Response to COVID-19: Minimizing Risks, Addressing Challenges and Maintaining Operations in a Complex Academic Radiology Department

Ivan Pedrosa, MD, PhD, Travis Browning, MD, Jeannie K. Kwon, MD, Michael Morriiss, MD, Lacy Matsler, MBA, Marco C. Pinho, MD, Daniel Lamus, MD, Anil Pillai, MD, Sweta Patel Karow, BAAS, Jon Garinn, MJ, Cecelia Brewington, MD, Eric Zeikus, MD, and Neil M. Rofsky, MD, MHA

Abstract: The coronavirus disease 2019 (COVID-19) pandemic has necessitated rapid response plans to minimize risks of infection in the workforce while ensuring maintenance of essential functions of radiology departments. Plan adoption is, however, challenged by the need to coordinate with institutional efforts, a rapidly expanding number of patients, and the diversity of clinical and administrative functions in the department. Here, we describe the implementation of a response plan in an academic radiology department, challenges encountered, and tactics used to address these challenges.

Key Words: COVID-19, response plan, radiology department, PACS, remote reading, residents

The outbreak of pneumonia caused by severe acute respiratory syndrome coronavirus 2 (a.k.a. COVID-19) has overwhelmed health care systems in many locations. Increasingly, health care providers are among those afflicted. Radiologists risk being exposed both on an occupational and a social basis with proceduralists at further risk. Radiology departments need to ensure continued operations with a healthy pool of providers and staff. Here, we present some of the approaches and lessons learned during the development and implementation of a response to the COVID-19 pandemic at a large academic multi-institutional medical center. Actions were framed by 3 basic principles:

1. Maintain service levels to meet the needs of our patients and referring physicians.
2. Maximize the safety of our faculty, staff, and trainees; and
3. Perform our civic duty of limiting viral spread.

CONSTITUTION OF A RADIOLOGY COMMAND CENTER

The Department of Radiology leadership constituted a radiology command center (RadCC) to rapidly develop and facilitate response plans and to furnish succinct communications from a single source to the rest of the department. In the context of preserving continuity, providing leadership experience, capitalizing on areas of expertise, and attaining diverse input, the committee was constituted with an even distribution of sex and age across most specialties. There was representation from each of the 4 hospital systems that compose our Medical Center: (i) [The University of Texas Southwestern Medical Center (UTSW)], a tertiary and quaternary health care center; (ii) [Parkland Health & Hospital System], the safety-net hospital for [Dallas] County; (iii) [Children’s Health System Texas], the associated pediatric health care network which includes 2 free-standing hospitals; and (iv) [Texas Health Frisco], a community hospital resulting from a partnership between [Texas Health Resources ] and [UT Southwestern]. Table 1 shows the composition of the RadCC.

The RadCC had daily virtual meetings using a digital platform. A RadCC email account was created to address questions and concerns submitted by the department personnel. A daily communication summarizing new developments or implementation of new initiatives was sent from the RadCC e-mail account to the entire department. The RadCC maintained constant and direct contact with institutional leadership and COVID-19 emergency operations center to harmonize tactics and information relays to department personnel. The imaging service line, a hospital-based suborganization that works closely with the department of radiology, consists of administrators, technologists, and nurses who provide vital roles for care for our patients. Figure 1 shows how the RadCC was positioned in the medical center's organizational structure.

MITIGATING RISK OF EXPOSURE IN THE RADIOLOGY DEPARTMENT

Employee protection safeguards were needed based on suspected high human-to-human hospital-associated transmission of COVID-19. The initial phase with limited COVID-19 testing availability prompted us to develop a standardized approach to imaging patients with both known and suspected COVID-19 infection. Personal protective equipment (PPE) is prioritized for front-line technologists and radiologists when they directly perform examinations on patients with suspected or confirmed COVID-19 infection. The PPE availability shapes its distribution and prioritization.

Below are some important considerations for these different scenarios:

1. Inpatients and emergency department. Early agreement between infectious disease, emergency medicine, hospitalist, and radiology teams on the indications for imaging a confirmed or suspected COVID patient focused on how the result would change management, and clear messaging of that to the frontline staff.
Changes to the electronic health record (EHR): Patients, with clinically suspected but unconfirmed COVID-19, were designated by flagging them as a patient under investigation (PUI). Similar precautions were used for PUIs and those with documented COVID-19 infection.

Reporting: The approach to reporting of imaging findings evolved and differed between PUIs and patients with documented COVID-19 infection.

Use and care of dedicated equipment: To facilitate cleaning procedures and to limit the chance for viral transmission, the use of dedicated portable imaging (ie, conventional radiographs, ultrasound) for PUIs and COVID-19 patients was prioritized. A designated computed tomography (CT) scanner, magnetic resonance imaging (MRI) scanner, and interventional suite were reserved for use in PUIs and COVID-19 patients and strict terminal cleaning protocols were instantiated. Based on input from infection control, a 30-minute vacant time before the next patient entering the room was reserved after cleaning, which allowed the air to clear and surfaces to dry.

2. Outpatient examinations performed at an inpatient facility. The aforementioned considerations applied to outpatients who needed a diagnostic or interventional procedure in a hospital-based facility (ie, only location available, specific equipment or expertise). In the early phase of the pandemic, there was an option to reschedule elective procedures, which transformed shortly thereafter, into a mandate to eliminate these. Automated phone and electronic messaging was implemented indicating the need for rescheduling based on the COVID-19 circumstance.

3. Outpatient facilities. Personnel stationed at the main entrance of every outpatient facility interacted with patients, screening them for relevant symptoms. If the patient screen was negative, they were checked in and proceeded for their examination. When 1 or more questions were answered positively, patients were instructed to return home and contact the institutional call center or to proceed to the emergency department if they were experiencing more severe symptoms (eg, shortness of breath, chest pain). Later, during the pandemic, temperature checks were performed in all patients and personnel before entering any of our facilities.

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**TABLE 1. Constituents of the Radiology Command Center**

| Role                                                                 | Notes                                                                 |
|----------------------------------------------------------------------|----------------------------------------------------------------------|
| Department Chair                                                     |                                                                      |
| Vice Chair, Clinical Operations                                      |                                                                      |
| Director of Quality                                                   |                                                                      |
| Department Administrator                                             |                                                                      |
| Operations Manager                                                    |                                                                      |
| Director of Radiology Education Programs                              |                                                                      |
| Vice Chair, Research                                                  |                                                                      |
| Chief Radiology Officer, [UT Southwestern] University Hospitals & Clinics | 1. Member of the Vascular and Interventional Radiology division       |
| Associate Chief Radiology Officer, [Parkland Health & Hospital System] | (1)                                                                 |
| Chief Radiology Officer, [Children’s Health System Texas]             |                                                                      |
| Pediatric Radiologist                                                 |                                                                      |
| Associate Chief, Neuroradiology                                      |                                                                      |
| Coordinator of Communications                                         |                                                                      |

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**STRATEGY TO DECREASE THE NUMBER OF ELECTIVE DIAGNOSTIC AND INTERVENTIONAL PROCEDURES**

Asymptomatic patients infected with COVID-19 can present a significant risk of transmission (up to 80%). Substantial reductions in the volume of elective studies and procedures, as emphasized by the American College of Radiology and based on recommendations from the Centers for Disease Control and Prevention (CDC) was pursued. A unilateral sorting of "elective" and "urgent" outpatient studies by radiologists may cause tension with ordering providers. Some inherent risks that are assumed with scheduling triage include: (1) potential delays in medical management, procedures, and interventions; (2) management errors; (3) increased patient morbidity; and (4) potential medicolegal implications. To help prioritize clinical operations, the following tactics were created:

- Team approach: A team-based approach, including administrators, schedulers, technologists, and physicians, was used to manage

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**FIGURE 1.** Organizational structure. The COVID-19 RadCC was created to focus on the development of tactics specific for radiology response to the pandemic, to ensure a high level of function, to serve as the resource for COVID-19-related communications to the department and to coordinate functions with the imaging service line as well as other clinical departments. Figure 1 can be viewed online in color at www.jcat.org.
the complex considerations. A coordinated triage effort between imaging and clinics, surgery and procedural services proved to link processes, increase efficiency, provide clarity, boost communication, and accelerate acceptance.

- Information technology expertise: We built customized reports, created system functionalities for generation of automatic notifications, and improved communication, as well as facilitated rescheduling efforts. For cases in which radiologists used their clinical expertise to defer imaging, we generated a standardized message in the EHR “InBox” functionality to alert providers about imaging studies being rescheduled, including instructions to reply and request those time-sensitive studies felt necessary to be maintained.

- Scheduling resources: Specialized schedulers embedded in different clinics worked directly with ordering providers to identify those imaging studies coupled to upcoming clinic visits versus those with lower time sensitivity for rescheduling.

- Effective communications: Carefully worded memos were crafted and disseminated through the faculty practice, listing the rationale for rescheduling, the process to be followed and offering an appeals process to ordering providers. At the time of this writing, a substantial reduction in outpatient imaging visits was achieved (~60% in aggregate) and proved to be most challenging for oncology patients.

- Prioritization of new imaging requests: As some outpatient clinics and telemedicine services continued to see patients during the pandemic, new imaging requests were anticipated. For requests placed by computerized provider order entry, a question was added that required the ordering provider to indicate medical necessity to prioritize scheduling of the imaging appointment within a shorter timeframe. Otherwise, studies were scheduled after a specified date, approximately 90 days after the onset of the pandemic in our region.

Rescheduling patients is a complex issue and influenced by the legitimate concerns of patients and providers about delays in care. However, other considerations intervene, and in our case, there was an evolution to near total outpatient imaging rescheduling, based on imperatives emanating from PPE shortages and consumption. Balancing the potential for jeopardizing urgent patient care and exacerbating the risk to health care professionals emerged as a priority.

RISK ASSESSMENT OF RADIOLOGY PERSONNEL

Early data from epidemiologic analysis of the epidemic in China illustrated a clear relationship between age and risk of death related to COVID-19. In addition to age, the CDC risk assessment includes comorbidities (Table 2). Accordingly, we distributed the radiology staff to minimize the risk of those who are more vulnerable.

Risk assessment of our faculty and trainees consisted of these elements: (1) recommendations provided by recognized sources; (eg, CDC; [1]); and (2) logical considerations based on the risk of those with whom the health care worker was living. To tabulate and incorporate risk into a reading site designation, a spreadsheet was generated based on identifiable data through employee demographics (age) and self-designated high-risk condition prompted by those listed by the CDC. The self-designation approach was implemented to preserve confidentiality.

RADIOLOGIST REDISTRIBUTION PLAN

Movement of radiology personnel across “shared” workstations is the norm in our radiology department. Picture Archiving and Communication Systems (PACS) reading stations rarely are committed to a specific radiologist. To limit movement and physical contact with devices, we pursued a redistribution of our clinical workforce based on designation of discrete workstations with the following principles:

- “Car-to-PACS, PACS-to-Car”: Here, we generalized the notion of “PACS” to include reconfigured work stations as will be described below. The rationale was to limit movement and in-person interactions. Noninterpretation work was reorganized into virtual constructs, such as computer-based, real-time video conferencing, and instruction.

- “One radiologist, one PACS”: Every radiologist was assigned a specific interpretation station. This minimized the risk of infection that could occur when equipment is shared and facilitated social distancing. Furthermore, wiping all surfaces using disinfectant wipes before and after each reading session was emphasized.

A priority list for at-home reading was created for each division based on risk category, the presence or absence of a risk factor in a cohabiting individual, the need for current or future child care, the status of at-home interpretation capability, the presence or absence of a leadership role, and the radiologist's preference.

To facilitate spacing and distancing, additional interpretation stations were created by repurposing physician’s offices and their standard personal computer (PC) into clinical reading areas. Office sites removed from patient areas were prioritized for reconfiguration. A small footprint PC (see Remote Interpretation below) was deployed with the department standard suite of imaging software. A nearby training room provided a source of these computers for repurposing, and these were rapidly reimaged with the standard software suite. The monitors in this same room where harvested to provide an ancillary workflow monitor in addition to the 4K monitors already existing in selected offices. At some locations, a limited number of fully configured PACS stations were moved to regional radiologist offices. Redistribution to office reading

| TABLE 2. CDC Risk Factors for COVID-19 Infection |
|-----------------------------------------------|
| People 65 years and older                     |
| People who live in a nursing home or long-term care facility |
| Serious medical condition:                   |
| • People with chronic lung disease or moderate to severe asthma |
| • People with serious heart conditions         |
| • Immunocompromised people, including those receiving cancer treatment |
| • People of any age with severe obesity (body mass index [BMI] >40) or certain underlying medical conditions, particularly if not well controlled, such as those with diabetes, renal failure, or liver disease |

People who are pregnant should be monitored since they are known to be at risk with severe viral illness, however, to date, data on COVID-19 has not shown increased risk.
plan was implemented across our 4 separate partner institutions. Those at higher risk from others (Fig. 2) and patients. The redistribution of working space to maximize distance between PACS stations. In this example, radiologists were assigned to locations without an "x" to maximize distance between them. Figure 2 can be viewed online in color at www.jcat.org.

locations allowed isolation and social distancing while remaining on the campus network without the variables of connectivity for remote or home reading.

The native computers in the faculty offices were relocated to the training room and reconnected to power and the network so that all displaced faculty could still access their systems through remote desktop functionality. This preserved access for continued scholarly and administrative pursuits beyond clinical activity.

After equipment redistribution, each radiologist was assigned to a specific location and instructed to use only that location (ie, 1 radiologist, 1 PACS). The traditional clinical assignments were maintained based on subspecialty expertise. The radiology dictation software could identify which workstation was actively being used by which radiologists. These real-time data were connected to a lookup table which identified the location and phone number for that workstation with the output delivered through a web-based data visualization tool (Power BI, Microsoft). This tool was used to facilitate contact with the radiologists, regardless of which hospital, office, or home station they were using.

Radiologists with patient contact, such as those performing interventions outside of the vascular and interventional radiology (VIR) team (eg, mammogram, musculoskeletal radiology, neuroradiology) or fluoroscopy, were assigned to workstations near their clinical activities. Seating arrangements were designated to maximize the space between different radiologists (“social distancing” at work) and isolate those at higher risk from others (Fig. 2) and patients. The redistribution plan was implemented across our 4 separate partner institutions.

REMOTE INTERPRETATION
Remote interpretation from home reduces occupational exposure risk. In considering this deployment, it is important to ensure adequate local coverage of clinical services (eg, contrast reactions). We also considered the optics of an entire diagnostic faculty practice reading from home while other frontline colleagues were bearing far greater risk. We elected to have a visible presence onsite to promote a sense of team collaboration and to boost community morale in the context of low risk relative to our frontline colleagues.

For remote interpretations we leveraged a preexisting, resource—a small-footprint computer (Intel NUC mini PC, Santa Clara, CA). These systems were uniformly configured with sufficient system resources to run the standard suite of office and radiology imaging applications (Fig. 3). The application suite includes the software for 2 different PACS systems, the EHR systems, and dictation capabilities.

A standard computer image for these systems was maintained by the informatics division, tested and updated routinely. To avoid home troubleshooting with performance degradation, users simply return their devices and swap their system for a current model. The returned system was cleaned, reimaged, and returned to the hot-swap pool. The medical school virtual private network (VPN) was used for connecting to the secure hospital networks.

This was adopted as the standard computing solution for physician offices and administrative support personnel. As mentioned above, preexisting on-hand NUC systems that had been used for a variety of training activities were quickly repurposed for clinical interpretation functionality, either remotely or onsite.

The capacity of the medical center’s VPN, essential for remote interpretations, emerged as a concern. The VPN access may be limited by bandwidth and/or number of licenses for concurrent connections. When the medical center moved over 1400 persons to work from home, a decline in global performance was attributed to bandwidth consumption; PACS software was identified as a dominant source. In response, we reduced the bandwidth need by adjusting display protocols to decrease the number of prior examinations automatically retrieved and by eliminating the automatic send function of source acquisitions (eg, spectral CT source data) from the modality to the PACS. These measures enabled high functionality for the entire remote workforce.

Remote reading was augmented in a stepwise fashion monitoring the VPN performance on a regular basis. Finally, encouraging radiologists to work in different shifts during the day and evening not only decreased the number of radiologists reading at

FIGURE 3. Standard configuration of a remote reading station. A small footprint computer that can be easily held in one hand is displayed at the center (arrow). A 4K monitor is used for image interpretation and an ancillary monitor provides additional functionality for workflow management. Figure 3 can be viewed online in color at www.jcat.org.
any given time but also helped address personal challenges that arose (eg, lack of childcare when schools closed).

**CLASSIFIED STAFF**

The administrative support of an academic radiology department is usually comprised of several offices, including accounting, grants and contracts, education, operations, faculty affairs, classified affairs, clinic support, clinical research, and staff in multiple research laboratories. Radiology command center planning followed our institutional definitions for classified staff (Table 3). Group 1 represented midlevel patient care and other laboratory animal-care providers. Expectations for group 1 personnel were to follow the COVID-19 requirements set by the CDC while on campus and continue business as usual. Groups 2, 3, and 4 required more planning, and efforts were made to facilitate these groups to work from home (Table 4).

**TRAINEES**

Daily virtual meetings addressed operational issues and continued routine education oversight, regulatory compliance, and morale in a time of disruption. We prioritized maintaining the integration of residents and fellows in the delivery of health care and implemented policies consistent with ACGME guidelines, including the health and wellness protections for trainees. Trainees in high-risk categories were identified and immediately removed from clinical service. First-year residents were redistributed within existing and newly converted office-space reading rooms in like manner with faculty applying the same “Car-to-PACS, PACS-to-Car” philosophy.

Residents in the postgraduate year (PGY) 3 to 5 were removed from daytime clinical rotations, and a large pool of call-eligible residents was created to cover the 3 tertiary care facilities allowing adequate time to rest and study between call duties. Further, the PGY 3 to 5 classes were divided into separate pools with stratification of junior- and senior-level experience. Three distinct call pools were created to cover the 3 hospitals. A policy of “one pool of residents—one hospital” was adopted to prevent mixing of trainees between institutions.

Remote NUC reading stations, previously deployed to the homes of all PGY 4 to 5 residents and configured in the manner described above, provided ample resources. Senior-level residents (PGY 5 level) were assigned call coverage exclusively from their home reading stations (no in-house duties). This preserved a pool of senior-level residents as a reserve team who could be redeployed in case exposure or infection adversely impacted clinical workloads while maintaining a degree of routine clinical quality interventional patient care while reducing staff exposure and unnecessary risks for those remaining on service.

A daytime pool of PGY 4 to 5 residents in between call shifts interpreted cases remotely and underwent a virtual “read-out” with assigned faculty, either on- or off-site. This plan assisted with daytime workloads while maintaining a degree of routine clinical education. Communication lines between faculty and trainees were established with resident contact information and location easily accessible on the Radiology Department website.

The PGY 2 residents remaining on daytime in-house services were assigned to be in reading rooms corresponding to the services they were on when the COVID-19 outbreak unfolded. Some residents were placed in clinical faculty offices that had been converted to reading stations. These private offices allowed for assignment of residents with special needs (eg, privacy for lactation). Plans were developed to have PGY 2 residents virtually rotate between services without changing PACS stations as described above. Faculty readouts were conducted “virtually” by telephonic communication.

Subspeciality fellows in the department operated on service at a junior faculty level and helped maintain daily operations while providing leadership and education to residents. The operating principles applied to resident safety were applied equally to fellows, identifying and protecting those in high-risk categories and eliminating unnecessary risks for those remaining on service.

**VASCULAR AND INTERVENTIONAL RADIOLOGY**

COVID-19 presents a unique challenge in providing a high-quality interventional patient care while reducing staff exposure and PPE utilization. Faculty, Advanced Practice Providers (APPs) and trainees were divided into 2 teams to cover the 2 major adult hospitals. Teams were segmented to specific hospital locations. Each hospital team was further divided into a frontline patient-facing team performing procedures and a non–patient-facing team taking care of consults, virtual clinic visits, rescheduling, and vascular image interpretation. The non–patient-facing team worked

| Group 1 | Individuals in Positions Essential to Continued Operations Who Must Perform Their Work on Campus (Eg, Inpatient Nursing, Animal Care) |
| Group 2 | Individuals in positions essential to continued operations but whose work can be performed remotely (eg, departmental administrator or financial analyst). Primary priority for remote and equipment access. |
| Group 3 | Individuals in positions that are not essential to continued medical center operations but can reasonably perform their essential work responsibilities remotely (eg, administrative associate). Secondary priority for remote and equipment access. |
| Group 4 | Individuals in positions that are not essential to continued medical center operations and cannot perform their work remotely. |
from the academic offices and was not exposed to the hospital environment. These teams rotated between the hospital and the academic offices every other day to reduce exposure. Nurses and technologists were assigned to work with one of the teams. Staff at higher risk or who had family members at higher risk were assigned to the non–patient-facing team. Substantial differences existed for inpatient and outpatient procedures:

- **Inpatients:** We converted all inpatient consults to teleconsults, and many were replaced by chart review. The provider who consented the patient performed the procedure to avoid multiple contacts. In general, trainees did not participate to avoid PPE utilization except in more complex cases requiring additional assistance. One team of nurses and a technologist was dedicated to a given patient throughout their VIRR visit. Specific rooms were designated for inpatient use only, and a negative-pressure room was reserved for patients who were suspected of or confirmed as having COVID-19 infection. Rounding after the procedure was performed remotely using teleconsults.

- **Outpatients:** These procedures were categorized into 3 groups: (1) procedures that were unable to be deferred; (2) procedures that could be deferred for 1 to 2 months; and (3) procedures that could be deferred for at least 2 months. This categorization was approved in consensus with representative referring physicians and hospital leadership. Patients were rescheduled after a discussion with the referent physician, and a note was placed in the patient’s EHR with a new procedure date. For procedures that could not be deferred, patients were screened using telemedicine. Screen-positive patients were tested for COVID-19 infection, and the procedure was deferred if infection was confirmed. The number of cases per day was reduced balancing the needs of PPE consumption with a reasonable rescheduling timeframe. Procedures requiring postprocedure admission were reduced and scheduled only twice a week to conserve hospital beds. Postprocedure visits were conducted using telemedicine.

**PEDIATRIC RADIOLOGY**

Preexisting at-home reading workstations for 24 pediatric radiologists allowed for immediate deployment of remote reading. Every day, 1 radiologist worked onsite at each of the hospital locations, available for emergent fluoroscopy procedures. All other interpretative work occurred remotely. A small pool of volunteer radiologists (approximately 25% of the diagnostic pediatric radiologists) were designated to rotate through the in-house coverage assignments. If substitutions were needed due to sickness or exposure, sufficient staff were available to rotate in.

In an attempt to decrease outpatient appointments for pediatric patients and consolidate the workforce, these tactics were employed: (1) postponement or rescheduling of examinations at outpatient facilities into tighter scheduling time blocks and fewer locations; (2) relocating urgent examinations to hospital locations; (3) rescheduling examinations performed under general anesthesia (mainly MRI examinations in young children) to reduce exposure risk during intubation.

Visitor restrictions were implemented with increasing restrictiveness in response to increasing community spread of COVID-19. At the time of this writing, visitation had been limited to 2 designated caregivers, 18 years or older, who were permitted during the patient’s entire stay and identified by use of an orange bracelet, to be worn at all times.

**RESEARCH**

Our decision to continue or suspend research activities followed institutional mandates. When possible, laboratories were closed and equipment turned off. Plans to maintain vital operations were, however, considered (eg, feeding animals, maintaining essential equipment). We allowed 1 member per laboratory to maintain such functions.

We adopted an early, aggressive approach that eliminated all research/academic time, allowing us to devote our clinical workforce to exclusively address clinical needs. Adjustments in academic time were made in the context of clinical volumes, institutional imperatives, governmental requirements and mandates, and the recommendations and requirements of grant sponsors. We anticipate a rebound of substantial clinical activity with expanded demand when the pandemic subsides, and hence, a delayed return to our pre–COVID-19 baseline activity levels.

**CONCLUSION**

The COVID-19 pandemic has broadly impacted radiology practices in the private sector, medical centers and academic institutions. Practice adjustments are needed to address these challenges and to prepare for future occurrences. Some of the solutions presented are unique to our circumstances, but it is our hope that some will be broadly applicable. It is our belief that radiology needs to be a visible part of the tactical responses to crises, such as this pandemic, and remain sensitive and receptive to the issues and concerns of providers at the front line of patient care. At the time of this writing, we are not inundated in the ways other regions have been and await to meet the challenges of an uncertain future. Undoubtedly, more lessons will derive from the occurrences that unfold and the experiences to be shared.

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