



Preparedness for the COVID-19 pandemic in a tertiary pediatric radiology department

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Introduction

The outbreak of the novel coronavirus disease of 2019 (COVID-19) has led to unprecedented challenges in health care systems worldwide. It was first described in Wuhan, China, in December 2019 and rapidly spread across the world. The Center for Systems Science and Engineering at Johns Hopkins University publishes international case numbers daily [1]. At the time of writing, many countries were in an exponential phase of spread, so numbers were expected to steeply rise further in the next weeks to months [1–3]. There is evidence that substantial undocumented infection and community transmission facilitate the rapid dissemination of the novel coronavirus [4]. In the following, we use the term COVID-19 regardless of the presence of clinical symptoms, even though this terminology is somewhat imprecise.

Radiology departments are at the crossroads of patient care. With high patient volumes, rapid patient throughput, a range from elective to high-urgency examinations, and often a mix of in- and outpatients, they face particular challenges in these unprecedented times. The Radiological Society of North America (RSNA) and its journal *Radiology* recently assembled a scientific expert panel on radiology department preparedness for COVID-19 and published their perspective [5]. The situation continues to evolve rapidly. Local, national and international rules and regulations vary widely and pediatric radiology departments are in a unique situation. Pediatric

patients generally tend to be less commonly affected and tend to have a less severe clinical course [6]. On the other hand, with children there is typically more patient interaction, a notable number of examinations require sedation, and children are usually accompanied by caregivers — all factors that need to be taken into account for patient, caregiver and staff protection during this pandemic. We therefore summarized our current experience in departmental preparedness for COVID-19 at a Canadian tertiary pediatric radiology department. We are aware that the situation is fluid and rapidly evolving on a daily basis. Recommendations valid today might become obsolete tomorrow, and new insights are bound to evolve in a short timeframe. Nevertheless, we consider it important to have a description and analysis of current processes as a basis for discussion for pediatric radiology departments at this point in time.

Departmental setting

The Department of Diagnostic Imaging of The Hospital for Sick Children (SickKids), located in Toronto, Canada, is an academic tertiary pediatric radiology department that embraces the entire spectrum of pediatric imaging, including general pediatric radiology (with specialized cardiac and musculoskeletal imaging), neuroradiology, interventional radiology, nuclear medicine and imaging-based research. The department consists of 30 staff radiologists. It has a large education program that includes approximately 20 fellows and 5–6 rotating residents. Front-line operational staff includes approximately 90 radiologic technologists and 30 registered nurses.

SickKids is a standalone children's hospital affiliated with the University of Toronto. It has approximately 300 inpatient beds and a very wide referral base, expanding across large parts of the province of Ontario and even the country in some situations. The Department of Diagnostic Imaging performs more than 140,000 examinations per year.

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General preparedness

Prior to the COVID-19 pandemic, the Department of Diagnostic Imaging had developed a high-level departmental emergency preparedness plan to ensure effective and timely response in the event of a disaster and to minimize risks to the health and safety of patients, families, staff and visitors. The plan includes up-to-date fan-out lists, provides clear instructions on what to do during an emergency and is easily accessible to staff even when computer systems are down. The departmental preparedness plan was used and adapted during the severe acute respiratory syndrome (SARS) outbreak in 2002–2003. Although SARS necessitated departmental preparedness, as well, there are notable differences to the COVID-19 pandemic, making the current situation novel and necessitating new preparedness strategies. Compared to COVID-19, SARS was characterized by an overall lower case number, more contained geographic distribution, and lower community transmission.

The departmental emergency preparedness plan is fully aligned with the hospital incident management system and serves as a standardized framework for dealing with a wide range of emergencies and disasters. We adapted this plan for the COVID-19 pandemic in terms of key operating principles that include but are not limited to having defined command structure; proactive risk management; streamlined, centralized and integrated communication pathways; clear roles and responsibilities; use of common terminology; defined action planning; and coordinated management of resources. Compared to preparedness for other disasters, such as natural disasters or infrastructure collapse, planning for a pandemic situation such as COVID-19 requires a much longer-term adaptation of processes. In the current preparedness planning for the COVID-19 pandemic, change management and people management are of paramount importance.

Preparedness in the pre-pandemic phase

In the pre-pandemic phase, as information on COVID-19 emerged initially from China and subsequently from other countries, preparations for a potential Canadian epidemic or global pandemic began in our department (Table 1). The current literature emphasizes social distancing to be an important factor in disease containment [7, 8]. As information on COVID-19 containment in China [9] and disease evolution in Italy [10] and other countries was becoming available, we continuously updated and adapted our processes for pandemic preparedness.

Departmental preparedness in the pre-pandemic phase was planned in coordination with the general hospital preparedness while taking into account the radiology-specific contexts. During the pre-pandemic phase, services in all areas and modalities continued as per regular schedule. All employees were

Table 1 Checklist of preparations in the pre-pandemic and pandemic alert phase

Measures of preparedness in the pre-pandemic and pandemic alert phase ^a
✓ Ensure ongoing compliance with mask fit testing requirements
✓ Ensure compliance with all mandatory staff training requirements
✓ Re-educate staff on proper infection control protocols and donning and doffing of personal protective equipment (PPE)
✓ Maintain appropriate stock of PPE and centralize distribution of departmental PPE supplies to prevent shortages
✓ Ensure proper placement and maintain hand hygiene stations
✓ Ensure that all fan-out lists are up-to-date and accessible to radiology leadership team
✓ Schedule and complete regular updates of the Radiology Emergency Preparedness Plan
✓ Ensure that downtime procedures are up-to-date and available to staff, and re-educate staff
✓ Build infrastructure for video-conferencing and remote interpretation of images
✓ Identify essential resources required to maintain delivery of services
✓ Establish a radiology incident management team (IMT) with clear roles and responsibilities
✓ Coordinate all pandemic planning activities with the hospital IMT
✓ Increase situational awareness and involve staff in the pandemic planning process
✓ Prepare for fully segregated isolation in collaboration with other programs
✓ Determine and prepare for radiology role in the screening and diagnosis of pandemic patients
✓ Create appropriate warning and room access control signage
✓ Define activities that will be maintained during the pandemic and activities that will have to be discontinued
✓ Establish a plan to manage staff absenteeism and to address service gaps
✓ Complete an accurate skill set inventory for all non-physician staff
✓ Identify opportunities for staff redeployment and designate back-ups for key roles
✓ Designate rooms for rapid isolation of suspected cases and specify process steps
✓ Determine standardized protocol for decontamination of equipment and imaging rooms
✓ Develop pandemic communication plan and build redundancy into communications
✓ Identify staff members that are particularly vulnerable to the pandemic

^aNote that this is an abbreviated list as an excerpt from our pandemic preparedness plan. Also note that parts were adapted as the situation evolved

encouraged to meet with occupational health to update their N-95 mask-fitting requirements and immunization records. Hand hygiene stations were properly placed and maintained. A skill-set inventory was created for all non-physician staff to allow for potential re-deployment to areas in need within (and potentially also outside) radiology. The infrastructure for virtual on-line conferencing was updated. Opportunities for

remote reporting were enhanced, and an increasing number of workstations for remote reporting were deployed. Signage was created for the different patient areas. Initially, this mostly pertained to patients and families with a recent travel history, but this was subsequently broadened as the situation evolved. Screening tools and alerts were implemented within the hospital electronic medical record (EMR) to provide centralized communication and information-sharing across distributed registration areas. Specific alerts were created to recommend the use of PPE for aerosol-generating procedures for patients who may have been exposed to COVID-19 or had had recent travels outside Canada.

Early response period in the pandemic phase

The World Health Organisation (WHO) declared the COVID-19 outbreak a pandemic on March 11, 2020 [11, 12]. As the global situation evolved into the pandemic period, our department followed a pandemic preparedness plan (Table 2). An inter-professional radiology incident management team (IMT) was established, consisting of physician leaders, operational leaders, senior managers including quality and technology leaders, and nursing leaders. Roles and responsibilities were assigned. Virtual huddles of the IMT via a videoconferencing system were established, twice daily on weekdays and once a day on the weekends. These IMT huddles aimed to augment situational awareness, to allow for a centralized decision-making and to establish a consistent communication to the entire team. The responsibilities of the Radiology IMT were aligned with the Hospital IMT.

In the following sections we discuss the processes we initialized in the current early pandemic phase. At the time of writing, the situation continued to evolve rapidly and we were still in the early phase. Many of the concepts outlined might become obsolete. A critical post hoc analysis will be necessary after the pandemic phase subsides.

Personal protective equipment (PPE)

As the COVID-19 pandemic continues to progress rapidly, shortages of personal protective equipment (PPE) are becoming a reality in many countries and geographic areas. In addition, our knowledge about the novel coronavirus continues to grow. Therefore, rules and regulations regarding PPE are bound to evolve further. They depend on local infection prevention and control guidelines and vary across institutions, regions and countries.

At the time of writing the PPE recommendations in our institution were as follows (Fig. 1):

Table 2 Checklist of preparedness in the pandemic phase

Measures of preparedness in the pandemic phase ^a
✓ Implement and monitor standardized screening of patients prior to examinations
✓ Implement and monitor standardized triaging and workflow process
✓ Use standardized protocol for decontamination of imaging rooms
✓ Ensure that all staff complete employee attestation document and retain a copy
✓ Operationalize team rotations and separate patient streams to reduce exposure
✓ Establish a team rotation system, where possible
✓ Organize daily radiology incident management team (IMT) meetings to manage resources and respond to the pandemic
✓ Implement pandemic communication plan and keep staff, patients and families informed
✓ Anticipate and address fear and anxiety, rumors and misinformation
✓ Limit all non-essential activities and personnel in the department including research and teaching of pre-licensure students
✓ Defer elective outpatient examinations; make decisions for deferral on a case-by-case basis in consultation with radiologist and referring physicians
✓ Ensure that patients requiring urgent imaging will not be impacted
✓ Aim to perform imaging at sites with less foot traffic and with fewer patients
✓ Eliminate or reduce the possibility for staff to work using the same work stations
✓ Wipe workstations, dictaphones and telephones before use
✓ Ensure the most judicious use of personal protective equipment (PPE) and infection control supplies
✓ Monitor inventory levels and order PPE and infection control supplies as required
✓ Store PPE in areas not available to public or in areas that can be monitored
✓ Apply a wide range of strategies to increase social distancing
✓ Perform an ongoing assessment of risks from the interaction of all potential hazards
✓ Take proactive steps to protect staff that are particularly vulnerable to pandemic
✓ Assess the need to enact downtime procedures
✓ Provide the ability for staff to work from home while balancing needs in the hospital
✓ Use video-conferencing for necessary meetings whenever feasible
✓ Show compassion and provide support to staff experiencing fatigue, burnout and distress
✓ Sharpen and maintain focus on patient, family and staff safety during pandemic
✓ Monitor evolving situation and rapidly respond to changing needs

^aNote that this is an abbreviated list as an excerpt from our pandemic preparedness plan. Also note that parts were adapted as the situation evolved

- During routine patient care for children without precautions only a surgical mask should be worn. Goggles or face shields and gowns and gloves are generally not necessary, unless required by a specific procedure.


















Aerosol Generating Medical Procedures (performed or anticipated)	Droplet/Contact Isolation	Routine Care	All Code Blues
	 +  or 		
 or 	 or 	 Unless required for Routine Practices	 or 
		 Unless required for Routine Practices and/or special procedures	

Fig. 1 Diagram shows current guidelines on use of personal protective equipment (PPE) at our institution. Please note that concepts are likely to evolve and vary depending on local and institutional regulations and availabilities. Column 1 recommends N-95 mask, goggles or face shield, and gown and gloves for aerosol-generating medical procedures. Column 2 demonstrates surgical face mask plus goggles or face shield, or

- A surgical mask should also be worn for interacting with other staff or caregivers, when an appropriate social distance (6 ft) cannot be maintained.
- For direct care of children under droplet/contact isolation, a surgical mask and goggles or a face shield (or a combined mask and face shield) should be worn. In addition, gowns and gloves should be worn.
- For select interventional radiology procedures of suspected or confirmed COVID-19 patients, an N-95 mask, goggles or face shield, gown and gloves should be worn.
- For aerosol-generating medical procedures, an N-95 mask, goggles or face shield, and gown and gloves should be worn.
- For all code blue situations, an N-95 mask, goggles or face shield, and gown and gloves should be worn.

These regulations are likely to evolve and are likely to differ across institutions, and therefore we strongly advise consultation of the respective current institutional guidelines.

The donning and doffing of PPE was re-trained at the beginning of the pandemic phase, and the hospital released an e-learning module on this, which became mandatory across the organization. Staff was encouraged to handle the masks with care and to minimize the amount of times masks are taken on and off. They were reminded that masks need to cover the nose fully and should not be hung around the neck and ears when taken off.

We established an inventory of PPE and started monitoring supply and usage. Staff was encouraged to bundle tasks where

a combination of mask and face shield, as well as gown and gloves as recommended for droplet/contact isolation. Column 3 shows surgical masks only as recommended for routine cases, unless specifically required otherwise. Column 4 recommends N-95 mask, goggles or face shield, and gown and gloves for all code blue situations

possible to preserve PPE. The number of staff requiring PPE was limited as far as possible (e.g., limiting the number of technologists to position patients).

In addition, solutions to potential shortages needed to be considered, including the use of one mask for several procedures, sterilization and reuse of PPE, and 3-D printing methods.

Examination rooms

Dedicated rooms are used for all imaging examinations or image-guided interventions in patients with confirmed COVID-19 and those with respiratory symptoms and suspected COVID-19 infection. Additional rooms were identified and designated to serve for rapid isolation for when cases were identified. These rapid isolation rooms allowed for a secondary screening to determine the next steps.

Concepts regarding room disinfection and turnover as well as equipment decontamination continue to evolve and depend on local infection prevention and control (IPAC) guidelines, which are likely to vary across institutions. Standardized protocols were developed, implemented and adapted according to the current evidence for decontaminating imaging rooms. Our room preparation processes are continuously adapted to our institutional IPAC guidelines. When feasible, portable imaging of patients with suspected COVID-19 is performed. The choice of modality used (e.g., CT vs. ultrasonography) depends on the specific situation, symptomatology and available resources.

In Interventional Radiology, the minimum number of people required for the procedure is allowed in the room. If possible, technologists control the angiography equipment from the control room. Access to the room is limited to one entrance only. All interventional team members have to adhere to donning and doffing at the entrance of the room. Personal radiation protection lead aprons have to be wiped with virucidal wipes containing 0.5% hydrogen peroxide after each procedure.

Imaging examinations and interventional procedures under general anesthesia or sedation

Because endotracheal intubation is an aerosol-generating medical procedure, special care needs to be taken. We made every effort to defer all elective, non-emergent and non-urgent examinations and interventions under general anesthesia. For people with pending COVID-19 testing results and urgent imaging or image-guided interventions under general anesthesia, test results are expedited. Induction for general anesthesia is to be performed in a designated contaminate area. Crying and coughing should be reduced with sedative premedication. All unnecessary room equipment should be removed; drawers and shelves should be closed and surfaces covered with a clean sheet. Traffic should be minimized. Appropriate signage should be displayed. Only necessary disposables should be taken out. A special tray should be used for placement of contaminated equipment, and a high-efficiency particulate air (HEPA) filter between the patient and the circuit should be used during mechanical ventilation.

A pre-intubation/pre-procedure time-out should be done to ascertain that the required equipment is present, that personnel is limited to only those who are clinically required, that in-and-out movement is minimized and that the correct PPE is donned.

Examinations or image-guided interventions should be completed expeditiously. A safety coach should be present before beginning the examination or image-guided intervention under general anesthesia or sedation to oversee actions and processes. This safety coach should remain outside the interventional/examination room. Safety coaches are individuals with special training in infection control and the correct use of PPE. In our department, two senior registered nurses are trained as safety coaches.

After the procedure, a post-intubation/post-procedure timeout should be done to verify that all soiled equipment and soiled medical supplies are properly disposed of. Non-disposable personal equipment such as lead aprons should be cleaned, e.g., with appropriate virucidal wipes containing hydrogen peroxide 0.5%, after each use.

Access to the department

There has been restricted access to the hospital since the beginning of the COVID-19 pandemic. Screeners at the hospital entrance triage whether access to the hospital is granted. Employees have had to fill in an electronic attestation form prior to coming into the hospital since March 16, 2020; this includes an attestation not to have respiratory symptoms including but not limited to cough, runny nose or fever, not to come to work with respiratory symptoms, to adhere to return-from-travel regulations (14-day self-quarantine) and to access information regarding COVID-19 on the website on a regular basis, among others. The list of symptoms was later adapted and broadened. The e-mailed confirmation of this attestation form has to be presented at the hospital entrance and employees are subsequently provided with special stickers to their hospital badges clearing them for access. Pre-licensure trainees (e.g., medical students) and volunteers were no longer allowed on-site at the time of this writing.

All patients, families and visitors have to present to special screening stations with glass windows. The number of caregivers accompanying patients is restricted to one (two in exceptional circumstances). Specialized medical equipment representatives are only allowed in clinical areas if required to deliver supplies for urgent medical care.

Care was taken to allow for enough distance in the waiting areas of the radiology department. This was facilitated by the deferral of elective outpatient examinations outlined above and would have otherwise been very challenging. All communal toys and books were removed and, where feasible, seating areas (benches, chairs) were separated by 6 ft (2 m) in waiting areas.

If outpatient examination numbers rise again in a continuing pandemic situation, different strategies might need to be discussed. Among these is the potential solution to have patients and their caregivers wait either in their cars in the parking garage (where feasible) or in a larger but more remote waiting area and to call them into the examination area only shortly before the examination is to commence to avoid waiting and reduce traffic in imaging areas.

Reduction in patient volumes — deferral of elective examinations

On March 15, 2020, the radiology leadership in consultation with hospital leadership decided that all outpatient elective, non-urgent and non-emergent examinations should be deferred. The overarching aim for this measure was to primarily reduce potential exposure for patients, their families and staff, and to create additional capacity for potential surges in patients with COVID-19. This created a considerable logistic challenge because the radiology department has a very large elective outpatient population and is one of the sole providers of sub-

specialized pediatric imaging in a large and very populated area.

Even though it was considered preferable by the Radiology IMT to have the referring provider (being the most responsible provider, usually a physician and occasionally a nurse practitioner) prioritize the examinations for potential deferral, this was considered not feasible because examination deferral was expected to start the very next day. Therefore, data from the electronic scheduling system were extracted and spreadsheets were created that included all elective outpatient examinations scheduled for the 3 weeks starting March 16, 2020, for each imaging modality. The spreadsheets were kept on a secure in-house server and contained the ordering information and medical record number for each examination. The excel spreadsheets were assigned to the radiology division head (body radiology, neuroradiology, interventional radiology, nuclear medicine). Radiologists reviewed the ordering information, available imaging and electronic patient charts to decide whether an elective outpatient examination could be deferred. A standardized approach was chosen for the decisions on examination deferral. A small group of radiologists decided on the deferrals in their area of subspecialty based on urgency. Electronic medical records and prior imaging studies were reviewed. Categories for non-deferral of diagnostic examinations and interventional procedures included cancer care, acute infection/sepsis risk, risk of obstruction, severe pain management, acute risk of progression from delay, immediate diagnostic necessity, prevention of major surgery, time-sensitive treatment sequence, promotion of immediate hospital discharge, and urgent vascular access. Deferred examinations to be reassessed in 3 weeks were specifically flagged. Four columns were created for the division heads (or radiologists designated by them) to fill in: who reviewed the order, comments, whether the examination should be deferred (yes/no), and whether the examination should be re-assessed in 3 weeks (yes/no). The last of these columns was designed to indicate elective outpatient examinations that should be re-booked with priority as soon as the

situation allowed for this. Another four columns were created for the radiology administrator contacting the family to indicate: who contacted, when the contact was made, who was spoken to, and comments. Four additional columns were made for the radiology administrator contacting the referring provider to show: who contacted, when the contact was made, who was spoken to, and whether a prioritized rebooking was requested. In addition, it was checked whether the radiologic examination was coordinated with any other in-house patient visits at SickKids. If so, the coordinating clinic was contacted, it was discussed whether to keep the booking, and the results were documented in the spreadsheet. In addition, referring providers were asked to provide lists of their most urgent patients and these lists were amalgamated with our spreadsheet to ensure timely examinations for more urgent indications. Table 3 gives an example of the column headers with fictional data for illustration. A sample of standardized communication with parents/caregivers is provided under supplementary material.

For the 3 weeks starting March 16, 2020, the elective outpatient examination requests were screened, labeled to be deferred and marked to be reassessed in 3 weeks for prioritized rebooking as follows:

- For **MRI**, 672 requests were screened, 581 (86%, 581/672) were labeled to be deferred and 178 of these (31%, 178/581) were marked to be reassessed in 3 weeks.
- For **CT**, 89 requests were screened, 58 (65%, 58/89) were labeled to be deferred and 29 of these (50%, 29/58) were marked to be reassessed in 3 weeks.
- For **ultrasonography**, 1,077 requests were screened, 598 (56%, 598/1,077) were labeled to be deferred and 23 of these (4%, 23/598) were marked to be reassessed in 3 weeks.
- For **interventional radiology**, 108 requests were screened, 63 (58%, 63/108) were labeled to be

Table 3 Example of the spreadsheet column headers for examination deferrals; examples are fictional for illustrative purposes only

To be filled in by the radiologist			
Who assessed?	Comments (including indication, urgency and last imaging if applicable)	To be deferred (yes/no)	To be reassessed in 3 weeks for preferential rebooking (yes/no)
Dr. A. B.	Juvenile pilocytic astrocytoma, long-term follow-up off therapy, last MRI 03/2019 stable, no new symptoms, low urgency	Yes	No
To be filled in by the radiology administrator contacting the family			
Who contacted?	Who was spoken to and how?	When was the contact made?	Comments
Administrator C.D.	Spoke to Mom on the phone	March 16, 2020, 9:15 am	Mom was agreeable to deferral
To be filled in by the administrator contacting the referring provider			
Who contacted?	Who was spoken to and how?	When was the contact made?	Prioritized rebooking necessary
Administrator E.F.	Spoke to Dr. Y.Z. on the phone	March 16, 2020, 10:10 am	No

deferred and 8 of these (13%, 8/63) were marked to be reassessed in 3 weeks.

- For **nuclear medicine**, 125 requests were screened, 77 (62%, 77/125) were labeled to be deferred and 23 of these (30%, 23/77) were marked to be reassessed in 3 weeks.
- For **fluoroscopic gastrointestinal or genitourinary examinations**, 59 requests were screened, 27 (46%, 27/59) were labeled to be deferred and none was marked to be reassessed in 3 weeks.

Please note that these numbers only reflect *elective outpatient* imaging requests with low urgency for the 3 weeks starting March 16, 2020. Inpatient examinations, examinations referred by the Emergency Department and all urgent outpatient examinations were performed as before, so the actual number of examinations was markedly higher.

For radiographic examinations, the schedule did not explicitly change. These are usually performed on a short-term notice without long-term advance scheduling. As the COVID-19 pandemic evolved, the stream of walk-in patients with external orders for outpatient imaging and the requests for non-urgent radiographic examinations largely subsided as outpatient clinics were canceled and parents and caregivers were reluctant to come to the hospital.

Starting at the beginning of the second week (March 23, 2020), we created a process to have the referring providers decide on whether to defer an elective outpatient examination for all examinations scheduled for the 4 weeks starting on April 6, 2020. Figure 2 outlines the process. Almost 5,000 examination requests have been screened with over 600 referring providers. It will be important to monitor this process closely in the weeks to come. As the situation continues to evolve very dynamically, the time horizon of the deferrals and rebookings needs to be continuously monitored and adapted in a rolling plan.

The rapid deployment of manual-entry dependent processes outside the hospital’s EMR is susceptible to human error and communication gaps. To mitigate the risk of an appointment being overlooked, a custom program was built in Python to merge spreadsheets containing (1) radiologist prioritization, (2) provider phone calls and emails, and (3) patient/family confirmations, with EMR extracts containing (4) previously scheduled appointments, (5) newly deferred appointments and (6) unexpected patient/family no shows because of COVID-19 travel concerns. This daily reconciliation program further integrated ambulatory clinic cancellations to provide a master list, ensuring that all appointments scheduled during COVID-19 were accounted for, and rescheduled in a timely manner.

DI COVID Deferral Provide Review Process – External Provider

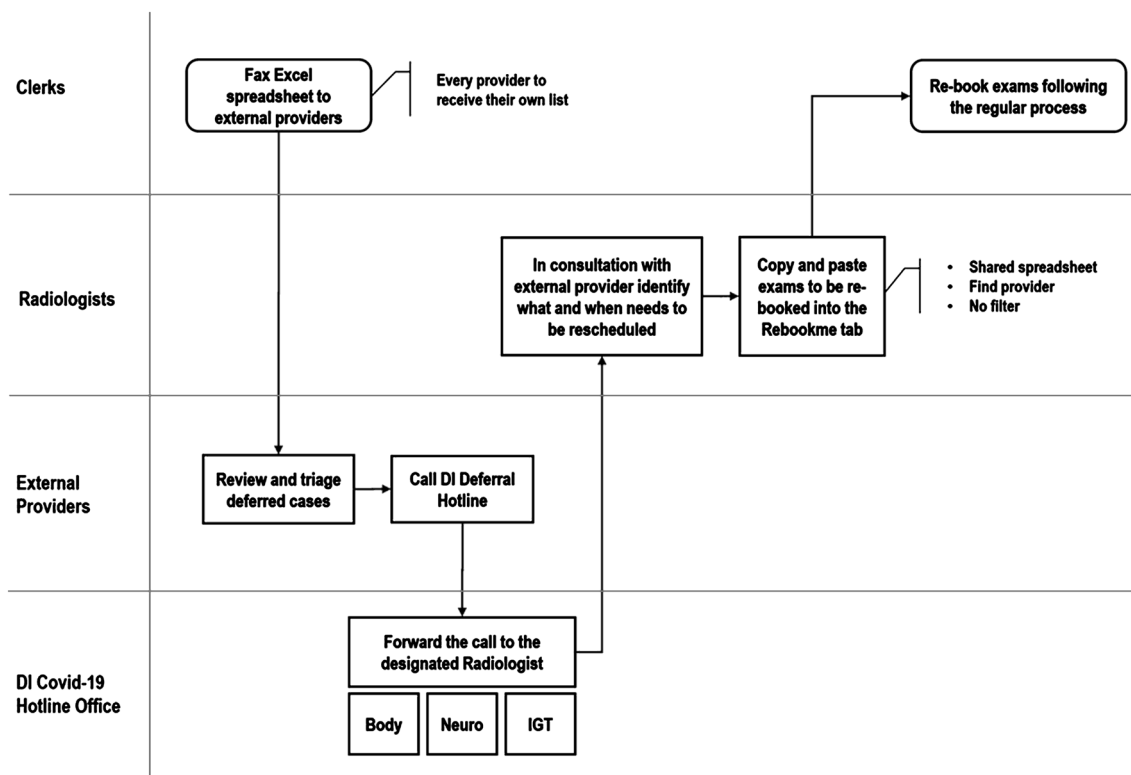


Fig. 2 Flow chart of the process for deferral of elective outpatient examinations in consultation with the referring provider. *DI* diagnostic imaging, *IGT* image-guided therapy

Multi-team rostering approach

As the number of COVID-19 cases continued to escalate both locally and worldwide, we decided that further measures were needed to brace for the impact of potential further surges in infections [1], so we initiated a multi-team rostering approach. The overarching aims of this multi-team approach were to: (1) prevent contamination and spread of the virus, (2) allow for social distancing and (3) have a backup team in case of sick leaves or quarantines.

The teams were formed within each subspecialty area (e.g., neuroradiology, body radiology, interventional radiology and nuclear medicine) and there were no overlaps between the two teams. Each team was rostered to work for 1 week and be away from the hospital practicing social distancing and self-quarantine at home during the other week, with alternating schedules. Radiology teams consist of staff radiologists and radiology fellows and cover day-service and on-call services for the given week. Teams not in-house were asked to stay at home, practice social distancing, provide remote image reading, administrative help and academic work, and be available to be called into the hospital within 30 min, if the situation required it. It was also decided to protect especially vulnerable staff members while maintaining a high level of confidentiality. Staff with pre-existing conditions or immunosuppression and those who are more vulnerable because of their age were enabled for home reporting. They were removed from direct patient/caregiver contact. The roster was created for 2 weeks at a time; the multi-team approach will be continued if the situation continues to evolve.

Radiology residents usually rotate through various sites in Toronto to gain a wide spectrum of experience. In the current pandemic situation, rotations were halted. Each site now has a fixed team of residents covering weekday nights and weekends. Daytime resident coverage was paused because it was not considered an essential service.

Other frontline staff was distributed into multi-team models where possible. The following guiding principles were considered to review and adapt staffing models based on personnel, equipment and patient streams. Personnel considerations included shift length, frequency, team size and other personnel considerations (age, co-morbidities, dependants requiring care, recent travel, and illness/symptoms/rate of absenteeism). Because the majority of frontline staff is compensated on an hourly pay model, care was taken to balance work hours. Implementation varied by department. In some areas, teams moved to 10- or 12-h shifts, reducing their onsite presence to 4 or 3 days a week, respectively. Where appropriate, staff members were redeployed into support or administrative work rotations that could be completed in a non-patient-facing or work-from-home capacity. Staff members are expected to be available to be called into clinical duty within 30 min if the situation requires it (sick leaves or quarantines). Equipment and modality room considerations were intended to minimize exposure among patients and were based on cleaning

protocols (process and turnaround times), volumes of cases, potential downtime and location (i.e. portable vs. fixed rooms). Where possible, patient streams are considered to rotate staff and protect vulnerable staff performing imaging on patients.

As the pandemic situation started to evolve around the time of March school break in Ontario, numerous employees were returning from travel. Provincial regulations regarding self-isolation initially exempted health care workers, but eventually all employees with an international travel history within the last 14 days had to be in home self-isolation for 14 days following the date of their return to Canada. This rule was also retrospectively applied. A notable portion of employees therefore had to be sent home to self-quarantine and the schedules and rosters had to be accommodated accordingly.

Reading room preparation

The reading situation needed to be adapted to allow for social distancing. Everyone was encouraged to use the same workstation throughout a shift and, where feasible, for the rest of the week. Wherever possible, fellows are deployed to separate reading rooms. If more than one fellow needs to read in one large reading room, care is taken that adequate distancing is possible (at least 6 ft/2 m). As outlined, residents are only providing weekday night and weekend coverage and have separate reading rooms. Staff radiologists are mostly using individual work stations in offices. Options for home reporting have been expanded. Depending on the subspecialty and service, home reporting for on-call situations had already been in place. This was further expanded in the pre-pandemic planning phase. For home reporting, full workstations with medical-grade imaging monitors are used in a three-monitor configuration, identical to the in-hospital workstations. The workstations are connected to the hospital's picture archiving and communications system (PACS), Radiology Information System (RIS) and EMR system via a virtual private network (VPN). Departmental networking resources had already been managed separately from the hospital-wide resources before the COVID-19 pandemic and could be rapidly expanded.

Hand disinfectant and disinfecting virucidal wipes containing 0.5% hydrogen peroxide were distributed to all reading rooms. Everyone was instructed to thoroughly wipe the workstation (keyboard and mouse), dictaphone and phone with a virucidal wipe prior to use and to use only one given workstation and phone throughout the shift and if possible throughout the week.

Staff and fellows are encouraged to read out over the phone, with both sitting in separate rooms at workstations and going over the cases on the phone. The fellow then creates the initial report in the radiology information system, and the report is reviewed and signed electronically by the radiology staff. Access to the reading rooms is limited. Within the firewalls of our hospital, consultations and clinical conferences are

performed using Microsoft Teams, which allows for the sharing of PACS screens. The hospital also quickly moved to virtual clinics via the province-wide Ontario Telemedicine Network.

Communication

The current pandemic situation creates a high degree of uncertainty among employees, trainees, patients and their families. Communication needs to find a fine balance between informing, supporting and encouraging on the one hand, and not overwhelming with information on the other. Ideally, the information should be timely and clear, top-down and consistently from the same source. However, in this unprecedented and highly dynamic situation, information changes rapidly. What holds true one day might not be relevant the next. This needs to be acknowledged and openly dealt with. Provincial return to travel policies, for example, rapidly changed in Ontario, and communication to employees necessarily had to be updated in rapid succession. It will be important to regularly communicate and update the information and policies for the weeks to come. Fear and anxiety, rumors and misinformation need to be anticipated and addressed. Care must be taken to ensure that communication is as consistent as possible.

Communication for clinical rounds has also rapidly changed with the need for social distancing and tight limits of people in one room. Clinical rounds are now held electronically. It is important to follow data protection guidelines for protected health information, which may vary among provinces, states and countries. At SickKids, an institution-wide license allows us to use secure Microsoft Teams for discussing patient information at clinical case conferences and multidisciplinary rounds (e.g., neonatal intensive care unit rounds, oncology rounds); these have been successfully conducted from within the hospital or via VPN connection from home.

Teaching rounds have been continued using a wider variety of web conferencing solutions with videoconferencing options and shared screens. It is important to remember that these teaching rounds should not contain any protected health information.

Last but not least, communicating a sincere thank you to the teams regularly is important as we all struggle together to get through this unprecedented situation. Daily leadership walk-arounds were instituted in the department to support and boost morale. These leadership walk-arounds are also conducted on the weekends and care is taken to maintain social distance.

During this pandemic situation, staff and trainees may experience stress, fatigue and challenges regarding self-isolation, provision of additional clinical services, exam postponements, or child care in the face of the school closings. Several resources are available to provide support for staff, physicians and trainees through the hospital, university and medical association such as the wellness office and physician health program.

Looking ahead to recovery and mitigation

While we are all desperately waiting for the post-pandemic time, this period will bring specific challenges, and preparing for these challenges is of utmost importance (Table 4).

One of the major challenges will be to catch up with the large number of elective outpatient examinations that were deferred. Waiting lists are already long, especially for examinations under general anesthesia, and extra shifts will become necessary to make up for the deferred examinations. Plans need to be developed and implemented to prioritize and address this backlog of examinations. Currently, we are operating on a rolling plan, in which deferred elective examinations are continuously reassessed for prioritized re-booking. Deferred elective examinations that need to be reassessed after 3 weeks are specially flagged.

It will be crucially important to develop a process to rebook the deferred appointments without any patient being lost to follow-up. This process will need to be continuously monitored.

Teams should be recognized and rewarded for their exemplary performance and dedication during challenging times.

In addition, a post hoc analysis of our response and processes during the pandemic should be performed and lessons learned should be documented. The pandemic preparedness plan should be updated and adapted as required because it is uncertain when another pandemic may arise.

Conclusion

We are in a highly dynamic situation that is bound to evolve further. Our processes outlined here are expected to develop

Table 4 Checklist for the post-pandemic phase

Measures of preparedness in the post-pandemic phase ^a
✓ Ramp up activities and services in all modalities to appropriate levels
✓ Assess and address radiology inventory needs related to equipment and supplies
✓ Rebook canceled or deferred appointments due to pandemic
✓ Initiate communication and consultations with referring physicians as required
✓ Develop and implement plans to prioritize and address the backlog
✓ Conduct post hoc analysis of the pandemic response and document lessons learned
✓ Improve processes and update pandemic plans as required
✓ Initiate strategic planning for innovative models of diagnostic imaging operations
✓ Recognize and reward teams

^a Note that this is an abbreviated list as an excerpt from our pandemic preparedness plan

and change. New processes are likely to become necessary. We provided a snapshot and analysis of our status quo situation at the time of writing and of the changes we implemented thus far. The literature suggests that swift measures are vital in containing the pandemic spread [2, 4, 9–12] and radiology departments play a major role in this.

We need to monitor the situation continuously and to react and adapt to the changes around us rapidly. In all the uncertainty, we need to stay focused, alert and informed and need to stand together and united to master this unprecedented challenge.

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Compliance with ethical standards

Conflicts of interest None

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