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Original Research

Impact of COVID-19 on Breast Imaging Practice Operations and Recovery Efforts: A North American Study

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Abstract

Objective: To assess the impact of the COVID-19 pandemic on breast imaging facilities' operations and recovery efforts across North America.

Methods: A survey on breast imaging facilities' operations and strategies for recovery during the COVID-19 pandemic was distributed to the membership of the Society of Breast Imaging and National Consortium of Breast Centers from June 4, 2020, to July 14, 2020. A descriptive summary of responses was performed. Comparisons were made between demographic variables of respondents and questions of interest using a Pearson chi-square test.

Results: There were 473 survey respondents (response rate of 13%). The majority of respondents (70%; 332/473) reported 80%–100% breast imaging volume reduction, with 94% (447/473) reporting postponement of screening mammography. The majority of respondents (97%; 457/473) continued to perform biopsies. There were regional differences in safety measures taken for staff ($P = 0.004$), with practices in the West more likely reporting no changes in the work environment compared to other regions. The most common changes to patients' experience included spacing out of furniture in waiting rooms (94%; 445/473), limiting visitors (91%; 430/473), and spacing out appointments (83%). A significantly higher proportion of practices in the Northeast (95%; 104/109) initiated patient scheduling changes compared to other regions ($P = 0.004$).

Conclusion: COVID-19 had an acute impact on breast imaging facilities. Although common national operational patterns emerged, geographic variability was notable in particular in recovery efforts. These findings may inform future best practices for delivering breast imaging care amid the ongoing and geographically shifting COVID-19 pandemic.

Key words: COVID-19; breast imaging; recovery; operations; screening; diagnostic breast imaging.

Key Messages

- COVID-19 acutely impacted breast imaging across North America with the majority experiencing 80%–100% overall decreases in volume and postponement of screening mammography in 95% of practices despite geographic variance in disease burden.
- Diagnostic imaging, biopsies, and preoperative localizations were variably impacted based on urgency and level of suspicion, with statistically significant geographic variability observed between regions in their approach to delaying diagnostic imaging and procedures.
- Geographic differences were noted with respect to safety measures taken to increase physical distancing for staff and patients, both of which were more commonly reported in the Northeast.

Introduction

The coronavirus disease (COVID-19) pandemic was first reported in the United States in Washington state in February 2020 and spread rapidly across the country with geographically heterogeneous impact (1,2). In an effort to both limit infection rates and in anticipation of a large-scale COVID-19 health care burden, a federal state of emergency and an array of state orders were issued, halting elective and nonurgent medical care (3). Subsequently, the Society of Breast Imaging (SBI), the American College of Radiology, and the American Society of Breast Surgeons issued official statements on March 26, 2020, recommending the postponement of all breast screening examinations as well as routine and nonurgent breast visits (4).

Radiology practices across the country faced drastic decreases in imaging volume (5) and altered their practice patterns to keep patients and staff safe. Breast imaging was particularly vulnerable to these effects (6,7) for two main reasons: (1) screening mammography—the foundation of breast imaging—is considered part of routine health care maintenance and, as such, may be more amenable to delays during a crisis, and (2) breast imaging involves close face-to-face contact among patients, technologists, and radiologists, posing a challenge for executing safe practices, especially when also faced with a national shortage of personal protective equipment (PPE).

After a precipitous drop in imaging volume and changes to breast imaging workflow in the spring of 2020, strides were made in curtailing the COVID-19 surge, particularly in the northeastern United States (1). Stay-at-home orders began to lift, and phased reopening strategies were executed across the country. In May 2020, the SBI released guidance on a safe return to providing breast imaging care (8), and in July 2020 the American College of Radiology published recommendations for the cautious recovery and resumption of all types of imaging practices (9). However, the logistics of safely resuming routine imaging care were left up to individual practices.

Breast imaging practices have been challenged with revamping their established pre-pandemic imaging workflows to meet both the evolving safety and regulatory requirements as well as the backlog of delayed breast imaging studies. This mission is made more difficult by new patient barriers to screening such as the fear of COVID-19 exposure and financial hardships due to unemployment and loss of insurance (5).

Given rapid policy changes amid unprecedented circumstances, current literature on the impact of COVID-19 on breast imaging practices is limited to single institution experiences and expert opinion (10–13). With the resurgence of COVID-19 cases in the Southern and Western United States in the summer of 2020 (1), followed by disease surges across the country in the fall of 2020, it has become increasingly clear that the pandemic will have long-lasting effects on breast imaging. The aim of this study was to assess the impact of the COVID-19 pandemic on the operations of breast imaging facilities across the United States during the initial six months of the pandemic—in particular, how these facilities managed and recovered from record low imaging volumes and what strategies have been implemented to keep patients and staff safe amid an ongoing pandemic. Results of this survey study may provide guidance and inform recommendations for ways in which breast imaging facilities may resume operations and respond if COVID-19 requires additional restrictions on breast imaging practices in the future.

Methods

This study received a waiver from the Institutional Review Board. A cross-sectional survey was designed to assess the impact of the COVID-19 pandemic on the operation of breast imaging facilities during the pandemic as well as policies and practices that emerged during the recovery phase. The survey consisted of 21 multiple-choice questions with a limited number allowing for multiple answers as well as free response answer choices (Supplementary Material). The survey was developed jointly by the Patient Care and Delivery Committee from the SBI and the National Consortium of Breast Centers (NCBC). The survey questions were written in collaboration with 10 fellowship-trained breast radiologists. Prior to implementation, the survey was piloted at 10 breast imaging practices to elicit feedback regarding question clarity and overall survey design. Changes to the question length, wording, and organization were incorporated based on this pilot testing.

The survey was created in SurveyMonkey (SurveyMonkey, Inc, San Mateo, CA) and distributed by e-mail to the 3594 members of the SBI and NCBC. The survey was open from June 4, 2020 to July 14, 2020. An initial e-mail and two

subsequent e-mail reminders were sent to encourage participation. Completion of the survey was optional, and participants received no compensation. Questions could be skipped, and partial surveys could be submitted.

Survey responses were summarized descriptively using the SurveyMonkey software. Analysis was performed via Excel for Mac (version 16.39; Microsoft Corporation, Redmond, WA) and JMP Pro (version 15; SAS Institute, Cary, NC). Comparisons were made between the demographic variables of respondents (eg, practice type and region) and the survey questions of interest using a Pearson chi-square test.

Results

In total, 473 surveys were completed by 400 SBI members and 73 NCBC members. The overall response rate was 13% (473/3594). Response rate from SBI members was 18% (400/2219), and response rate from NCBC members was 5% (73/1375). Eight of the respondents practice in Canada; the remaining 465 respondents practice in 48 of the 50 states, with only Alaska and Hawaii not represented. The highest proportion of respondents were from the following states: California at 9% (41/473), Florida at 7% (33/473), New York at 6% (31/473), and Texas at 6% (27/473).

The majority of respondents were radiologists (83%; 393/473), and practice groups were primarily private practice (42%; 201/473), academic (28%; 133/473), or a community practice affiliated with academic medical center (20%; 92/473). Table 1 summarizes the respondent demographics and practice characteristics.

Table 1. Respondent and Breast Imaging Practice Characteristics

	N (473)	%
Specialty		
Radiologist	393	83%
Technologist	33	7%
Administrator	22	5%
Other	25	5%
Practice type		
Private	201	42%
Academic	133	28%
Academic/private hybrid	92	20%
Multispecialty medical group radiology practice	41	9%
Military/Veterans Affairs	3	0.6%
Teleradiology	1	0.2%
Did not respond	2	0.4%
Country		
United States	459	97%
Canada	6	1%
Did not respond	8	2%
Region[a]		
South	150	32%
Northeast	109	23%
Midwest	106	23%
West	93	20%
Did not respond	8	2%

[a]Canadian respondents not included. Geographic classification according to the U.S. Census Bureau (https://www2.census.gov/geo/pdfs/maps-data/maps/reference/us_regdiv.pdf).

Reduction of Imaging Volume

The vast majority (80%; 381/473) of respondents fell under a stay-at-home order during the COVID-19 pandemic. Half of breast imaging facilities (53%; 251/473) closed one or more of their imaging sites at one point, while 37% (177/473) dedicated specific sites either to particular types of examinations or populations (Table 2). Only one respondent reported no decrease in breast imaging volume, while 70% (332/473) saw an 80%–100% peak reduction of their pre-COVID-19 breast imaging volume.

The majority of respondents reported that all screening exams were postponed as follows: 94% (447/473) reported postponement of screening mammography, 65% (309/473) reported postponement of screening ultrasound, and 65% (307/473) reported postponement of screening MRI (Table 2). No geographic differences were seen regarding the decision to postpone screening mammography (Table 3).

Respondents also reported postponement of certain diagnostic exams and image-guided interventions (Table 2). The most commonly postponed diagnostic exam was short-term interval follow-up studies for Breast Imaging Reporting and Data System (BI-RADS) (14) final assessment 3–probably benign at 50% (239/473). The majority of respondents reported that their facilities continued to perform biopsies (97%; 457/473), with variable rescheduling based on degree of suspicion. Similarly, the majority of facilities continued to perform breast localizations (87%; 411/473), with more facilities reporting delay in localizations for high-risk lesions (28%; 132/473) compared to malignancies (13%; 62/473).

Statistically significant geographic variability was observed between regions in their approach to delay in diagnostic breast imaging and procedures (Table 3). Delay in diagnostic breast imaging was less likely to be reported in the West ($P < 0.001$) compared to the other regions, with no respondents from the West reporting a delay in diagnostic MRIs and only 3% (3/93) reporting delay in biopsy for BI-RADS 4A lesions. Similarly, a statistically significant regional difference in reporting delays in preoperative localization procedures for malignancy ($P < 0.001$) and high-risk lesions ($P = 0.003$) was noted, with a higher proportion of malignancy localizations delayed in the Northeast (24%; 26/109) and a lower proportion of high-risk lesions delayed in the West (17%; 16/93).

Practice type variance was also noted, with academic practices significantly more likely than private practices to

Table 2. Operation of Breast Imaging Facilities During the Initial Stages of the COVID-19 Pandemic

	***N* (473)**	**%**
Did you fall under a stay-at-home order?		
Yes	381	81%
No	91	19%
Did not respond	1	0.2%
Did all of your sites stay open?		
No	251	53%
Yes	196	41%
N/A (single site)	25	5%
Did not respond	1	0.2%
Did certain sites become dedicated to a particular exam or population?		
No	237	50%
Yes	177	37%
N/A (single site)	57	12%
Did not respond	2	0.4%
What was the most your breast imaging volume decreased?		
100%	19	4.0%
80%	313	66%
60%	102	22%
40%	22	5%
20%	12	2%
No decrease in volume	1	0.2%
Did not respond	4	1%
Did your practice postpone any of the following?		
Screening mammography	447	94%
Diagnostic mammography-symptomatic	32	7%
Diagnostic mammography-screening callback	103	22%
Diagnostic-BI-RADS 3	239	50%
Biopsies-BI-RADS 4A	76	16%
Biopsies-BI-RADS 4B, 4C, 5	16	3%
Screening Ultrasound	309	65%
Screening MRI	307	65%
Diagnostic MRI	35	7%
Localization for cancer	62	13%
Localization for high-risk lesions	132	28%
Nothing was postponed	19	4%
How long do you anticipate screening to be postponed?		
Never postponed	27	6%
Less than 1 month	66	14%
1 month	71	15%
2 months	230	49%
3 or more months	75	16%
Did not respond	4	1%
How did trainee participation change? (check all that apply)		
Not applicable (no trainees)	225	48%
Reduce and/or eliminate on service	156	33%
Trainees work remotely from attending	66	14%
Reduce and/or eliminate direct patient contact	51	11%
Trainees redeployed	54	11%
Other	33	7%
No change	23	5%

Abbreviation: COVID-19, coronavirus disease.

postpone screening mammography (97%; 218/225 vs 91%; 182/201, $P = 0.010$), diagnostic workup for screening callbacks (26%; 58/225 vs 16%; 32/201, $P = 0.009$), BI-RADS 4A biopsies (20%; 45/225 vs 12%; 24/201, $P = 0.034$), and localizations for high-risk lesions (34%; 76/225 vs 21%; 42/201, $P = 0.003$) (Table 4).

Table 3. Regional Differences in Survey Responses

	NE (*N* = 109)	S (*N* = 150)	MW (*N* = 106)	W (*N* = 93)	*P*-value
Postponement of exams/procedures					
Screening mammography	99%	94%	93%	94%	0.076
Screening ultrasound	77%	64%	63%	57%	**0.016**
Screening MRI	71%	60%	75%	57%	**0.015**
Diagnostic mammography—screening callback	28%	22%	22%	12%	**0.042**
Diagnostic mammography—symptoms	5%	8%	8%	4%	0.445
Diagnostic MRI	12%	7%	9%	0%	**<0.001**
BI-RADS 4A biopsies	20%	20%	17%	3%	**<0.001**
Localizations for cancer	24%	9%	16%	4%	**<0.001**
Localizations for high-risk lesions	39%	25%	33%	17%	**0.003**
Longest screening mammography postponement (≥3 months)	28%	7%	16%	13%	**0.003**
Scheduling changes					
No scheduling changes	5%	18%	12%	17%	**0.004**
Space out appointments	92%	76%	87%	78%	**0.003**
Extend hours of service	46%	35%	30%	32%	0.075
Minimize physical registration forms in favor of electronic registration	50%	31%	32%	28%	**0.002**
Physical distancing					
No changes in physical distancing of technologists	31%	49%	35%	49%	**0.004**
Fewer technologists working at one time	50%	31%	44%	30%	**0.004**
Spacing out technologist workstations	36%	23%	27%	25%	0.153
No changes in physical distancing of radiologists	28%	41%	35%	51%	**0.004**
Fewer radiologists working at one time	38%	30%	31%	22%	0.097
Increase remote working for radiologists	24%	19%	19%	11%	0.101
Increasing remote reading options					
Spacing out radiologist workstations	33%	15%	21%	16%	**0.005**
Increase use of technology to communicate with patients	30%	23%	22%	12%	**0.014**
Use of personal protective equipment					
Surgical masks, face shields, goggles	95%	93%	94%	97%	0.666
Gowns	72%	46%	48%	53%	**0.004**
N95 masks	48%	36%	37%	30%	0.070
Trainee changes					
Reduce/eliminate trainee patient contact	20%	5%	15%	3%	**<0.001**
Trainees working remotely from attendings	22%	9%	18%	4%	**<0.001**
Trainees redeployed to other clinical services	28%	6%	9%	4%	**<0.001**

P-values in bold are statistically significant.
Abbreviations: MW, Midwest; NE, Northeast; S, South; W, West.

Safety Measures Taken

Changes in the work environment to improve physical distancing of radiologists and technologists in an effort to minimize COVID-19 spread were reported by 63% (296/473) and 59% (278/473) of respondents, respectively (Table 5). Regional differences were noted with respect to physical distancing measures taken for radiologists (P = 0.004) and technologists (P = 0.004), with practices in the West more likely to report no changes to physical distancing for breast radiologists (51%; 47/93) compared to other regions, and practices in the West (49%; 46/93) and South (49%; 74/150) significantly more likely to report no changes to physical distancing for technologists (Table 3). Respondents from private practices were

Table 4. Differences in Responses between Academic and Private Practice

	Academic[a] (*N* = 225)	Private (*N* = 201)	*P*-value
Postponement of exams/procedures			
Screening mammography	97%	91%	**0.010**
Screening ultrasound	66%	63%	0.512
Screening MRI	68%	59%	0.059
Diagnostic mammography—screening callback	26%	16%	**0.009**
Diagnostic mammography—symptoms	7%	7%	0.903
Diagnostic MRI	8%	7%	0.685
BI-RADS 4A biopsies	20%	12%	**0.034**
Localizations for cancer	16%	10%	0.063
Localizations for high-risk lesions	34%	21%	**0.003**
Longest screening mammography postponement (≥3 months)	17%	14%	0.371
Scheduling changes			
No scheduling changes	9%	18%	**0.009**
Space out appointments	86%	80%	0.091
Extend hours of service	39%	30%	0.056
Minimize physical registration forms in favor of electronic registration	36%	35%	0.884
Physical distancing			
No changes in physical distancing of technologists	38%	46%	0.115
Fewer technologists working at one time	36%	36%	0.553
Spacing out technologist workstations	33%	21%	**0.008**
No changes in physical distancing of radiologists	22%	51%	**<0.001**
Fewer radiologists working at one time	42%	19%	**<0.001**
Increase remote working for radiologists	24%	14%	**0.012**
Spacing our radiologist workstations	38%	5%	**<0.001**
Increasing remote reading options	24%	14%	**0.012**
Increased technology use to communicate with patients	29%	16%	**0.002**
Use of personal protective equipment			
Surgical masks, face shields, goggles	95%	95%	0.949
Gowns	57%	48%	0.061
N95 masks	36%	39%	0.615

P-values in bold are statistically significant.
[a]Combination of academic and academic/private hybrid.

significantly ($P < 0.001$) more likely to report no changes in physical distancing of radiologists (51%; 102/201) compared to respondents from academic practices (22%; 50/225) (Table 4).

Physical Distancing of Technologists

Common interventions that were reported to increase physical distancing of technologists included decreasing the number of technologists working at one time (38%; 180/473) and spacing out workstations (28%; 133/473). "Other" methods of physically distancing technologists were reported by 7% (31/473) of the respondents, and associated free text comments included assigning the same technologist to one machine or procedure room for the whole day, staggering working hours, and staggering lunch hours.

Physical Distancing of Radiologists

Common interventions that were reported to increase physical distancing of radiologists included decreasing the number of radiologists working at one time (31%; 147/473), limiting physician–patient contact (23%; 108/473), increasing use of technology to communicate with staff and patients (22%; 106/473), spacing out workstations (21%; 100/473), and increasing remote reading options (19%; 91/473). Increased use of academic, conference, or administrative time from home on a temporary basis was reported by 25% (120/473) of respondents. "Other" methods of physically distancing radiologists were reported by 7% (35/473) of respondents, and associated free text comments included remote multidisciplinary conferences and tumor boards, installation of Plexiglas between workstations, and increasing hours of operations. Three respondents reported forced or strongly encouraged use of vacation days for radiologists, and two described furlough of part of the department resulting in fewer radiologists on site.

Physical Distancing of Patients

Reported scheduling interventions to increase physical distancing of patients included spacing out appointments (83%; 394/473) and extending hours of service (35%;

Table 5. Practice Patterns During Recovery

Staff and the work environment	***N* (473)**	**%**
What changes were made to improve physical distancing of breast radiologists? (check all that apply)		
No change	177	37%
Fewer radiologists working at one time	147	31%
Temporarily increased utilization of conference, administrative, or academic time to work from home	120	25%
Limiting patient contact	108	23%
Increased use of technology to communicate with patients/staff	106	22%
Creating additional spaces and/or spacing out workstations	100	21%
Increasing remote reading options	91	19%
Other	35	7%
What changes were made to improve physical distancing of technologists? (check all that apply)		
No change	195	41%
Fewer technologists working at one time	180	38%
Creating additional spaces and/or spacing out workstations	133	28%
Other	31	7%
What personal protective equipment is available to staff? (check all that apply)		
Surgical masks	447	94%
Gloves	440	93%
Wipes	418	88%
Face shield	296	63%
Gowns	256	54%
Goggles	192	41%
N95 masks as needed and/or requested	179	38%
N95 masks—only for contact with suspected or confirmed COVID-19 patients	93	20%
None of the above	0	0%
Other	15	3%
Patient scheduling, COVID-19 screening, and imaging		
What changes are you making to your scheduling process to minimize COVID-19 spread? (check all that apply)		
Space out appointments so fewer patients are present at one time	394	83%
Extend hours of service on weekdays and weekends	166	35%
No changes	61	13%
Other (please specify)	20	4%
What changes are you making to your waiting rooms/check-in process to minimize COVID-19 spread? (check all that apply)		
Space out seating arrangements in the waiting rooms	445	94%
Limit visitors accompanying patients	430	91%
Minimize waiting rooms—patients check in remotely and are called when it is time to enter exam room	201	42%
Minimize physical registration forms in favor of electronic registration	166	35%
Other (please specify)	20	4%
No changes	2	0.4%
What changes are you making to your changing rooms/service protocols to minimize COVID-19 spread? (check all that apply)		
More frequent cleaning and sanitization of facility and equipment	412	87%
Eliminate changing rooms and have patients change in the procedure rooms	163	34%
Limiting what and/or how much patients can bring into the facility	72	15%
No changes	42	9%
Eliminate reusable gowns	26	6%
Other (please specify)	26	6%

Table 5. Continued

Patient scheduling, COVID-19 screening, and imaging		
How will your practice screen patients scheduled for an imaging appointment for symptoms of COVID-19? (check all that apply)		
On-site screening for symptoms, travel history, and/or contacts	434	92%
Protective mask requirement	428	90%
On-site temperature check	345	73%
Pre-visit phone screening for symptoms, travel history, and/or contacts	334	71%
Chart review	28	6%
Blood test (either PCR or serology)	27	6%
Other (please specify)	11	2%
If patients do not pass the prescreening or in-person screening for COVID, or are known COVID-positive, what is done?		
They are not admitted into the clinic and are rescheduled once asymptomatic, confirmed COVID negative, or completed a home quarantine (with the exception of urgent cases such as an abscess drainage)	387	82%
Rescheduling is recommended, but it is not required and these patients are still seen at that time if they insist, with additional precautions taken	61	13%
Patients are still seen for their breast imaging visit with additional PPE measures taken	11	2%
Patients are still seen for their breast imaging visit and no additional PPE measures are taken	2	<1%
Other (please specify)	8	2%
Did not respond	4	1%
Will your protocol regarding same-day reads for screening patients change in the next few months due to COVID-19 (or has it changed already)?		
No change (will remain the same as your pre-COVID-19 protocol)	369	78%
Decrease same day reads	52	11%
Increase same day reads	37	8%
Did not respond	15	3%
Will your protocol regarding same-day biopsy add-ons for diagnostic patients change in the next few months due to COVID-19 (or has it changed already)?		
No change (will remain the same as your pre-COVID-19 protocol)	327	69%
Increase same-day biopsy add-ons	88	19%
Decrease same-day biopsy add-ons	46	10%
Did not respond	12	2%

Abbreviations: COVID-19, coronavirus disease; PCR, Polymerase chain reaction; PPE, personal protective equipment.

166/473). Additional interventions to increase physical distancing included spacing out seating arrangements in the waiting rooms (94%; 445/473), limiting the number of accompanying visitors (91%; 430/473), minimizing waiting rooms by remote patient check-in (42%; 201/473), remote registration (35%; 166/473), and eliminating dedicated changing rooms (34%; 163/473). Regional differences in reporting changes to patient scheduling were seen ($P = 0.004$), with a lower proportion of respondents from the Northeast (5%; 5/109) reporting no changes to the scheduling process compared to the Midwest (12%; 13/106), the West (17%; 16/93), and the South (18%; 22/150) (Table 3).

A minority of respondents reported adoption of new same-day imaging protocols, including an increase in biopsies (19%; 88/473) and same-day reads of screening examinations (8%; 37/473). Conversely, some facilities reported actually decreasing same-day interpretation of screening studies (11%; 52/473) and add-on biopsies (10%; 46/473).

Personal Protective Equipment

Nearly all respondents reported the availability of surgical masks (94%; 447/473), gloves (93%; 440/473), and wipes (88%; 418/473). A minority of respondents reported access to N95 masks: 38% (179/473) reported availability only for use during contact with suspected or confirmed COVID-19 cases, and 20% (93/473) reported availability upon request. Almost all respondents (90%; 428/473) reported that their facilities require patients to wear masks. No statistical difference was seen among the four geographic regions regarding available surgical masks, gloves, face shields, and goggles (Table 3).

COVID-19 Pre-appointment Screening

Most respondents reported their facilities perform pre-visit phone screening (71%; 334/473) and also on-site screening (92%; 434/473) for symptoms, travel history, and contact with COVID-19 confirmed individuals. The majority reported on-site temperature checks (73%; 345/473). A small number of respondents (6%; 27/473) reported negative

polymerase chain reaction (PCR) serology testing as an essential component of pre-appointment screening.

Treating COVID-19 Patients

The majority of respondents (82%; 387/473) reported that their facilities currently do not permit into the facility patients who are COVID-19 positive or who do not pass the prescreening for COVID-19, unless these patients present for an urgent exam such as an abscess drainage. A minority reported that these patients would still be seen as follows: rescheduling would be recommended but not required (13%; 61/473), patients would be seen but with additional PPE measures (2%; 11/473), patients would be seen without any additional precautions (0.4%%; 2/473). No regional differences were seen regarding treating COVID-19 confirmed or suspected patients ($P = 0.832$).

Trainee Education

Of the 52% of facilities associated with a medical school, residency, or fellowship program, the majority reported either an elimination or reduction of the number of trainees on service (63%; 156/248), and a minority reported no change in educational operations (9%; 23/248). Major changes in trainee participation included increased remote working (27%; 66/248), redeployment or volunteering in other clinical areas (22%; 54/248), and reduction in patient contact (21%; 51/248). Thirty-three respondents (7%) reported "other" educational practice changes, and common free text responses included remote read-outs using screen sharing, eliminating trainees performing procedures due to inability to maintain social distancing, and providing remote academic work specifically for trainees who were pregnant or who were deemed immunocompromised.

The impact of COVID-19 on trainee education varied geographically (Table 3). For example, reporting of reduction or prevention of trainees from direct patient contact ($P < 0.001$) and remote trainee work was significantly ($P < 0.001$) higher among Northeast respondents. Similarly, a significantly higher proportion of respondents from the Northeast (28%; 31/109) reported redeployment of their radiology trainees to other clinical services compared to any other geographic region (Midwest 9%; 10/106, South 6%; 9/150, West 4%; 4/93, $P < 0.001$).

Discussion

Our survey demonstrated the acute impact of COVID-19 on breast imaging across the United States and Canada within the first six months of the pandemic in North America, with the majority of facilities experiencing 80%–100% volume decreases, more than half closing down operations in at least one site, and postponement of screening examinations at 94% (447/473) of the practices despite geographic variance in disease burden and stay-at-home orders.

Diagnostic imaging and procedures were variably impacted based on urgency and level of suspicion. Short-term follow-up examinations (BI-RADS 3) and biopsies of BI-RADS category 4A lesions were most commonly postponed, consistent with cancer care expert recommendations to triage breast patients during COVID-19 pandemic and delay follow-up of probably benign (BI-RADS 3) lesions and postpone the biopsy of low likelihood of malignancy (BI-RADS 4A) lesions until "after the end of the pandemic" (15). However, at the time of publication of these recommendations in April of 2020, the prolonged duration of the pandemic with several secondary waves may not have been anticipated. As such, the clinical implications of delaying follow-up or diagnosis even of low likelihood of malignancy lesions for nearly the length of a screening interval may prove to be more significant.

Similarly, postponement of preoperative breast localization procedures paralleled the recommendations from the American Society of Breast Surgeons of patient prioritization based on urgency of care (15), with deferment of surgical excision of high-risk lesions (reported at 28%; 132/473 of facilities) and breast cancers (reported at 13%; 62/473 of facilities). Evidence of no difference in survival with or without surgery within the first three years for patients with hormone receptor positive breast cancer on tamoxifen (16,17) allowed for justified delays in breast surgery for this patient population. This shift in the breast cancer treatment algorithm observed across the United States during the COVID-19 pandemic may provide further insight into the longitudinal validity of the above studies; however, conflicting data are currently emerging (18,19).

The significant delays in both screening and diagnostic breast imaging exams should be carefully considered in both the way breast imaging practices recover and in defining "recovery" itself. The consequence of deferment of thousands of breast imaging examinations is not simply a decrease in volume that needs to be resumed, but also a potential public health crisis with 10 000 additional breast cancer deaths projected to stem from delays in the United States alone (20–22). Therefore, practice recovery efforts ought to address both operational challenges and strategies to diminish the likely downstream effects of months-long delays in breast imaging (23).

Although breast imaging experienced the most significant reduction in patient volume during the 2020 COVID-19 pandemic, other breast care services such as breast surgery and genetic counseling were also significantly impacted (24). Therefore, recovery of operations and efforts to mitigate the impact of delayed breast care should be undertaken in a multidisciplinary fashion (25). For instance, increasing the use of non-wire localization to queue patients for surgery may alleviate the bottleneck of preoperative surgical patients and thus reduce further delays in treatment during what is likely to be a prolonged recovery phase. The full clinical implications of delayed cancer diagnosis and its impact on staging, prognosis, and mortality will not be appreciated for years to come; however, understanding the depth and breadth of the pandemic's impact on breast imaging care will help inform breast care strategies during the current and any future health care crises.

Once stay-at-home orders began to lift and cautious ramp-up of breast imaging was recommended by medical

societies (9), breast imaging facilities were faced with the challenge of resuming routine and nonurgent examinations within a framework of patient and employee safety. Other than sheltering in place, the two primary methods of minimizing spread of COVID-19 are PPE and physical distancing (26). It is notable that the vast majority of survey respondents reported access to surgical masks (94%; 447/473), but only 38% (173/473) reported access to N95 masks as requested, and 20% (93/473) reported availability of N95 masks only when caring for COVID-19 positive or suspected patients. These results may reflect either limited supply of N95 masks or preservation of these masks for potential future disease surges.

With respect to physical distancing, although common national patterns emerged, geographic variability was vast. Respondents from practices in the West were significantly more likely to report that no physical distancing measures were implemented for their staff. On the other hand, the highest reported implementation of physical distancing practices came from the Northeast, including physical distancing of staff and scheduling changes to decrease the number of patients and staff on-site at one time. The geographic variability is not surprising given regional differences in disease burden and state mandates at the time of survey responses. At the time the survey was administered, the Northeast (New York in particular) had faced the worst COVID-19 outbreak in the country (1). However, geographic patterns of COVID-19 are shifting, and future surges are anticipated (1). There is an opportunity for other geographic areas to learn from regions hit hardest and earliest and to implement more effective and safe approaches to providing breast imaging care.

The most commonly reported actions taken to physically distance staff included decreasing the numbers of the breast imaging team members working at one time and increasing spacing between workstations. Significant changes to scheduling were noted in an effort to increase physical distancing with an increase in the spacing of appointments and increased hours of breast imaging facilities' operations. Sustaining such physical distancing practices during a return to pre-COVID-19 capacity—while the threat of COVID-19 exposure is yet to be curtailed—will be challenging. In fact, approximately 40% of respondents reported no changes in their practice to increase physical distancing of either technologists or radiologists. Overall, private practices were less likely to implement changes to physically distance staff compared to academic practices. Lack of physical distancing efforts by a large number of practices may be due to limited spacing or operational costs related to extending or changing work hours. Physical distancing recommendations are likely to last many months to years and are a vital factor in planning for recovery (25). Finding more creative and semipermanent ways to maximize physical distancing are needed. Staggered radiologist and technologist work hours may improve job flexibility and result in increased staff satisfaction and well-being, as was described by Katzen et al (27). Such solutions would require investment in additional staff, a financial proposition not available to many breast imaging facilities at present (28) but which should be considered in budgeting for the upcoming fiscal year.

Not surprisingly, leveraging of technology to allow for connectivity while maintaining physical distancing was a common thread among all aspects of recovery. Technology was used to communicate among staff as well as between staff and patients, with some respondents even noting successful use of "low-tech" walkie-talkies. Physical forms gave way to electronic registration, allowing for the flexibility of a remote check-in process—a practice that may decrease appointment wait times and increase patient satisfaction. Remote learning by trainees, virtual tumor boards, and virtual read-out sessions allowed for continued education and multidisciplinary collaborations and may have promoted work–life balance by allowing radiologists to read from home. This transition to a more virtual mode of health care delivery, while sometimes fraught with technical barriers, is likely here to stay. Embracing the added value that a virtual health care platform with remote and flexible work capabilities provides may ultimately lead to a more advantageous position for our field with increased patient satisfaction, ease of creating and attending educational forums, increased cross-institutional collaboration, and increased gender diversity and career satisfaction. However, careful evaluation of which aspects of breast imaging provision of care and education benefit most from virtual platforms, rather than indiscriminate replacement, is warranted.

A significant impact on the educational environment was experienced, with 63% (156/248) of respondents who work with trainees reporting the elimination or reduction of trainees on service and 21% (51/248) reporting steps taken to reduce trainee–patient contact. Although medical education was affected across all levels of training and specialties, resident exposure to breast imaging is usually limited to approximately 12 weeks over the course of four years of residency as per the Accreditation Council for Graduate Medical Education minimal requirement (29). Therefore, missing several weeks may represent up to 25% of a resident's overall breast imaging experience. This consideration should guide future radiology residency rotation scheduling and inform our approach and commitment to breast imaging education once trainees are back on service. Additional concern may be raised with regard to the breast imaging fellow class of 2020, as these new attendings had diminished breast imaging volume and patient interaction experience. Mentoring, vigilant mammography auditing, and provision of extra financial support for virtual breast imaging review courses may be considered to support this new group of attendings. Further studies on the long-term effects this educational interruption may have had on trainee education and choice of breast imaging as a subspecialty may be warranted.

Limitations of this study include the possibility that multiple respondents were from the same facility, thus skewing the results. The data are also self-reported and not verified by facility volume reports. As is typical for professional society surveys, the response rate was relatively low; however, the responses were reflective of diverse geographic regions

and practice types (30,31). Additionally, the timing of the survey during the height of the COVID-19 pandemic, which has significantly impacted radiologists' employment and work environment, may have contributed to the lower rate of response. The lower NCBC response rate may in part be related to overlap in membership with the SBI. The study is also limited by the cross-sectional nature of a survey. However, it is precisely its snapshot nature that allows us to assess current recovery approaches of breast imaging facilities across the United States in near-real time in the face of rapidly evolving guidelines and disease burden.

Conclusion

This North American survey study demonstrates the acute impact of COVID-19 on breast imaging facilities, which is likely to result not just in workflow difficulties as practices begin to recover, but in significant public health implications. Although common national patterns emerged regarding widespread reduction in imaging volume, significant geographic variability was noted regarding safely ramping up operations. Implementation of physical distancing of staff and patients was overall greatest in the Northeast, where early COVID-19 hotspots occurred. These patterns for delivering safe and effective breast imaging care may inform future recommendations and breast imaging facilities amid an ongoing pandemic. Some of the lessons learned—such as leveraging technology to improve patient care and trainee education—may have a long-lasting impact on healthcare delivery in a post-COVID-19 world.

Supplementary Material

Supplementary material is available at the *Journal of Breast Imaging* online.

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Conflict of Interest

None declared.

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