	1.02%
Contractor	3,463	22	0.64%
Self-reports	Not applicable	235	Not applicable
Total	62,970	1,670	2.28%

reopening and a significant increase in cases in the Waco community. This finding was demonstrated on the Waco-McLennan County COVID-19 Dashboard, which indicated there were surges of cases in the community during the summer (while the university was closed) followed by a slight decline and then holding steady until around October 31, 2020 (Halloween).[24] Cases in the community then continued to increase and remain high through Thanksgiving, Christmas, and the New Year. The Waco case trends were similar with what occurred across Texas.[25] Based on this experience, implementing a "Swiss Cheese" risk mitigation model and using a multidisciplinary team approach to guide decisions and interventions is vital to reduce the risk of COVID-19 spread from colleges and similar institutions into the broader community.

As cases began to rise early in the summer, Baylor worked with the health department to identify ways to best support the local community. It was agreed that the best option was for Baylor University to contact trace using its own personnel (students, faculty members, and staff), a process that began in July 2020. While easing the burden on the local health department, it also allowed the university to conduct same-day contact tracing following positive case determination. Positive cases were isolated immediately, and contacts quarantined within 24 h, allowing clusters to be rapidly controlled. For this reason, it is recommended that colleges and other similar institutions prioritize testing and contact tracing capabilities to mitigate the impact of disease outbreaks and sustain operations.

A lesson from this experience is the need for rapid results from surveillance testing. Surveillance testing was a vital component for success, however, a disadvantage of using the qPCR test with a nasal swab was relatively long turnover for results (24-72 h). Once notified of the results, the university continued the same protocols, including contact tracing, isolation, quarantine, and follow-up with students for medical attention. In recognition of this challenge, Baylor established on-campus qPCR testing and lab processing for the Spring 2021 semester, permitting much faster test results.

The benefits of rapid antigen testing at the on-campus respiratory clinic helped to protect both university associates and the local community. If a student received a rapid positive diagnosis, they immediately received a phone call from a medical professional who notified them of their isolation responsibilities, advised about treatments for signs and symptoms, and answered any questions they might have about the result. Within hours a contact tracer collected information about close contacts the students may have had in the previous 48 h. Because this was all happening in near real time, the university was able to isolate the student who was positive and quarantine close contacts. All these measures took place to lessen the impact on the university and surrounding community.

Involvement of parents in communication was vital. Multiple methods were used to connect with parents. This included emails, call centers, and for those affected by reside in place orders direct engagement with representatives from leadership and the health management team. This helped get their buy-in and reinforce student compliance. Based on this experience, it is recommended that other colleges and similar institutions prioritize parent communication during an outbreak, pandemic, or other crises.

There is a need for an increased focus on testing and enforcement of public health recommendations in off-campus students. This was a known challenge before the semester commencing; however, strategies to actively mitigate the risks beyond existing structures (eg, County and State mechanisms) were unknown. As the semester progressed, the need to address this challenge was identified. Most Baylor students live off campus (approximately 66%), and proportionally, this is where most cases occurred. Efforts were made throughout the semester to engage private residential property managers on the situation and to recommend mitigation measures. This took longer than anticipated; however, progress was made toward the end of the semester, and property managers were grateful for the engagement. Based on this experience, it is recommended that active relationships be established and maintained with off-campus accommodation managers to help mitigate the spread of COVID-19 and other diseases, particularly within the greater community outside of the university. This consideration appears particularly relevant in regions with limited delivery of local public health services and areas with a high percentage of highly susceptible individuals (eg, large minority populations, many living below the poverty line and without access to adequate health insurance).

Throughout the semester we actively investigated cases to determine pathogen transmission. Spread of cases was generally associated with informal student social gatherings. Early in the semester, Baylor became aware of some planned social events and worked with organizers to cancel them. For any of these canceled events that still took place, disciplinary action was taken, particularly early in the semester. This enforcement combined with constant messaging, monitoring of safety measures on campus, and strict health protocols were effective in mitigating COVID-19 and sustaining university operations. This demonstrates that a combination of testing, compliance monitoring, and sustained implementation of public health measures (face coverings and social distancing) can minimize the impact of COVID-19 and other potential pathogen outbreaks.

Conclusions

The establishment of multidisciplinary teams was vital for Baylor University to resume and sustain operations during the COVID-19 pandemic. Our population-based team approach along with implementation of a "Swiss Cheese" risk mitigation model enabled development of comprehensive mitigation strategies and priority areas for action. As a result, the university was able to sustain activities, even during multiple case surges. These situations were addressed rapidly through testing, surveillance, tracing, isolation, and quarantine. There was no evidence of transmission within classes or lecture rooms due to our intensified safety protocols. A key lesson from this experience was the need for rapid results from surveillance testing because qPCR test results took 24 to 72 h. In recognition of this challenge, Baylor worked to establish

high throughput qPCR testing on campus (including in-house laboratory processing), which further enhanced our capability to identify and control clusters and subsequently expand operations. Although resources were highly used, they were never stretched beyond capacity. This result was only possible due to the measured preparations in the summer, which included numerous tabletop exercises, scenario planning activities, and addressing priority areas for action. The successes and lessons learned at Baylor University provide a framework and pathway for other colleges and similar institutions to mitigate the ongoing impact of COVID-19 and sustain operations during a global pandemic.

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