

Shared Resource Laboratory Operations: Changes Made During Initial Global COVID-19 Lockdown of 2020

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THE true impact of the COVID-19 pandemic caused by the novel coronavirus SARS-CoV-2, which saw a lockdown of millions worldwide and the temporary closure of many Scientific Laboratories and Shared Resource Laboratories (SRL), is yet to be known. Therefore, this article will concentrate on the effects of the lockdown from March to June 2020, ongoing effects upon operational management issues on SRLs worldwide and will conclude with a set of recommendations for planning for similar situations in the future.

Pandemics are widely considered a once in several generations event with the last significant occurrence being the Spanish Flu of 1918 which killed an estimated 20–50 million people worldwide. However, throughout history, there have been other examples of lockdowns of scientific institutions due to widespread illnesses. The University of Cambridge closed its doors temporarily in 1665 due to the Great Plague. This closure forced Isaac Newton to return to his family home and gave him time to reflect and develop his theories on optics, calculus, and the laws of motion and gravity. In fact, much of his work on prisms was done during this time when he bore holes in his parent's window shutters to allow

beams of light to enter prisms thus separating the light into colors (1-3). Only time will tell whether the COVID-19 pandemic will similarly reveal new scientific discoveries. We do know that it has allowed researchers and SRL managers to re-think how laboratory operations, including training, safety and staffing numbers, are carried out and determine what is a truly essential or critical experiment. In most Institutes, the criteria of a critical experiment are defined and managed by institutional management and not at the SRL level. These operational changes are particularly important as it has been predicted that COVID-19 infections will continue to occur in several waves and new novel viruses are likely to arise in the future. (4)

As described in the “Best Practices in a Flow Cytometry SRL” publication by Barksy et al., one of the key aspects of a well-run SRL is the operational structure of the facility (5), including their use for oversight, management and review of the facility's performance. However, during the lockdown, the operational aspects of SRLs worldwide have been tested. The current pandemic will ultimately shape the way that our SRLs are run and many of these new practices will continue beyond

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the pandemic and become our new best practices. Many of the decisions related to the continued running or temporary closure of an SRL were made at the highest levels of management in many institutions. Because institutional governance structures vary widely, this article seeks to provide generalized insight of SRL management of the COVID lockdown, show specific examples of operational practices adopted by some SRLs, and highlight best practice options that may be used by all SRLs in the future.

The Uniqueness of the COVID-19 Crisis

In the case of localized emergencies like natural disasters, civil unrest, or acts of war or terrorism, there is often a concomitant impact on infrastructure. Following Hurricanes Katrina (2005) and Sandy (2012) in the United States, massive flooding and high winds caused damage to municipal power grids, public transportation, and institutional infrastructure. Additionally, the residents of New Orleans and surrounding areas (Katrina) experienced extensive losses of personal property and many were displaced or relocated to be closer to personal support systems. These environmental impacts were experienced with little forewarning and had long-lasting effects on the research institutions in these locations: Louisiana State University Health Sciences Center, New Orleans (LSUHSC-NO) took approximately 9 months to re-establish a presence in New Orleans and resume research activities; the research core facilities at New York University Langone Medical Center (NYULMC) were shutdown for at least 2 weeks with 12 cores requiring relocation into significantly less space and until infrastructure repairs were completed (6). The full impact to the NYULMC research community lasted approximately 3 years (7). In each of these cases, once the initial emergency response and assessment was completed, a timeline for return of operations was established, and pre-event normal operations eventually returned. During a natural disaster, there is little opportunity to adapt to the situation as it occurs, so emergency response protocols should be well established according to recommended minimum standards for SRL operations guided by best practices (5).

Despite the early warnings of a highly contagious novel virus outbreak in the province of Wuhan (China) in early December 2019, the world was unable to stop the progression of COVID-19 into a pandemic. The extent to which countries have been affected by this global crisis has followed a similar pattern, albeit with differences in time, extent, and duration of viral infections. During the early days of the pandemic, the increases in cases were sudden with rapid accumulation of severe cases that threatened the collapse of healthcare systems worldwide. Taken together, the impossibility of establishing population-wide prevention policies and the lack of widespread testing or an effective therapy, created a perfect storm that resulted in the implementation of measures that ranged from a temporary state of alarm (e.g., Italy, France, and Spain) to mild recommendations for the general population (e.g., Sweden). The declaration of a state of alarm or lockdown enabled multiple countries to restrict the free

movement of their citizens with the goal of reducing the spread of the virus and minimizing the impact on local healthcare systems. In addition to the official measures taken by governments, hospitals, academic medical research centers, and universities implemented additional measures that in many cases still persist. These measures varied by research institution, but many involved the temporary restriction of personnel visiting countries affected by the COVID-19 pandemic, restrictions/bans on external visitors, and the cessation of research activities that were not considered essential. In many research institutes, the lockdown restrictions were in place for approximately 2–3 months.

While virtually all aspects of SRL operations can be impacted in any crisis or disaster, the COVID-19 pandemic has presented unique obstacles and opportunities for SRL operations encompassing staff, equipment, and users (Fig. 1). The variety of circumstances experienced by SRLs around the world have been simultaneously globally common and locally unique. Some SRLs were forced to shut down operations completely and abruptly. Some SRLs were given the benefit of foresight depending on viral spread and regional or institutional guidelines and were able to fully or partially shut down operations in a controlled manner. Other SRLs never shut down operations and continued to work with enhanced distancing and/or personal protective equipment (PPE) measures in place. As facilitators of research, it is incumbent upon SRLs to engage in strategic planning in a volatile, uncertain, complex, and ambiguous (VUCA) environment such as the one generated by a global pandemic. Ramirez and Selsky (8)

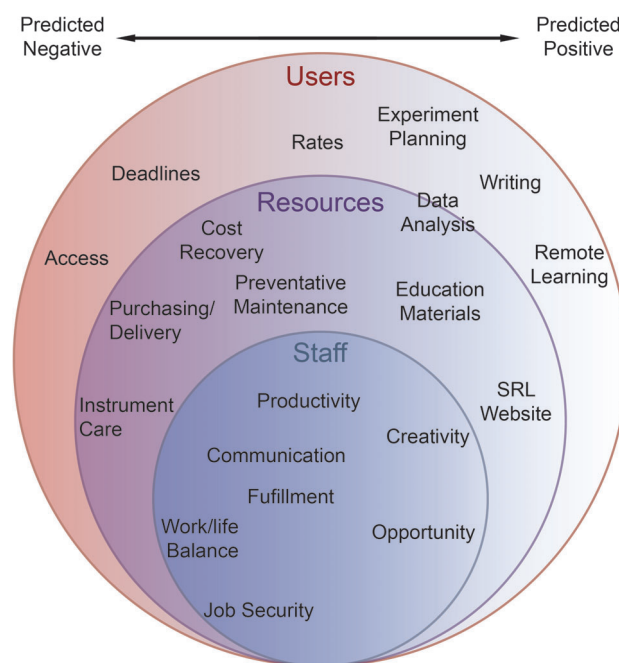


Figure 1. Anticipated impact (positive, negative, or neutral) of a global health crisis on key aspects of SRL operations among users, staff, and resources. [Color figure can be viewed at wileyonlinelibrary.com]

described a three-step strategy for “engaging turbulence” in a VUCA environment that can be used to decrease the effect of disturbances on operations and increase collaboration to ultimately transition through the crisis. Fortunately, many of these tactics have been embraced by SRLs and their stakeholders throughout the pandemic: (1) share resources, (2) assess the environment, and (3) strategize effort (Table 1).

Impact on Key Operations of SRLs

In SRLs, the goal is to increase one’s ability to adapt to the VUCA conditions and reduce levels of uncertainty. This has been observed through several collaborative efforts within the SRL community including virtual forums on operational concerns (*flowcytometryUK* & Royal Microscopical Society [RMS]) (9) and sorting COVID-19 infected samples (Australian Cytometry Society (10)). We have also seen significant efforts by instrument and software vendors as well as SRLs, working groups, and professional societies to provide educational materials through videos, webinars, and learning portals. Commercial vendors also granted short-term free remote access to analysis software in support of scientific research during lockdowns and expanded core management platform offerings to assist with enforcement of social distancing measures.

When assessing the environment, the goal is to “predict to prepare” to mitigate disturbances in normal operations as much as possible. In the case of COVID-19, this strategy tended to occur at the government and institutional level with regulations developed for social distancing, PPE, and budget restrictions. In some cases, these top-down policies

have been problematic for SRLs particularly when it comes to the travel or visitor restrictions imposed on instrument service technicians. A thoughtful approach for mitigating these effects, for example, would be to schedule preventive maintenance before lockdown measures are put into place or to stockpile an excess of frequently used lab supplies which will be needed when operations begin again. SRL managers can also ensure that remote access is available to field service technicians so more extensive troubleshooting can be done when they are unable to be on location. It should be noted that remote access is not always possible due to Institutional IT policies and security concerns. SRL members are encouraged to liaise with their IT department to see whether there are any work around fixes to allow remote access to instrumentation without compromising security.

Finally, strategizing effort attempts to reduce redundancies. During the pandemic many SRLs have accomplished this by sharing online learning tools and tutorials from reliable sources with their users, developing remote training tools, increasing networks of contacts within the SRL community, and finding new methods for clear and effective communication with users and between staff. For example, in one core facility when staff were restricted to being onsite only for essential work during lockdown, the Flow Cytometry Specialist with extensive Luminex Amnis Imagestream experience and knowledge gave over 12 h of Imagestream training to the other members of the SRL. This was split over half a dozen sessions over several weeks using Zoom and data sets for live data analysis training were shared.

Table 1. Examples of strategic approaches for SRLs in VUCA conditions

PURPOSE	CHALLENGE	ACTION	EXAMPLE
Share resources to increase adaptability	Uncertainties on how to adapt to new regulations Access management for user and SRL staff to resources	SRL collaborative forums for advice on adaption operations to regulations Use of online resources and management software	Guidelines for COVID-19 sample handling Free access to analysis software provided by vendors
Assess environment for situational preparedness	How new regulations will be implemented Travel restrictions hindering service visits	Form or recruit institutional committees to assess local and international regulations Assess which instruments will likely need service or are due for preventative maintenance	Establish occupancy limits, distancing guidelines, and provide PPE Schedule preventative maintenance in anticipation of lockdown
Strategize to reduce redundancies	Train and educate SRL staff and users Effective communication to SRL stakeholders	Collaborate with vendors and other SRLs to create new educational materials Establish a one-stop information point	Share virtual learning resources from reliable providers (i.e., ISAC’s CYTO U) Weekly e-mails, website updates, or intranet postings with the latest news

Source: Adapted from Ramirez and Selsky (8).

This intensive training would not normally be possible during normal operations.

The Specific Impact of the COVID-19 Pandemic on SRLs

For the purpose of a systematic overview of the impact on SRL operation management, we will review the effect of COVID-19 according to the areas defined by Barsky et al. (5): namely Management, SRL oversight, SRL performance assessment, annual reports/business plans, annual budget development with quarterly review, facility use policies and procedures, and facility communications.

The COVID-19 pandemic being a Global issue and with there being different governmental guidelines, it has become apparent that every Institute and SRL have dealt with the lockdown differently, some shutting SRLs but maintaining critical work such as animal units while others have carried on as normal but with added safety measures. The ISAC SRL-Services committee polled members between May 15 and 22 2020, to acquire a snapshot of SRLs globally during lockdown (11). The results showed that a majority of SRLs were still open in some capacity, most with limited capacity (91% of 123 answers). Figure 2 shows the global effect of this pandemic on cytometry SRLs. Some of these labs (about one-third) had been closed at some point during the initial part of lockdown (March 2020). Polls also showed that in both the open labs and those closed but planning to reopen changes in operations included: limiting user access, limiting training, staff working in shifts, extra cleaning and additional PPE. Due to SRL closure and user restrictions, many labs placed some or all of their cytometers into long-term storage.

As the scale of the pandemic became apparent, swift decisions were made which had an impact on the SRLs, this included reduced numbers of staff on site, closure of facilities

and changes in operations. As lockdown eased, new operational practices were established to encompass social distancing and enhanced PPE to allow scientific work to ramp-up, working toward some levels of normalcy. Figure 3 illustrates the theoretical impact of the pandemic on an SRL with ramping down of research leading to only critical experiments being carried out during lockdown, followed by the release back to normality. This is superimposed with the number of cases of COVID-19.

The RMS virtual meeting (9) held on May 15, 2020 (during lockdown) revealed that 81% of delegates felt Flow Cytometry SRLs should be run as a combination of user-run service for those already trained and full service with core staff running samples for untrained users (118 delegates polled). The follow-up meeting on June 12 (as worldwide government restrictions were being lifted), revealed that 12% of SRLs remained closed, 7% were re-opening in the next week, and 81% were already open with 14% of those only open for COVID-19 work (84 delegates polled). Many of the SRLs that were reopened were working with reduced staffing levels due to institutional restrictions on the number of people allowed on site, staff with health conditions making them more vulnerable to COVID and therefore unable to attend work or staff that had childcare restrictions reducing their hours at work (79%, 67 delegates).

Management

Although the functions of SRL managers/directors may vary in different SRLs, in general, the individuals appointed to this role are given reasonable authority to make decisions that ensure the efficiency and effectiveness of SRLs in the short, medium, and long-term. In times of crisis and in the absence of a higher authority taking temporary control, SRL managers

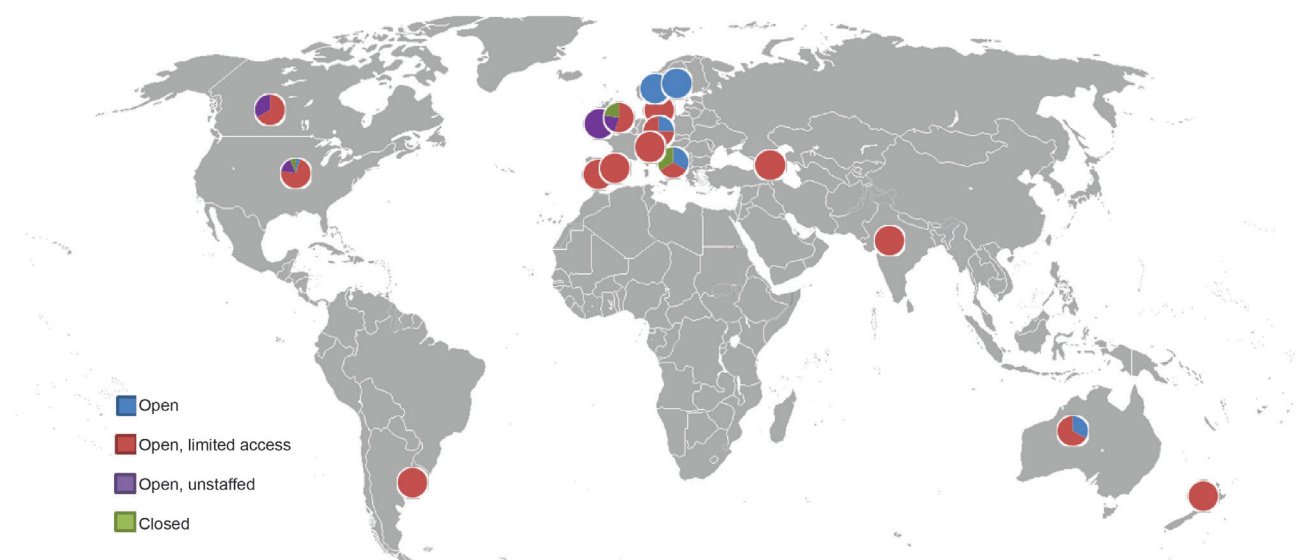


Figure 2. SRL operations status as of June 2020 (11) *ISAC SRL Services Committee* March 6, 2020. [Color figure can be viewed at wileyonlinelibrary.com]

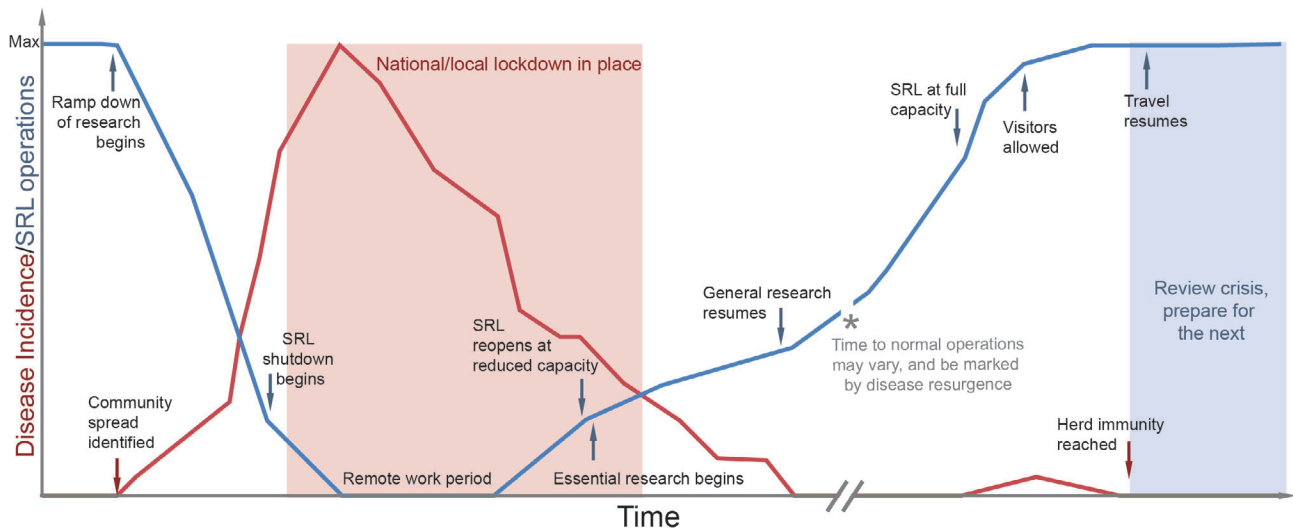


Figure 3. Hypothetical timeline of SRL operations over the course of a global health crisis. [Color figure can be viewed at wileyonlinelibrary.com]

must step in to perform the functions corresponding to crisis management in their business unit (the SRL). In general, crisis management actions are those that managers take in the time of a crisis involving the acquisition and monitoring of crisis indicators, as well as applying measures intended to minimize negative impact on the business. In the particular case of COVID-19, crisis monitoring was performed by every government and further nuanced by the research institution; therefore, crisis management was reduced to the application of institute-wide measures and the downstream communication to users involved. During a crisis, people with a unique skillset or insight in a situation but not used to decision-making or management are often moved to the forefront of Institutional committees. This can have a lasting effect on their confidence, giving them additional skills and ultimately may give them a career boost. As such, the COVID-19 pandemic has represented a unique opportunity for SRL managers to test and further develop their leadership skills in facing various COVID-19-related factors, mostly related to dealing with fear (becoming infected or severely ill), uncertainties (length of the crisis, economic implications, job security), and demoralized personnel (isolated at home, dealing with domestic stress, or loneliness).

Depending on the structure of the Institute, a crisis team may have been making decisions for the whole organization, a department or an individual SRL. An example of a crisis team for an individual SRL includes a group of three to five individuals at varying levels throughout the SRL and its parent organization who guide the shared resource through the crisis. In the case of academic SRLs, this would include the SRL director, department head, and the dean of the school governing the SRL. The highest-ranking member of the crisis team should have direct access to the highest levels of the organization, such as the board of directors. Other

representatives could be considered from the following departments, depending on the size of the SRL and organization: operations management, facilities management, representatives of all research groups using the SRL, finance, human resources, and IT. Representatives from these departments would only need to be at meetings where particular details relevant to their departments are discussed. It is also important that the crisis team include at least one member intimately involved in the day-to-day activities of the SRL to provide feedback on the exact conditions within the SRL. Depending on the size of the resource this could be a managing director, lab manager, or senior staff member. During regular operations of the SRL (outside the crisis), the crisis team should meet regularly, ideally quarterly but at least annually, to build relationships and foment trust between the team members. During a crisis, these meetings will increase to monthly or weekly where high-ranking team members will review institutional guidelines for dealing with the crisis and discuss implementation with SRL management, who will provide feedback on feasibility, and later communicate the implications of these guidelines to SRL users. Discussion points may include emergency shutdown (partial or full), reopening guidelines, modified safety guidance, budget shortfalls, and IT needs (i.e., remote screen connection). In some cases, institutional crisis teams may already exist at a higher level of administration than the SRL. In these situations, it may still be useful for the SRL to have an internal crisis team to discuss and implement crisis-dependent policies. One best practice is to recommend that a member or a line manager of the SRL is involved with crisis management teams in the future.

Regardless of the structure or power of the crisis team, in health crises like a pandemic, it is important to also discuss a chain of command within the crisis team in case of death or extended illness of one or more team members. It is also

recommended that one individual, perhaps a responsible senior SRL staff member, be given absolute local decision responsibility in the case that communications are interrupted.

Oversight, performance assessment, annual reporting, and budgeting

As the main impact of the COVID-19 crisis has been an almost complete cessation of activities, the impact on SRL oversight and performance assessment is likely to be observed during the course of the annual reporting. It is expected that 2020 annual reporting for every SRL will include a chapter on COVID-19 impact, likely dominated by the loss of usage hours, drastic decrease in user-fee-dependent income, delayed maintenance, and unexpected staff leaves due to COVID-19 or COVID-19-related post-traumatic stress. Partial or complete lockdown provided a unique opportunity for SRL staff working from home to expand their knowledge and skills through online webinars and more traditional forms of education. This can be assessed by the SRL manager during appraisals and catch up meetings. Thus, the pandemic has had the potential of providing a positive impact on the personal development of staff and allowed them to return to the lab during ramp-up with new skill sets and increased knowledge. For those staff tasked with reporting to the SRL during lockdown, they have been given invaluable experience of working during a crisis with reduced hands-on assistance from colleagues and the potential of making timely executive decisions about experiments and activities within the core.

Facility communications

Face-to-face communication is essential in any SRL, both in interactions with users (i.e., sort consultation, training, and operational feedback) and between SRL staff (i.e., appointment and instrumentation management). For obvious reasons, COVID-19 has forced SRLs to minimize face-to-face communication and switch to more digital platforms, predominantly involving e-mail and video conferencing. The publication of periodic updates on SRL websites and through e-mail distributions has become common practice as well as the use of apps for improved communication between staff members.

The most important objective to remember for communication with users during a crisis is consistent directionality of information. Directives should flow from the highest levels of the organization, such as the board of directors, to SRL leadership through the crisis team and organizational communications, and from SRL leadership to their users. Before or at the very beginning of the crisis, one individual should be selected to communicate with SRL users. This should be someone with a pre-existing relationship with the users and with some level of authority, such as a managing director. A back-up communicator should also be identified in case the primary communicator becomes incapacitated or unavailable. Once the key communicator has been established the manner and method of communication must be consistent.

Information must be relayed promptly to users, preferably via multiple methods like online communication as well as posting the relevant hardcopy in a visible manner inside the core. The key communicator must be empathetic, recognizing and validating user's reactions to restrictions and disruptions, while still maintaining a firm stance on required changes to operations. Communication must be honest and not understate or gloss over the challenges created by the crisis and be informative and not allow space for users to make assumptions. This also means letting users know that there is no new information or that the organization has not issued any new directives. Finally, the communication should be interactive, welcoming, field any questions from users as they occur, and provide a place where concerns are taken seriously and addressed.

After a crisis, it can be useful for the designated communicator to notify users of a return to normal operations as well as provide a summary of how the crisis was handled and its impact on operations moving forward. There may be a backlog of work after a crisis, meaning longer than usual wait times for instrumentation, delayed user training, or unavailability of specialized staff. This coupled with extended periods of limited operation (i.e., social distancing, reduced staffing) is certain to stress users eager to resume research as usual. It is essential to maintain open and clear communication with users as the SRL slowly returns to precrisis operations.

Prioritization of work done in the SRL during lockdown and during the ramping up phase

During the lockdown of Spring 2020, many institutions completely closed their doors; however, a number continued working with critical experiments, specifically COVID work, being prioritized. This work was often performed on minimal numbers of instruments with other instruments placed into long-term storage while staff worked shifts or only came into the lab to carry out sorts, QC and other essential core activities. In many institutions, the work being performed was deemed essential and critical with priorities set by a committee. In some institutes, this was SRL based, but in many, this committee comprised senior management and senior scientists using a set of criteria for prioritization. An example of this is given in the case study in Table 2.

The RMS meeting on June 12, 2020 (9) revealed that 45% of the attendees worked in an SRL that had some say in which researcher or work got priority. When asked whether COVID samples should be given priority, 42% of the attendees replied no, 38% yes and 20% did not know (95 delegates polled).

Facility use policies and procedures

The imposition of restrictive measures during the COVID-19 crisis has been a common denominator in the majority of Cytometry SRLs across the world. SRL staff have been considered by the majority of research institutions as crucial for normal operations. Thus, while many researchers were asked

to work remotely, SRL staff had to attend to the operation of the facility when research involving COVID-19 or other essential research activity was involved. Changes in user policies often included a cessation of user training and restricted access to the SRL. These changes likely also resulted in the generation of new policies regarding facility access and procedures to ensure adherence to the new more restrictive safety measures. Institution's Health and Safety Managers have worked with SRLs using published risk assessments and guidelines from organizations such as Institution of Occupational Safety and Health (12). These Institutional specific guidelines were implemented when COVID cases began to drop and lockdown measures were gradually lifted; first, researchers performing nonessential research were allowed in with a restriction on the number of users per square meter/lab space unit, then allowing external visitors to SRLs (such as engineers to repair instruments), and later expanding to users maintaining a minimal distance of 1–2 m (depending on Institutional and Government social distancing guidelines) and the compulsory use of personal protection measures (face mask, lab coat, and gloves). Because of the difficulty to keep sufficient social distancing during one-to-one trainings, the re-implementation of these has generally been the final sign of returning to normal activities. For the safety of the SRL members, they were encouraged to work in set “bubbles,” for example, two members of the SRL only ever worked together (still socially distancing). Special bubbles were needed for SRL staff who work between different SRLs or are part-time. This measure helped to prevent the spread of potential SARS-CoV-2 infections and also meant that if there was a suspected or confirmed case the SRL does not need to shut while all members self-isolate. During lockdown and going forward, institutes also need to have a contingency plan if a user of the SRL tests positive for SARS-CoV-2. If close working has been kept to a minimum, then it is unlikely that the core will need to close but will probably need to be deep cleaned. If a user tests positive, all SRL staff should be asked to be extra vigilant and self-isolate if any close working or breeches in social distancing has occurred.

Some of these policies, such as increased work from home and the use of remote meeting platforms, may remain in effect long-term as a way to free up space and resources for laboratory-based activities. In the event that the crisis team determines that local and institutional guidelines are lacking, the members of the team may elect to implement their own policies. For example, many institutions have implemented mandatory daily temperature and symptom screenings for on-site staff. Some organizations, especially biotech companies have also introduced weekly PCR screening for COVID-19.

The Future: Preparing for the Next Crisis

The SARS-CoV-2 pandemic has provided a unique opportunity for SRLs to operationally prepare for future crises, including natural disasters, which could facilitate the

discontinuance of cytometer use for an extended period of time. Many institutions found that their business continuity plans did not factor in immediate close of the SRLs and the institute and remaining either closed or doing critical experiments only for several months. Therefore, these plans need to take this into account for future lockdowns and how to reopen an SRL after partial/full closure. Careful future planning on behalf of the SRL management team should involve both practical and communication procedures for staff and SRL users that can be implemented as soon as the event occurs. Best Practices for crisis planning should at minimum include the creation of a crisis team and a communication plan. The advent of the COVID-19 pandemic has highlighted the importance of forming a crisis communication team to share any actions resulting from the crisis to both staff and SRL users. Points to consider for this committee include emergency shutdown (full or partial closure of SRL and cessation of all activities), reopening guidelines, modified safety guidance, budget shortfalls, and IT needs such as remote screen connection. Each SRL should have a standard operating procedure (SOP) for varying degrees of shutdown and other contingencies, including how to shut machines down for long-term storage and whether trained users can be in the facility. Re-establishment of the facility post-lockdown also needs to be addressed in the SOPs including what to do if an instrument is not performing correctly when resurrected. While no emergency is happening, the committee should meet either annually or bi-annually. When the emergency is in process, the committee should virtually meet weekly, with any institutional or guideline communications being transmitted to staff immediately through an agreed platform.

Communications

Updated procedures and protocols released from the communications committee necessitates dissemination on a platform that is easily accessible to both staff and users of the SRL. Currently available tools such as WhatsApp, Slack, Facebook Messenger, Teams, and email lists have all been valid ways to communicate, and regular maintenance should be carried out to ensure these lists are up to date. It should be noted that if there were a future pandemic, online tools are likely to have changed so due diligence of online and remote working tools is necessary. Guidelines on safely using the core are the most important as the noncompliance of staff and users can have serious health consequences for the researcher and other people within their professional and social sphere. Dissemination of these guidelines should be in two different ways—first by electronic means followed by a physical copy on the door of the core and inside the lab by every cytometer as a visual reminder for everyone using the core. If any users do not conform to any new ways of working, then these users should initially be spoken to about the importance of the

new guidelines and this should be escalated higher to their PI and/or Institute Director if compliance is not adhered to. The SRL management should consider a ban (temporary or permanent) for violators of rules.

Virtual operation/maintenance of instrumentation

In the case of a global or local health disaster, it is inevitable that some SRLs will continue to operate in order to carry out important research on the issue at hand. Depending on circumstance, there may also be reduced SRL staff coverage leading to a potential need for virtual/remote assistance on equipment. The use of Slack to answer frequently asked questions, Teams, and other messenger/video calling networks along with training of users to run daily QC and perform basic troubleshooting can aid in the smooth operation of the SRL. Future proofing should include production and dissemination of videos and images on the correct maintenance and operation of equipment. Although institution and instrument-specific resources are ideal, platforms such as YouTube and instrument manufacturer websites provide ample resources that may be sent to all users, placed on the SRL website or on the cytometer workstation desktop (e.g., Refilling the Sheath and Emptying the Waste on an LSRII, Changing Sheath and Waste on a Canto II, BD FACSAria start-up procedure). In the event of a natural disaster such as a flood or fire that destroys equipment, unaffected SRLs in the immediate or relatively near vicinity could be contacted to assist with running samples. Local guidelines, relevant procedures and any other regulations of the assisting SRL should be adhered to by any visiting researchers. It is important to have prior formal or informal agreements in place to use an SRL at another Institute if needed.

Drills

As with any disaster or emergency, drills should be carried out regularly to ensure and improve efficiency of procedures in preparation of a real disaster. If we have learnt anything from this pandemic, it is that anything can happen and new rules and regulations can be put in place overnight. In order for drills to be effective, regular sessions should be held where SRL staff learn/practice the correct emergency shutdown/startup protocols as indicated by the equipment manufacturer. These could be held right before or after national holidays when the lab is likely to be operating at reduced user capacity. Furthermore, a more flexible work schedule could be put in place that gives staff members the option of working from home when they do not need to be physically on site so that remote troubleshooting and QC can be rehearsed.

Model statements/standardized guidelines

Model clear and concise statements can be prepared and ready for adjustment based on the disaster at hand. This will ensure the efficient and accurate communication is sent out to all SRL users, to retain user confidence and avoid speculation and unsafe user practices. Standardized return to work guidelines can be prepared and ready for editing depending

on circumstances (e.g., to include social distancing) to plan for the reopening/increase of activity within an SRL, although this is likely to be controlled by institute management,

Staff delegation for crisis preparation

The importance of including all SRL staff in emergency preparedness should not be understated. Staff who are aware of the decisions regarding what to do and how to handle questions and concerns of the users are more likely to enforce guidelines and procedures that ensure safe and efficient operation. Staff involvement can also be applied to specific tasks including production of effective virtual training session/s, placement of all core-specific and outside resources online, maintenance of communication platforms or virtual/remote oversight of equipment. Regular group and individual virtual meetings with staff members ensure that tasks and deadlines are on track. Reduced staff coverage due to individual circumstances such as illness or family caring responsibilities should

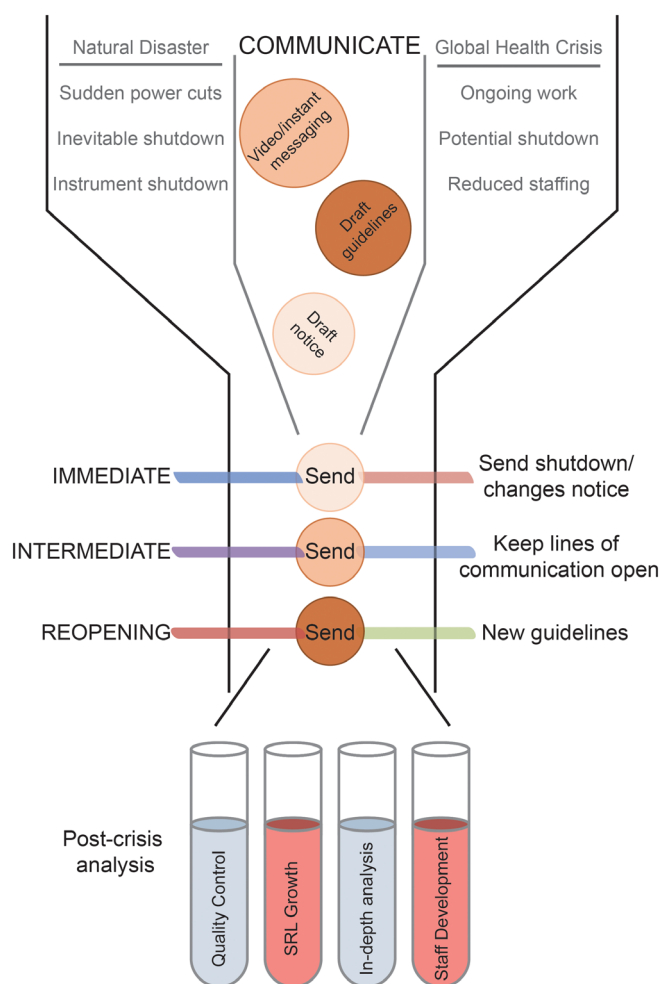


Figure 4. The flow of disaster preparation that each SRL should consider in future contingency plans. [Color figure can be viewed at wileyonlinelibrary.com]

Table 2. An example of how the SARS-CoV2 pandemic has affected the operations of one Flow Cytometry SRL

	UK GOVERNMENT ADVICE	INSTITUTE MANAGEMENT	EFFECT ON FLOW CYTOMETRY SRL
contingency planning	N/A	The Head of Risk Management coordinated contingency plans for each department, SRL and admin teams for a variety of “disasters” including fire, flood, and terrorism. A reciprocal agreement is in place with a neighboring Scientific Institute to allow space and resources for an Incident response centre. This forms part of the Institute Business Continuity Plan, along with the Crisis Management Team framework	Head of SRL reviews and updates contingency plan and risk register every year. Informal agreements in place with other SRLs in city that if SRL had to close due to major incident, essential cytometry work could be carried out in their SRLs.
Phase 1 Ramping down Wrapping up experiments, reducing numbers of staff in work and reduction in numbers of new experiments.	March 3, 2020: Govt. published guidelines on dealing with COVID-19 in the United Kingdom: Contain: detect early cases, follow-up close contacts, and prevent further infection Delay: slow the spread in this country Research: better understand the virus Mitigate: provide the best care possible for people who become ill and minimize the overall impact of the disease on society, public services and on the economy	February 2020: Information sent to all staff with emerging Government Coronavirus action plan Crisis Management Team for COVID established including directors, senior administrators, and group leaders. Early March 2020: Information sent to staff with hygiene guidance (personal and using communal equipment) and guidelines on Institute travel. Plan for all employees: A designated self-isolation room if someone has symptoms of COVID Each department and SRL prepared a contingency plan in case of reduced staffing Intranet regularly updated with information for all staff members including guidance from gov. uk website, health and well-being.	No direct effect on day-to-day operation Risk assessments written and contingency plans updated.
Phase 2 Critical experiments and crucial functions Institute remained open	March 16, 2020: Work from home if possible Most vulnerable asked to shield at home Social distancing of >2 m Schools and childcare providers closed March 23, 2020: <i>Lockdown</i> Only allowed to leave house for basic necessities, to exercise once a day, for a medical needs or provide care or to	March 19, 2020: Institute limited time on site and encouraged remote working. <i>Only critical experiments to be carried out</i> , defined as: COVID-19 research Ongoing long-term studies Experiments with staff are reaching the end of their contracts Experiments required for ongoing work, for example, for grant application, paper submission, and so on.	All analyzer and sorters put into long-term storage except one analyzer and one sorter. Core staff only allowed in for critical functions, and for the minimum time required to perform that function All other core staff are working from home. All Institute scientific work is triaged by Critical Experiment Committee (CEC) External customers initially barred, then required to submit experiments to CEC as well

(Continues)

Table 2. Continued

	UK GOVERNMENT ADVICE	INSTITUTE MANAGEMENT	EFFECT ON FLOW CYTOMETRY SRL
Phase 3* Crucial functions only *never implemented	travel to/from work if you cannot work from home. Stay At Home-Protect the NHS-Save Lives	Maintenance of mice stocks, cell lines and equipment This was in response to lockdown and Science Minister Amanda Solloway's letter to the research community, both on March 23	ALL SRLs fully closed.
Phase 4a Ramp up	May 23, 2020: Phased reopening of schools, nursery from June 1, 2020. May 28, 2020: Some easing of lockdown Stay Alert-Control the virus-Saves Lives	Only staff performing crucial functions that could not be paused (e.g., animal care, essential building maintenance) allowed on site. Prior to June 1, 2020: Ramp up committee formed to discuss and implement measures to increase the amount of scientific work done without compromising safety in line with government guidance and emerging best practice. June 1, 2020: Scientists encouraged to work from home when not required in the laboratory. Social distancing in place in laboratories. CEC still reviewing and approving experiments.	No immediate effect on the Flow Cytometry SRL
Phase 4b Ramping up Increase numbers in work	June 19, 2020: Government reduced threat level to 3, meaning gradual relaxation of restrictions. June 23, 2020: Social distancing reduced to 1 m +	June 19, 2020: Group leaders now prioritize work, keeping in mind reduced personnel capacity Remote work when possible. One <i>scientist per bay and office space</i> . Ramping Up Working Group still meets to review and update measures in place, and has expanded capacity in some areas where possible	Now with more demand, an additional analyzer and two more sorters brought back on line. Restrictions in place on number of people in office and in lab space (one person per 25 m ²). Main analyzer room capped at three people at any one time; main sorter lab 2 and smaller sorting room 1. This restriction in capacity has created a bottleneck for scientific work.
Phase 4c Future		Opening offices for operational teams	Increase SRL capacity.
Phase 5 Normal Operations		Normal Operations with review of crisis response and future planning	Normal Operation

The table shows the response of a medium-sized independent research institute based in the United Kingdom (~360 total staff and ~200 scientists/technical staff). The table shows how the operations of the institute were guided by advice from the national government. Decisions were often made quickly following statements from the government. The institute was limited to critical experiments and operations during the national lockdown period (Phase 2) and avoided having total closure (Phase 3). As this manuscript is being prepared institute remains in Phase 4b.

be considered, with an alternative staff member identified to complete any outstanding tasks if possible.

Contingency planning

Although it is not known if or when another crisis like a pandemic or natural disaster will strike, it is important to plan contingencies that will be put into action if it does. A contingency plan should include a combination of all points raised in this section and can be summarized in Figure 4.

CONCLUSION

The current COVID-19 pandemic has required swift decisions be made, often at the highest level of the organization, to ensure safe and effective continuation of scientific research. This may have meant that work in some Institutions and SRLs ceased overnight. Lessons have been learned about what is deemed as a critical experiment and essential work. As institutions and SRLs ramped their work back up, additional lessons have been learned about prioritization of work, operating remotely and adapting to new Best Practices.

Government furlough schemes and current project grants/funding means that there has been very little impact of COVID-19 in terms of job losses within the scientific research community; however, the next several years are likely to be economically difficult for many with potential tax increases, reductions in science funding and future lockdowns. This could lead to a reshaping of many SRLs with reduced staff numbers and budgets, which could have a long-term impact on the SRL operations around the world. The best method for mitigating these circumstances is to develop a robust plan for reacting to these types of crises in the future.

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CONFLICTS OF INTEREST

C.E.R. has received speaking honoraria from Fluidigm, Inc.

ISAC EMERGING LEADERS

C.E.R. and E.O.O. are ISAC SRL Emerging Leaders. R.V.W. and J.B.B. are past ISAC SRL Emerging Leaders.

LITERATURE CITED

1. Westall RS, Mirabiles A. *Never at Rest: A Biography of Isaac Newton*. Cambridge: Cambridge University Press, 1983; p. 140–175.
2. Fara P. *Isaac Newton at Woolsthorpe Manor Lincolnshire*. Aylesbury: National Trust, 2018; p. 1.
3. Matthewson-Grand A. Available from: <https://www.cam.ac.uk/alumni/life-in-lockdown>; 2020.
4. Kissler SM, Tedijanto C, Goldstein E, Grad YH, Lipsitch M. Projecting the transmission dynamics of SARS-CoV-2 through the postpandemic period. *Science* 2020;368(6493):860–868.
5. Barsky LW, Black M, Cochran M, Daniel BJ, Davies D, DeLay M, Gardner R, Gregory M, Kunkel D, Lannigan J, et al. International Society for Advancement of Cytometry (ISAC) flow cytometry shared resource laboratory (SRL) best practices. *Cytom Part A* 2016;89A(11):1017–1030.
6. Hollier L. Hearing Before the Subcommittee on Bioterrorism and Public Health Preparedness of the Senate Committee on Health, Education, Labor and Pensions. *The Impact of Hurricane Katrina on Louisiana State University Health Sciences Center New Orleans*; 2006.
7. Mische S, Wilkerson A. Disaster and contingency planning for scientific shared resource cores. *J Biomol Tech* 2016;27(1):4–17.
8. Ramirez R, Selsky JW. Strategic planning in turbulent environments: A social ecology approach to scenarios. *Long Range Plann* 2016;49(1):90–102.
9. Meeting RMS. Available from: <https://www.rms.org/discover-engage/online-microscopy-talks/summary-virtual-flowcytometryuk-meeting-covid.html>; 2020
10. ACSC. Available from: <https://cytometry.org.au/acs-covid-resources/>; 2020
11. https://cdn.ymaws.com/isac-net.org/resource/resmgr/docs/srl_newsletter/srl_covid-19_survey_results.pdf [press release]. 2020.
12. Health IoOSa. Available from: <https://iosh.com/media/7811/iosh-risk-assessment-guide.pdf>; 2020