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Wait List Strategies for CT and MRI Scans

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Key Messages

- There are various potential causes of long wait times for CT and MRI scans, and conducting a situation-specific assessment of available resources and potential cause(s) of wait times may help to identify appropriate strategies for their management.
- Identified principles for developing a plan to address wait times include engaging stakeholders, taking a coordinated approach to develop short- and long-term plans, ensuring plans are flexible to account for changes in technologies, and developing a plan for quality monitoring and assessment of specified outcomes.
- Identified strategies for reducing wait times for CT and/or MRI scans include increasing capacity, improving efficiencies, reducing low-value scans, improving communication, and adopting new technology.

Context

CT and MRI scans are used for multiple clinical indications (e.g., cardiac, inflammatory, respiratory, and oncology) and play a key role in treating patients.[1,2] In Canada, an estimated 5.41 million CT scans and 2.33 million MRI scans are conducted each year.[1,2] Concerns have been raised regarding wait times for scans, particularly with anticipated growing demand.[1,2]

Before the COVID-19 pandemic, patients in Canada waited an average of 50 to 82 days (7.1 to 11.7 weeks) for a CT scan, and up to 89 days (12.7 weeks) for an MRI scan.[3] These wait times are longer than the recommended 30 days for semiurgent patients; recommended wait times for urgent and emergent patients are within 7 days and 24 hours, respectively.[1,4] Wait times grew due to the pandemic because nonurgent imaging services were postponed. In a poll of 1,049 adults living in Canada that was conducted in early 2022, 53% of respondents stated that wait times for diagnostic imaging had worsened since the pandemic, and 90% supported the federal government making new investments in medical imaging to reduce wait times.[3] A survey of medical practitioners reported that, in 2022, patients in Canada could expect to wait a median of 5.4 weeks for a CT scan and 10.6 weeks for an MRI scan, with variation between provinces; some provinces reported a median of 7 to 8 weeks for a CT exam and 12 to 20 weeks for an MRI exam.[5] While these estimated wait times are comparable to prepandemic wait times at a national level, they are still longer than recommended. They may also indicate that some provinces are experiencing longer wait times for an MRI exam compared to prepandemic wait times.

In addition to the impact of the COVID-19 pandemic, long wait times can result from a range of causes, including:[1,4,6-9]

- increased demand
- staffing issues
- lack of equipment or older and less efficient equipment
- funding issues (e.g., with a set level of funding, there may be a limited number of exams that can be performed)
- performing low-value exams.

Long wait times for a CT or an MRI scan may lead to adverse outcomes for patients. While waiting for a scan, patients may become anxious or their illness may worsen, including

becoming more difficult to treat. Thus, enacting strategies intended to reduce wait times may help to improve patient outcomes and reduce the burden on health care systems.

Objective

The purpose of this report is to provide a summary of strategies aimed at addressing wait lists for CT and MRI scans.

Methods

This report summarizes information from wait list strategies presented in frameworks, action plans, recommendations, and research studies and reviews related to addressing wait times for CT and MRI scans.

Literature Search Methods

A limited literature search was conducted by an information specialist on key resources, including MEDLINE, the Cochrane Database of Systematic Reviews, the international HTA database, the websites of Canadian and major international health technology agencies, as well as a focused internet search. The search strategy comprised both controlled vocabulary, such as the National Library of Medicine's MeSH (Medical Subject Headings), and keywords. The main search concepts were wait lists, diagnostic imaging, CTs, and MRIs. Comments, editorials, and letters were excluded. The search was also limited to English-language documents published between January 1, 2017, and November 9, 2022.

Results

A total of 91 publications were identified and included in this report. Among the Canadian publications, some were from pan-Canadian groups or were relevant to Canada in general[3,8,10-18]; others were action plans, initiatives, or studies from specific provinces, including British Columbia,[19-21] Alberta,[6,22] Saskatchewan,[23,24] Manitoba,[25,26] Ontario,[27-38] Quebec,[39] Prince Edward Island,[16] Newfoundland,[40] Nova Scotia,[41,42] New Brunswick,[43] and Yukon.[44] Publications were also identified from Australia,[45,46] China,[47,48] the European Union,[49] France,[50,51] India,[52] Ireland,[53] Israel,[54,55] the Netherlands,[56] New Zealand,[57-60] Norway,[61] Saudi Arabia,[62] Singapore,[63] South Korea,[64] Sweden,[65] Taiwan,[66] the UK,[67-81] and the US.[82-97]

The following section is a high-level summary of some of the commonly reported themes and strategies from the included publications. Additional details regarding the included publications are available in Appendix 1 on frameworks (Table 2), Canadian implementation plans and recommendations (Table 3), international implementation plans and recommendations (Table 4), and strategies to address wait times (Table 5).

Developing a Plan to Address Wait Times

There are various potential causes of long wait times, and specific causes may differ between countries, jurisdictions, and facilities. Consequently, it is unlikely that a single solution will apply for every situation.[9] A local assessment of health system needs may help guide the choice of strategies used to help reduce wait lists. Some factors to assess may include:[14,15,19,22,45,58,68-70,82]

- current demand (including if there is a backlog) and wait times as well as projected demand
- available resources (e.g., equipment, staffing, funding) and their use (e.g., if a scanner is not being used during evenings and/or weekends)
- if protocols can be optimized (e.g., workflow, imaging, image processing)
- if low-value scans are being ordered (i.e., scans that are not considered best practice).

Some suggested principles when developing a plan to address wait times included:[6,10-12,16,26,45,49,54,57,68-70]

- use a coordinated approach (e.g., provincial, national) to develop short-term and sustainable long-term plans, including assessments of relevant and clearly defined outcomes, which may include
  - specified performance targets (e.g., number of scans, wait times)
  - workforce planning (e.g., to achieve desired staffing levels and lower vacancies, particularly in positions that are experiencing shortages and/or high levels of burnout)
  - how to decide when a new scanner should be purchased and/or when equipment should be replaced (e.g., what factors need to be assessed to determine need, expected required resources)
- assign a dedicated task force (e.g., an independent organization with an advisory committee) to oversee the plan
- adopt a multidisciplinary approach with stakeholders, including clinicians
- ensure initial and sustained investment in the plan
- have systems that are flexible and adaptable over time (to account for changes in technology)
- consider if strategies require additional supports (e.g., for technological interventions, may need improved internet connectivity, secure data sharing systems; for artificial intelligence [AI] and/or machine learning, may need to develop frameworks to regulate their use).

Strategies to Reduce Wait Times

A variety of strategies were identified that could assist with alleviating wait times for a CT or MRI scan; a summary of some types of strategies and examples is presented in Table 1. Common themes across Canadian and international publications included increasing scan capacity, improving efficiency, reducing low-value scans, improving communication, and implementing new technologies. New technologies, such as AI, may be applied at various stages in the scanning process, including referral, scheduling, scanning, and processing. Strategies related to health human resources were also identified, including developing workforce and training plans (particularly for positions with staff shortages), and assigning dedicated staff to assist with various processes.

Based on the publications identified for this report, most strategies were found in both Canadian and international settings. Strategies that were not found in Canadian publications but were reported in international research studies or recommendation reports included:

- outsourcing scans to the private sector
- adding a new staff position dedicated to coordinating the workflow (e.g., check protocol, assess patients for allergies or other concerns)
- reserving capacity at a hospital's scanner for emergency scans
- procuring dedicated adult and pediatric scanners
- reducing use of sedation or anesthesia for pediatric MRI scans
- avoiding duplicate exams (e.g., imaging when patient's health has not changed; it may be appropriate in some cases to extend time intervals between repeat exams).

It should be noted that some of these strategies, although not captured in the literature, are known to be used in Canada.

Table 1: Summary of Strategies to Reduce Wait Times for CT and MRI Scans

Type of strategy	Examples
Increase scan capacity	• If demand warrants, purchasing more scanners, especially newer, more efficient machines and/or mobile units[3,12,25,72] • Increasing scanner use (e.g., expanding working hours to include weekday evenings and/or weekends, having a cancellation list)[26,41,43,54,72,85] • Increasing number of staff (e.g., training and education opportunities, increasing salaries)[3,22,45,54,57,68,69,72,85] • Outsourcing scans to the private sector; this may require a plan to determine a pricing model[57,59,65,68] • Provide financial incentives to the insurer for reduced wait times[54] • Assessed in research: using research scanners for clinical scans when appropriate[36]
Process improvements: referral and scheduling	• Standardize exam referral forms (e.g., electronic order systems that require specific fields to be filled before they can be submitted) and triage processes (e.g., a clear classification system for patient urgency)[6,17,22,26,59,67,84,97] • Using a central intake system or coordinated referral pathway,[23,26,30,40] which may also include incorporating cross-zone booking between different facilities or regions to allow facilities with constraints to collaborate with nearby centres with capacity[15,22,71] • Booking similar patients together (e.g., similar examinations)[14,15,59] • Streamlining the check-in process (e.g., by text or phone call)[19] • Providing additional navigation and/or support services related to intake[26] • Having a designated staff to oversee and manage triaging, prioritizing[27,82,96] • Implementing technology (e.g., for schedule optimization, identifying which imaging facility has the fastest turnaround time for the specific patient's needs)[15,20,52,66,82,87,95] • Adjusting amount of time allocated per appointment (e.g., if time needed was overestimated, reduce accordingly)[28] • Reserving capacity for emergency patients[47]

Type of strategy	Examples
Optimizing time needed for scanning and processing	Various stages in the process can be shortened (without compromising diagnostic yield): • door-to-scan time (e.g., providing patients with information before their appointment, streamlined or rapid pathways [e.g., not requiring contrast agent, patients who meet defined criteria do not require a full prescan review])[14,15,29,32,51,74,77,78,82,92,93] • time spent in scanner (e.g., remove unnecessary sequences, optimize parameters, rapid acquisition protocols)[8,14,72,83,90,91,94] • processing time (e.g., new algorithms that speed up processing of scan images)[88] General strategies to improve efficiency may include: • assessing workflow to determine potential areas for improved efficiency (e.g., reallocating tasks, simplifying paperwork)[15,73,79] • rapid access or walk-in clinics (e.g., receiving diagnostic scans and information on disease stage in 1 setting)[31,53,56,60,80] • using artificial intelligence and/or machine learning (e.g., identify most appropriate procedure, personalize contrast doses, enhance low-quality images so scanning time can be shortened, flag unusual scans)[3,12,49,55,64,67,88,89] • using teleradiology (e.g., to allow for remote coverage in areas with a shortage of radiologists so radiologists in other areas can interpret scans)[15,45] • having dedicated adult and pediatric scanners[46] • having dedicated staff to assist with patients (e.g., checking protocol, assisting with administration of oral contrast)[96]
Decreasing low-value scans	• Providing guidance regarding appropriate referrals, such as:[3,8,12,13,15,19,24,26,33-35,39,68,70,73,81,83] ◦ clinical decision support tools (e.g., computerized tools, evidence-based guidelines or checklists, additional information on referral forms regarding appropriate scans) ◦ physician education (e.g., regarding low-value scans) ◦ encourage physicians to consult, collaborate, or communicate with radiologists • Referring patients to alternative exams or care pathways when appropriate[21,62,63,75,76] • Implementing monitoring and feedback mechanisms for referring clinicians[18,26] • Avoiding duplicates (imaging when patient's health has not changed, such as extending time intervals between repeat exams as appropriate) and exams when there is insufficient patient information[61]
Improving communication	Improve communications between: • referring physicians and imaging staff as well as within the imaging team[27,48,57,72,83] • imaging staff and patients (e.g., provide information, inform of delays, sending automated reminders about their appointment to minimize no-shows)[19,27]

Conclusion

As long wait times can be caused by a variety of issues, it may be helpful to conduct a situation-specific assessment of potential causes and available resources. This may assist with planning and choosing a strategy that is appropriate and practical for a specific facility or jurisdiction.

General strategies to address wait times for CT and MRI scans identified in this report include increasing capacity (e.g., purchasing new scanners, expanding operating hours, hiring additional staff to develop and support a sustainable workforce), improving efficiencies along the imaging pathway (e.g., standardizing exam referral forms, using a centralized referral pathway, and optimizing imaging protocols), reducing low-value imaging (e.g., using clinical decision support tools and evidence-based recommendations), and implementing new technologies (e.g., electronic order systems, scheduling optimization software, AI or machine learning, teleradiology).

This report is not intended to provide recommendations for or against specific strategies; the effectiveness of a specific strategy may depend on various factors, including a facility's circumstances and procedures, type of scan (e.g., scheduled versus emergency, different diseases or areas requiring a scan), and availability of resources. It may be helpful to develop a plan that is flexible, allows for modifications, and incorporates regular assessments of performance measures, such as wait times and patient backlog. These assessments may help to determine if the strategies are working as intended and flag them if they are having any unintended negative effects on patient outcomes (e.g., to ensure that shortened protocols are not negatively impacting diagnostic accuracy), so that appropriate changes can be made in a timely manner.

References

1. Sutherland G, Russell N, Gibbard R, Dobrescu A. The Value of Radiology, Part II. Ottawa (ON): The Conference Board of Canada; 2019: https://car.ca/wp-content/uploads/2019/07/value-of-radiology-part-2-en.pdf. Accessed 2022 Nov 17.
2. CADTH. The Canadian medical imaging inventory 2019 - 2020. 2021; https://www.cadth.ca/canadian-medical-imaging-inventory. Accessed 2022 Nov 17.
3. Canadian Association of Radiologists. Improving access to lifesaving imaging care for Canadians. 2022; https://car.ca/wp-content/uploads/2022/11/CAR_Multistakeholder_Brief_FINAL_2022_Nov.pdf. Accessed 2023 Jan 4.
4. CTV News Vancouver. B.C. radiologists sound alarm over backlogs as province claims wait times are down. 2022; https://bc.ctvnews.ca/b-c-radiologists-sound-alarm-over-backlogs-as-province-claims-wait-times-are-down-1.5757968. Accessed 2022 Nov 17.
5. Fraser Institute. Waiting Your Turn: Wait Times for Health Care in Canada, 2022 Report. 2022; https://www.fraserinstitute.org/sites/default/files/waiting-your-turn-2022.pdf. Accessed 2023 Jan 4.
6. Alberta Health Services. Use of Publicly Funded CT and MRI Services. 2021; https://www.oag.ab.ca/wp-content/uploads/2021/04/oag-ahs-ct-mri-report-apr-2021.pdf. Accessed 2022 Nov 16.
7. Novarad. Tips for reducing patient wait times in radiology. 2021; https://blog.novarad.net/reducing-patient-wait-times. Accessed 2022 Nov 17.
8. Roifman I, Paterson DI, Jimenez-Juan L, et al. The state of cardiovascular magnetic resonance imaging in Canada: Results from the CanSCMR Pan-Canadian survey. *Can J Cardiol.* 2018;34(3):333-336. PubMed
9. Nuti S, Vainieri M. Managing waiting times in diagnostic medical imaging. *BMJ Open.* 2012;2(6). PubMed
10. Brady AP, Bello JA, Derchi LE, et al. Radiology in the era of value-based healthcare: A multi society expert statement from the ACR, CAR, ESR, IS3R, RANZCR, and RSNA. *J Am Coll Radiol.* 2021;18(6):877-883. PubMed
11. Canadian Medical Association. Operational principles for the measurement and management of wait lists (Update 2011). 2019; https://policybase.cma.ca/link/policy10322. Accessed 2022 Nov 16.
12. Canadian Association of Radiologists. Enhancing patient care through medical imaging. 2019; https://www.ourcommons.ca/Content/Committee/421/FINA/Brief/BR10596272/br-external/CanadianAssociationOfRadiologists-e.pdf. Accessed 2022 Nov 16.
13. Canadian Cardiovascular Society. Guidance from the CSS COVID-19 Rapid Response Team: Management of referral, triage, waitlist and reassessment of cardiac patients during the COVID-19 pandemic. 2020; https://ccs.ca/app/uploads/2021/02/Refer-Triage-Wait-Mgmt-07Apr20.pdf. Accessed 2022 Nov 16.
14. Cancer Care Ontario. COVID 19 tip sheet for MRI and CT facilities. 2020; https://www.corhealthontario.ca/Access-to-Care_COVID-19-Diagnostic-Imaging-Tip-Sheet_20200810_Final.pdf. Accessed 2022 Nov 16.
15. Cancer Care Ontario. Recommendations to sustain diagnostic imaging services during the COVID-19 pandemic. 2020; https://www.ontariohealth.ca/sites/ontariohealth/files/2021-04/DIExpertPanelRecommendationstoSustainDiagnosticImagingDuringthePandemic.pdf. Accessed 2022 Nov 16.
16. Van Nynatten L, Gershon A. Radiology wait times: Impact on patient care and potential solutions. *Univ West Ont Med J.* 2017;86(2):65-66.
17. Vanderby S, Badea A, Pena Sanchez JN, Kalra N, Babyn P. Variations in magnetic resonance imaging provision and processes among Canadian academic centres. *Can Assoc Radiol J.* 2017;68(1):56-65. PubMed
18. Dunne CL, Elzinga JL, Vorobeichik A, et al. A systematic review of interventions to reduce computed tomography usage in the emergency department. Ann Emerg Med. 2022;01:01.
19. BC Centre for Disease Control. Provincial guidance for medical imaging services within British Columbia during the COVID-19 pandemic phases. 2020; http://www.bccdc.ca/Health-Professionals-Site/Documents/COVID19_MedicalImagingGuidePractitioners.pdf. Accessed 2022 Nov 17.
20. University of British Columbia Cloud Innovation Centre. Vancouver Coastal Health MRI project "CAN'T WAIT". 2021; https://communityhealthcic.sites.olt.ubc.ca/projects/vch-mri-project-cant-wait/. Accessed 2022 Nov 16.
21. Kandiah JW, Chan VWY, Luo J, Dong F, Nugent JP, Forster BB. Reducing the volume of low-value outpatient MRI joint examinations in patients >=55 years of age. *Can Assoc Radiol J.* 2020;71(1):83-91. PubMed
22. Alberta Health Services. Diagnostic imaging, CT and MRI implementation plan. 2021; https://www.albertahealthservices.ca/assets/about/publications/ahs-pub-di-ct-mri-implementation-plan.pdf. Accessed 2022 Nov 16.
23. Wu A, Liu L, Fourney DR. Does a multidisciplinary triage pathway facilitate better outcomes after spine surgery? *Spine (Phila Pa 1976)*. 2021;46(5):322-328. PubMed
24. Madani Larijani M, Azizian A, Carr T, Adams SJ, Groot G. Combined lumbar spine MRI and CT appropriateness checklist: A quality improvement project in Saskatchewan, Canada. *Int J Qual Health Care.* 2021;33(3):28. PubMed
25. Manitoba Health. Manitoba provides update on the Diagnostic and Surgical Recovery Task Force. 2022; https://news.gov.mb.ca/news/?archive=&item=54024. Accessed 2022 Nov 16.
26. Manitoba Health. Wait Times Reduction Task Force: Final Report. 2017; https://www.gov.mb.ca/health/documents/wtrtf.pdf. Accessed 2022 Nov 16.

27. CorHealth Ontario. Recommendations for an Ontario Approach to Triaging Hospital Based Cardiac Computed Tomography, Cardiovascular Magnetic Resonance Imaging and Cardiac Nuclear Imaging Services During COVID-19. 2020; https://www.corhealthontario.ca/CorHealth-COVID-19-Cardiac-Memo_15-Triaging-Cardiac-Imaging-Services-During-COVID-19.pdf. Accessed 2022 Nov 16.
28. Roussos J, Zahedi P, Spence T, et al. Optimizing computed tomography simulation wait times in a busy radiation medicine program. *Pract Radiat Oncol.* 2017;7(1):e77-e83. PubMed
29. Shakeel S, Dhanoa M, Khan O, Dibajnia P, Akhtar-Danesh N, Behzadi A. Wait times in the management of non-small cell lung carcinoma before, during and after regionalization of lung cancer care: A high-resolution analysis. *Can J Surg.* 2021;64(2):E218-E227. PubMed
30. Chiarelli AM, Muradali D, Blackmore KM, et al. Evaluating wait times from screening to breast cancer diagnosis among women undergoing organised assessment vs usual care. *Br J Cancer.* 2017;116(10):1254-1263. PubMed
31. Gulak MA, Bornais C, Shin S, et al. Implementing a one-day testing model improves timeliness of workup for patients with lung cancer. *Curr Oncol.* 2019;26(5):e651-e657. PubMed
32. Dawdy K, Bonin K, Russell S, et al. Developing and evaluating multimedia patient education tools to better prepare prostate-cancer patients for radiotherapy treatment (randomized study). *J Cancer Educ.* 2018;33(3):551-556. PubMed
33. Manta A, O'Grady J, Bleakney R, Theodoropoulos J. Determining the appropriateness of requests for outpatient magnetic resonance imaging of the hip. *Can J Surg.* 2019;62(4):224-226. PubMed
34. Zarrabian M, Bidos A, Fanti C, et al. Improving spine surgical access, appropriateness and efficiency in metropolitan, urban and rural settings. *Can J Surg.* 2017;60(5):342-348. PubMed
35. Xu SS, Berkovitz N, Li O, Garvin G. Reduction in inappropriate MRI knee studies after implementation of an appropriateness checklist: Experience at a tertiary care centre. *Eur J Radiol.* 2020;123:108781. PubMed
36. Roifman I, Li M, Connelly KA. Novel combined clinical and research protocol to reduce wait times for cardiac magnetic resonance. *Healthc Q.* 2020;23(2):62-66. PubMed
37. Ontario Ministry of Health. Plan to stay open: Health system stability and recovery. 2022; https://www.ontario.ca/page/plan-stay-open-health-system-stability-and-recovery. Accessed 2022 Dec 13.
38. Ontario Ministry of Health. Ontario expanding access to MRI services across the province. 2022; https://news.ontario.ca/en/release/1002581/ontario-expanding-access-to-mri-services-across-the-province. Accessed 2022 Dec 13.
39. Tan S, David J, Lalonde L, et al. Breast magnetic resonance imaging: Are those who need it getting it? *Curr Oncol.* 2017;24(3):e205-e213. PubMed
40. Common JL, Mariathas HH, Parsons K, et al. Reducing wait time for lung cancer diagnosis and treatment: Impact of a multidisciplinary, centralized referral program. *Can Assoc Radiol J.* 2018;69(3):322-327. PubMed
41. Lawlor A. 'The patients are so grateful' QEII COVID-19 Response Fund tackles wait times, reduces procedure backlogs for patients. 2022; https://www.qe2times.ca/new---the-patients-are-so-grateful-364. Accessed 2022 Dec 1.
42. Nova Scotia Health. Fiscal year 2021-22 quality and sustainability plan: August 2021. 2021; https://www.nshealth.ca/sites/nshealth.ca/files/bp.ar_.21.3.pdf. Accessed 2022 Dec 1.
43. Huizinga R. Horizon Health working overtime in March to clear MRI, mammogram backlog. 2022; https://www.cbc.ca/news/canada/new-brunswick/horizon-march-overtime-backlogs-1.6374389. Accessed 2022 Dec 1.
44. Yukon News. Waitlist for Whitehorse MRI scanner is a thousand patients long. 2022; https://www.yukon-news.com/news/waitlist-for-whitehorse-mri-scanner-is-a-thousand-patients-long/. Accessed 2022 Dec 1.
45. Parliament of Australia. Availability and accessibility of diagnostic imaging equipment around Australia. 2018; https://www.aph.gov.au/Parliamentary_Business/Committees/Senate/Community_Affairs/Diagnosticimaging/Report. Accessed 2022 Nov 17.
46. South Eastern Sydney Local Health District. St George integrated health services plan. 2018; https://www.seslhd.health.nsw.gov.au/sites/default/files/groups/Planning_Population_and_Equity/Health_Plans/StGIntegratedHealthServicesPlan_190726_web.pdf. Accessed 2022 Nov 25.
47. Luo L, Zhang Y, Qing F, Ding H, Shi Y, Guo H. A discrete event simulation approach for reserving capacity for emergency patients in the radiology department. *BMC Health Serv Res.* 2018;18(1):452. PubMed
48. Huang X, Zhou S, Ma X, et al. Emergency department treatment process planning: A field research, case analysis, and simulation approach. *Ann Transl Med.* 2022;10(10):545. PubMed
49. McKinsey & Company. Transforming healthcare with AI: The impact on the workforce and organisations. 2020; https://eithealth.eu/wp-content/uploads/2020/03/EIT-Health-and-McKinsey_Transforming-Healthcare-with-AI.pdf. Accessed 2022 Nov 25.
50. Moummad I, Jaudet C, Lechervy A, et al. The impact of resampling and denoising deep learning algorithms on radiomics in brain metastases MRI. *Cancers (Basel).* 2021;14(1):22. PubMed
51. Bargnoux AS, Beaufils O, Oguike M, et al. Point-of-care creatinine testing in patients receiving contrast-enhanced computed tomography scan. *Clin Chim Acta.* 2018;478:111-113. PubMed

52. Arun PP, Panicker VV. Development of a patient scheduling system for a radio diagnosis department. *Hosp Top.* 2019;97(3):87-98. PubMed

53. Saolta University Health Care Group. An options appraisal for Saolta model 4 hospital services in Galway. 2019; https://saolta.ie/sites/default/files/publications/GUH%20Options%20Appraisal%20Report%20-%20Final.pdf. Accessed 2022 Nov 25.

54. Boldor N, Vaknin S, Myers V, et al. Reforming the MRI system: The Israeli National Program to shorten waiting times and increase efficiency. *Isr J Health Policy Res.* 2021;10(1):57. PubMed

55. Mayberg M, Green M, Vasserman M, et al. Anisotropic neural deblurring for MRI acceleration. *Int J Comput Assist Radiol Surg.* 2022;17(2):315-327. PubMed

56. Paulino Pereira LJ, Heetman JG, van den Bergh RCN, van Melick HHE. Superfast magnetic resonance imaging-based diagnostic pathway for prostate cancer. *Eur Urol Open Sci.* 2022;46:30-32. PubMed

57. Doyle AJ. Radiology and Te Whatu Ora - Health New Zealand in 2022. Why we should all care. *N Z Med J.* 2022;135(1564):66-71. PubMed

58. Auckland District Health Board. 2020/21 annual plan. 2020; https://www.adhb.health.nz/assets/Documents/About-Us/Planning-documents/Auckland-DHB-Annual-Plan-2020-21.pdf. Accessed 2022 Nov 25.

59. Bhullar H, County B, Barnard S, Anderson A, Seddon ME. Reducing the MRI outpatient waiting list through a capacity and demand time series improvement programme. *N Z Med J.* 2021;134(1537):27-35. PubMed

60. van Sambeek J, Luinstra M, Te Loo E, Pijl M. The success of walk-in-computed tomography in practice. *Eur J Radiol.* 2018;109:88-94. PubMed

61. Hofmann B, Andersen ER, Kjelle E. Visualizing the invisible: Invisible waste in diagnostic imaging. Healthcare (Basel). 2021;9(12):07.

62. Alhowimel A, Alodaibi F, Alotaibi M, Alamam D, Alsobayel H, Fritz J. Development of a logic model for a programme to reduce the magnetic resonance imaging rate for non-specific lower back pain in a tertiary care centre. *Healthcare (Basel)*. 2021;9(2):23. PubMed

63. Law GW, Padki A, Tay KS, et al. Computed tomography-based diagnosis of occult fragility hip fractures offer shorter waiting times with no inadvertent missed diagnosis. *J Orthop Surg (Hong Kong)*. 2020;28(2):2309499020932082. PubMed

64. Lee S, Jeong B, Kim M, et al. Emergency triage of brain computed tomography via anomaly detection with a deep generative model. *Nat Commun.* 2022;13(1):4251. PubMed

65. Olofsson PT, Aspelin P, Bohlin J, Blomqvist L. The impact of contracts on outsourcing computed tomography examinations from a Swedish public university hospital to a private radiology unit. *Radiography (London)*. 2019;25(2):148-154. PubMed

66. Yao HC, Chen PJ, Kuo YT, Shih CC, Wang XY, Chen PS. Solving patient referral problems by using bat algorithm. *Technol Health Care.* 2020;28(S1):433-442. PubMed

67. NHS Grampian. Service transformation through digital: A strategy 2020-2025. 2020; https://www.nhsgrampian.org//globalassets/foidocument/foi-public-documents1---all-documents/07.00ServicetransformationthroughdigitalV4Grampianunapprovedfinal.pdf. Accessed 2022 Nov 25.

68. Auditor General for Wales. Radiology services in Wales. 2018; https://cwmtafmorgannwg.wales/Docs/Audit%20and%20Risk%20Committee/013%20February%2011%202019/4.3%20WAO%20Report%20Radiology%20Services%20AC%2011%20February%202019.pdf. Accessed 2022 Nov 25.

69. Auditor General for Wales. Radiology service – Cwm Taf University Health Board. 2017; https://www.audit.wales/sites/default/files/cwm_taf_health_board_radiology_english_6.pdf. Accessed 2022 Nov 25.

70. Auditor General for Wales. Radiology service – Cardiff and Vale University Health Board. 2017; https://www.audit.wales/sites/default/files/cardiff_vale_health_board_radiology_english_6.pdf. Accessed 2022 Nov 25.

71. Auditor General for Wales. Radiology service – Abertawe Bro Morgannwg University Health Board. 2017; https://www.audit.wales/sites/default/files/abertawe_bro_morgannwg_health_board_radiology_english_6.pdf. Accessed 2022 Nov 25.

72. NHS Lothian. Edinburgh Cancer Centre capital development. 2022; https://www.nhsfife.org/media/37363/ecc-ia-apps-v11-june-2022.pdf. Accessed 2022 Nov 25.

73. Barbour V, Thakore S. Improving door to CT scanner times for potential stroke thrombolysis candidates - The Emergency Department's role. *BMJ Qual Improv Rep.* 2017;6(1). PubMed

74. Al Kadhi O, Manley K, Natarajan M, et al. A renal colic fast track pathway to improve waiting times and outcomes for patients presenting to the emergency department. *Open Access Emerg Med.* 2017;9:53-55. PubMed

75. Cock K, Bromley R, Faux W. Adapting a 2-week-wait colorectal service in the pandemic using the quantitative faecal immunochemical test. *Br J Nurs.* 2021;30(7):404-408. PubMed

76. O'Donohoe N, Jamal S, Cope J, Strom L, Ryan S, Nunoo-Mensah JW. COVID-19 recovery: Tackling the 2-week wait colorectal pathway backlog by optimising CT colonography utilisation. *Clin Radiol.* 2021;76(2):117-121. PubMed

77. Buell KG, Sivasubramaniyam S, Sykes M, Zafar K, Bingham L, Mitra A. Expediting the management of cauda equina syndrome in the emergency department through clinical pathway design. *BMJ open qual.* 2019;8(4):e000597. PubMed

78. Fraig H, Gibbs DMR, Lloyd-Jones G, Evans NR, Barham GS, Dabke HV. Early experience of a local pathway on the waiting time for MRI in patients presenting to a UK district general hospital with suspected cauda equina syndrome. *Br J Neurosurg.* 2022:1-7. PubMed

79. Watura C, Kendall C, Sookur P. Direct access and skill mix can reduce telephone interruptions and imaging wait times: Improving radiology service effectiveness, safety and sustainability. *Curr Probl Diagn Radiol.* 2022;51(1):6-11. PubMed

80. Bhuva AN, Feuchter P, Hawkins A, et al. MRI for patients with cardiac implantable electronic devices: Simplifying complexity with a 'one-stop' service model. *BMJ Qual Saf.* 2019;28(10):853-858. PubMed

81. Mettias BAD, Lyons M. Magnetic resonance imaging for vestibular schwannoma: Cost-effective protocol for referrals. *J Laryngol Otol.* 2019;133(11):948-952. PubMed

82. Loving VA, Ellis RL, Rippee R, Steele JR, Schomer DF, Shoemaker S. Time is not on our side: How radiology practices should manage customer queues. *J Am Coll Radiol.* 2017;14(11):1481-1488. PubMed

83. Bor DS, Sharpe RE, Bode EK, Hunt K, Gozansky WS. Increasing patient access to MRI examinations in an integrated multispecialty practice. *Radiographics.* 2021;41(1):E1-E8. PubMed

84. Dako F, Cobb R, Verdi S, et al. Use of value stream mapping to reduce outpatient CT scan wait times. *J Am Coll Radiol.* 2018;15(1 Pt A):82-85. PubMed

85. Neal CH, Sakala MD, Houck GE, Noroozian M, Kazerooni EA, Davenport MS. Improving breast MR wait times: A model for transitioning newly implemented diagnostic imaging procedures into routine clinical operation. *J Am Coll Radiol.* 2018;15(6):859-864. PubMed

86. Beker K, Garces-Descovich A, Mangosing J, Cabral-Goncalves I, Hallett D, Mortele KJ. Optimizing MRI logistics: Prospective analysis of performance, efficiency, and patient throughput. *AJR Am J Roentgenol.* 2017;209(4):836-844. PubMed

87. Curtis C, Liu C, Bollerman TJ, Pianykh OS. Machine learning for predicting patient wait times and appointment delays. *J Am Coll Radiol.* 2018;15(9):1310-1316. PubMed

88. Monsour R, Dutta M, Mohamed AZ, Borkowski A, Viswanadhan NA. Neuroimaging in the era of artificial intelligence: Current applications. *Fed Prac.* 2022;39(Suppl 1):S14-S20. PubMed

89. O'Neill TJ, Xi Y, Stehel E, et al. Active reprioritization of the reading worklist using artificial intelligence has a beneficial effect on the turnaround time for interpretation of head CT with intracranial hemorrhage. *Radiol Artif Intell.* 2021;3(2):e200024. PubMed

90. Chang G, Doshi A, Chandarana H, Recht M. Impact of COVID-19 workflow changes on patient throughput at outpatient imaging centers. *Acad Radiol.* 2021;28(3):297-306. PubMed

91. Li J, Ma C, Chen Y, et al. The feasibility of a fast liver MRI protocol for lesion detection of adults at 3.0-T. *Front Oncol.* 2021;11:586343. PubMed

92. Rudder BS, Easley SJ, Robinson AL, Noel-MacDonnell JR, Nielsen DB. Effects of an MRI Try Without program on patient access. *Pediatr Radiol.* 2019;49(13):1712-1717. PubMed

93. Farrell CR, Bezinque AD, Tucker JM, Michiels EA, Betz BW. Acute appendicitis in childhood: Oral contrast does not improve CT diagnosis. *Emerg Radiol.* 2018;25(3):257-263. PubMed

94. Ma D, Jiang Y, Chen Y, et al. Fast 3D magnetic resonance fingerprinting for a whole-brain coverage. *Magn Reson Med.* 2018;79(4):2190-2197. PubMed

95. Pang B, Xie X, Ju F, Pipe J. A dynamic sequential decision-making model on MRI real-time scheduling with simulation-based optimization. *Health Care Manag Sci.* 2022;25(3):426-440. PubMed

96. Gyftopoulos S, Jamin C, Wu TS, et al. The use of an emergency department expeditor to improve emergency department CT workflow: Initial experiences. *J Am Coll Radiol.* 2019;16(3):327-332. PubMed

97. Small JE, Sullivan-Richard S, Kingsley Rocker LA, Kim JJ, Broder JC. Emergency magnetic resonance imaging 3-tiered prioritization. *Curr Probl Diagn Radiol.* 2018;47(2):84-89. PubMed

Appendix 1: Frameworks, Canadian Implementation Plans and Recommendations, International Implementation Plans and Recommendations, and Strategies to Address Wait Times

Table 2: Frameworks for Addressing Wait Times for CT and MRI Scans

Criteria	Description
Brady et al. (2020) – Radiology in the Era of Value-Based Healthcare: A Multi Society Expert Statement From the ACR, CAR, ESR, IS3R, RANZCR, and RSNA[10]	
Jurisdiction	Represents views of Radiology Societies in Canada, Europe, the USA, Australia, and New Zealand
Type of scan	CT, MRI; radiology scans in general
Brief description of framework	Describes steps to assess the value of radiology, which in turn may help to improve practice and reduce wait times for patients; includes: • Engaging directly and often with referring clinicians to understand their practices and needs, including supporting and reinforcing the use of evidence-based guidelines to assist with appropriate imaging • Utilizing available resources and tools (e.g., structured reporting, clinical decision support tools, AI tools) and, where possible, augmenting resources to optimize workflow to minimize patient waiting times
Assessment of effectiveness	Recommends constant quality monitoring and promoting a culture of constant quality improvement
Canadian Medical Association (2011; last reviewed in 2019) – Operational principles for the measurement and management of wait lists (Update 2011)[11] [a]	
Jurisdiction	Canada
Type of scan	Not specified
Brief description of framework	Policy statement providing operational principles to measure and manage wait list systems; principles include: • Involve stakeholders (including physicians) when developing strategy • Involve multidisciplinary panels in database development and waitlist management • Systems must require and provide reliable, current, useful, and valid data in a cost-effective manner, and be flexible so they can adapt over time with new technologies and treatments • Have initial and sustained investment • Be overseen by an independent, stakeholder-based, non-governmental organization with an advisory committee
Assessment of effectiveness	Systems for managing wait lists must be monitored and evaluated to identify opportunities for improvement, and regularly undergo independent data audits

Criteria	Description
Loving et al. (2017) – Time Is Not on Our Side: How Radiology Practices Should Manage Customer Queues[82]	
Jurisdiction	First author's affiliations are in the US (jurisdiction otherwise not reported)
Type of scan	Radiology in general
Brief description of framework	Describes a framework to resolve queues: • Analyze factors contributing to queue formation (e.g., use simulation models to calculate wait times and test strategies to improve wait times) • Improve processes to reduce service times (time required to complete a task), increase capacity, decrease utilization rates, and/or reduce variation; general process usually involves: ◦ systematically dissecting a process into its component tasks ◦ identifying potential problem points ◦ developing and testing solutions ◦ analyzing outcomes ◦ implementing successful solutions into a new process • Reduce variability (e.g., using the same image storing and sharing system) • Address psychology of queues (i.e., communication with patients about wait times)
Assessment of effectiveness	NR

NR = not reported.

[a]Although this report was not specific to CT, MRI, or medical imaging in general, it was included due to the limited number of identified frameworks and its potential applicability to CT and MRI, particularly in the Canadian context.

Note that this table has not been copy-edited.

Table 3: Canadian Implementation Plans and Recommendations

Citation	Criteria	Description
Implementation plans		
Ontario Ministry of Health (2022) – Plan to Stay Open: Health System Stability and Recovery[37]	Jurisdiction	Ontario, Canada
	Type of scan	CT, MRI
	Brief description of strategy	States they are investing in more than 150,000 additional hours for hospital-based MRI and CT machines
	Assessment of effectiveness	NR
Alberta Health Services (2021) – Diagnostic Imaging, CT and MRI Implementation Plan[22]	Jurisdiction	Alberta, Canada
	Type of scan	CT, MRI
	Brief description of strategy	Plan to manage demand for diagnostic imaging. Components specific to reducing wait times and reducing variation between zones included: • expand utilization modelling to determine need for imaging and use analytics to more accurately allocate capacity in each zone • implement cross-zone booking to manage surges in demand • standardize triage processes to minimize cross-zone variation • perform quality improvement initiatives on triage protocols • reallocate budget to increase capacity for high-priority scans Other components that were not directly related to improving wait times, but may have an indirect impact included: • managing cost: ensure radiologists' fees are comparable to Canadian peers, to help match service levels to clinical needs; reinvest savings to support sustainability and improve system capacity as demand for scans increases • managing demand: improve referral process; reduce low-value imaging (e.g., physician education, software to capture why an exam is being requested and determine if it is appropriate) Plan also reported who is accountable for each component

Citation	Criteria	Description
	Assessment of effectiveness	Planned assessments include: • scan rate per 1,000 residents • wait times • number of patients waiting • percentage of patients served
Nova Scotia Health (2021) – Fiscal Year 2021-22 Quality and Sustainability Plan: August 2021[42]	Jurisdiction	Nova Scotia
	Type of scan	MRI
	Brief description of strategy	• Updated radiology reporting system, plan to expand throughout province for a standard reporting system • Plans for 2021/22 to implement and expand MRI technology and use in multiple locations, to address wait times
	Assessment of effectiveness	NR
Recommendations		
Canadian Association of Radiologists (2022) – Improving Access to Lifesaving Imaging Care for Canadians[3]	Jurisdiction	Canada
	Type of scan	CT, MRI; radiology in general
	Brief description of recommendations	• Invest in new imaging equipment across the country • Develop a robust health human resources strategy for radiology departments • Harness new technologies (e.g., AI) to increase capacity • Implement a national directive for Clinical Decision Support tools, to provide health care providers better access to e-referral guidelines
	Assessment of effectiveness	NR
Ritchie (2022) – Waitlist for Whitehorse MRI scanner is a thousand patients long[44]	Jurisdiction	Yukon
	Type of scan	MRI

Citation	Criteria	Description
	Brief description of recommendations	News article noting the long wait list for nonurgent MRIs in Yukon (1,000 people); staffing is difficult, and recommendations include: • More funding • Longer hours running the machine • Overall plans to increase capacity One option is to send urgent patients to Vancouver if they cannot be accommodated in Yukon, but transportation can also be very costly ($3,500)
	Assessment of effectiveness	NR
Alberta Health Services (2021) – Use of Publicly Funded CT and MRI Services[6]	Jurisdiction	Alberta, Canada
	Type of scan	CT, MRI
	Brief description of strategy	Recommendations include: • Implement and measure effectiveness of standard operational policy and workflow for electronic order entry, to assist referrers when ordering exams • Improve and standardize outpatient intake, scheduling processes, and protocols
	Assessment of effectiveness	Recommends measuring and reporting on performance to identify areas of improvement and promote best practices
BC Centre for Disease Control (2020) – Provincial Guidance for Medical Imaging Services within British Columbia During the COVID-19 Pandemic Phases[19]	Jurisdiction	British Columbia, Canada
	Type of scan	CT and MRI; also provides recommendations for other types of scans
	Brief description of recommendations	Provides guidance regarding how to resume imaging services that were scaled back during COVID-19-related lockdowns, starting with: • Quantify backlog • Determine available and potential capacity Strategies to increase capacity included:

Citation	Criteria	Description
		• Extend hours of operation where possible, dependent on availability of supplies and human resourcing; consider that processes are sustainable • Identify part-time staff that can transition to full-time, increase supply of technologists, and determine overtime capacity • Review all scanning protocols and where possible, truncate protocols (e.g., scanning time, and/or time for interpretation) that do not compromise diagnostic yield • Refer practitioners to radiologist consultation to help inform test selection and appropriateness • Streamline check-in process (e.g., text or call) if possible • Minimize patient no-shows by sending patients reminders (electronically or by phone)
	Assessment of effectiveness	NR
Canadian Cardiovascular Society (2020) – Guidance from the CSS COVID-19 Rapid Response Team: Management of referral, triage, waitlist and reassessment of cardiac patients during the COVID-19 pandemic[13]	Jurisdiction	Canada
	Type of scan	Cardiac MRI; also includes other types of scans
	Brief description of recommendations	Provides guidance to help address the backlog of diagnostic tests due COVID-19, including: • Physicians and diagnostic laboratories should ensure all testing is warranted and informed by Canadian Cardiovascular Society Guidelines and Choosing Wisely recommendations • Referring providers should provide sufficient information to allow accurate triage Also provides guidance for resumption-of-service: • Recommends a phased-in approach with a planned process • Determine which services to expand first, resolve internal limited resource allocation disputes, develop plan to address deferred services

Citation	Criteria	Description
		• Accurate identification of referrals and testing will be needed • Consider human resources issues
	Assessment of effectiveness	NR
Cancer Care Ontario (2020) – COVID 19 Tip Sheet for MRI and CT Facilities[14]	Jurisdiction	Canada
	Type of scan	CT, MRI
	Brief description of recommendations	In context of resuming diagnostic imaging services following shutdowns due to COVID-19, suggestions to improve efficiencies (which may help to reduce wait times): • Consider block booking similar exams to reduce the need to change or clean the coil (e.g., exams that do not require patient's head inside the bore) • Review protocols to assess whether they can be shortened • Reassess need for oral and IV contrast for certain exams Also provides some suggestions regarding scheduling: • Ensure sufficient booking blocks or slots are available to accommodate presurgical planning and scheduling exams • Assess changes in demand for timed (follow-up) procedures, ensure future scan schedule does not over-allocate hours • Collaborate with referring physicians to consider if any follow-up exams could be moved to accommodate high-priority patients in the schedule • Leverage available wait time reporting products from your facility and region to inform immediate capacity planning
	Assessment of effectiveness	NR
Cancer Care Ontario (2020) – Recommendations to Sustain Diagnostic Imaging Services During the COVID-19 Pandemic[15]	Jurisdiction	Ontario, Canada
	Type of scan	CT, MRI, diagnostic imaging in general

Citation	Criteria	Description
	Brief description of recommendations	Recommendations to consider that may help reduce wait times: • Block booking strategies that could improve efficiencies • Processes to improve schedule accuracy and reduce idle time; e.g., reviewing local schedule and scan time data for accuracy, schedule optimization technology if available and applicable • Assess whether imaging protocols can be optimized, leverage best practices (e.g., rapid protocols) to meet local needs • Review previously booked scans not indicated as best practices; consider developing a communication strategy to patients on rationale for changing previously booked exams • Immediately adopt quality and evidence-based requisitions and/or appropriateness checklists; for support, implement processes to enable consultations between primary care physicians and radiologists • Consider if contrast utilization can be reduced • If have capacity and waitlist growth, should receive additional funding to perform maximum volume of quality-based scans • Providers with equipment constraints can collaborate with regional partners to assess need to temporarily redistribute outpatients (and related funds) to nearby facilities with capacity • Develop and implement provincially coordinated communication strategy to inform physicians and patients of alternate service locations with corresponding wait times within their respective and neighbouring regions • Expand operating hours during week and/or weekend; may also require recruitment of additional staff • Where there is a shortage of radiologists, recommend these locations receive funding to support technology and connectivity for remote coverage • Assess current technologist workflow to reassign tasks that could be completed by alternate staff, thus maximizing technologists' time for clinical tasks

Citation	Criteria	Description
	Assessment of effectiveness	NR
CorHealth Ontario (2020) – Recommendations for an Ontario Approach to Triaging Hospital Based Cardiac Computed Tomography, Cardiovascular Magnetic Resonance Imaging and Cardiac Nuclear Imaging Services During COVID-19[27]	Jurisdiction	Ontario, Canada
	Type of scan	CT, MRI; can also apply to nuclear imaging
	Brief description of recommendations	Recommendations to manage waitlists in the context of COVID-19, though may apply generally: • Designate a qualified medical staff to oversee triaging and prioritizing, collaborating with diagnostic imaging; and establish bidirectional communications between this designated staff and referring physicians to ensure clinical changes that impact triage or prioritization are communicated in a timely manner • Communicate with patients to inform of delays and provide information about their exams (e.g., mailing relevant exam information packages)
	Assessment of effectiveness	NR
Canadian Association of Radiologists (2019) – Enhancing patient care through medical imaging[12]	Jurisdiction	Canada
	Type of scan	CT, MRI; radiology scans in general
	Brief description of recommendations	Recommends additional funding for: • New, more efficient imaging equipment • Implementing clinical decision support tools to ensure appropriateness of referrals • Frameworks to regulate implementation of AI, as this may allow radiologist to view more images and see patients in a shorter time frame while minimizing burnout
	Assessment of effectiveness	NR
Manitoba Health (2017) – Wait Times Reduction Task Force: Final Report[26]	Jurisdiction	Manitoba, Canada

Citation	Criteria	Description
	Type of scan	MRI
	Brief description of recommendations	Strategies to reduce demand (and wait times) by appropriate ordering of tests, including: • Standardize referral forms including guidance; require radiologists to consult with referring clinicians to ensure requests are appropriate • Allow referring clinicians to identify patients' signs and symptoms and to consult with radiologists to choose best test • Provide needed funding to implement these recommendations • Education and training for providers regarding appropriate ordering; can target to clinicians who order large numbers of tests • Monitoring and feedback mechanisms for referring clinicians Increase MRI capacity: • Maximize use of existing machines (run 16 hours a day, 7 days a week) where appropriate • Improve scanner utilization (e.g., allowing patients to be on a cancellation list, reducing no-show and cancellation rates) • Standardize and harmonize protocols across Manitoba • Ensure processes, training and collective agreements support MRI technologists working at any MRI site • Do not purchase or install new machines unless demand warrants; additional demand must be analyzed first Recommends establishing a provincial program for diagnostic imaging (including MRI) so funding and resources can be directed to where they are most needed; this program should include: • Standardized wait time and wait list definitions, data collection and reporting from all sites; data should include complexity of scan and exact part of body scanned • Published data on a public-facing, patient-friendly website as close to real-time as possible • Evaluate demand and anticipated needed volume regularly so staffing volumes can be planned in advance

Citation	Criteria	Description
		• Enforce participation in central intake by all MRI sites • Ensure central intake processes are patient-centred, prepared to provide additional navigation and support services if needed, including providing a contact number for patients • Ensure central intake has sufficient staff to process referrals in a timely manner
	Assessment of effectiveness	Recommends: • Re-evaluating usage of scanners annually to determine if estimated benefits have been achieved, and if further adjustments are required • Implementing a provincial data reporting and standards review for the provincial diagnostic imaging program • Tracking and reporting key access indicators by site that are transparent to all stakeholders including the public
Manta et al. (2019) – Determining the appropriateness of requests for outpatient magnetic resonance imaging of the hip[33]	Jurisdiction	First author's affiliations are in Ontario, Canada (jurisdiction otherwise not reported)
	Type of scan	MRI
	Brief description of recommendation	Commentary focused on inappropriate MRI requests; to help reduce inappropriate referrals, recommends educating physicians on • identifying contraindications in pre-MRI radiographs • patient selection for hip arthroscopy
	Assessment of effectiveness	NR
Roifman et al. (2018) – The State of Cardiovascular Magnetic Resonance Imaging in Canada: Results from the CanSCMR Pan-Canadian Survey[8]	Jurisdiction	Canada
	Type of scan	MRI
	Brief description of recommendation	Recommends: • Develop rapid acquisition techniques • Improve automation and efficiency in reporting

Citation	Criteria	Description
		• Improve use of published appropriate use criteria among cardiovascular MRI professionals and referring physicians • Improve exposure to cardiovascular MRI and MRI-specific appropriate use criteria among cardiology trainees • Standardize implementation of appropriate MRI use
	Assessment of effectiveness	NR
Van Nynatten and Gershon (2017) – Radiology wait times: Impact on Patient Care and Potential Solutions[16]	Jurisdiction	Canada; includes a specific example in Prince Edward Island
	Type of scan	CT, MRI
	Brief description of recommendations	Narrative review; key points included: • Teleradiology has been successful in Canada when the primary problem is a lack of staff radiologists • In Prince Edward Island, implemented several changes including teleradiology, which allows scans to be interpreted by radiologists in other provinces • Ensure only appropriate diagnostic tests are ordered • Suggests dedicated task force investigate the causes and possible solutions of long wait times
	Assessment of effectiveness	• From 2009 to 2011, wait time for elective or nonurgent CT scans fell from 22 weeks to under 3 weeks, while MRI wait times fell from 33 weeks to 8 weeks • References a report that found appropriate use of guidelines reduced inappropriate radiology referrals by 23%
Vanderby et al. (2017) – Variations in Magnetic Resonance Imaging Provision and Processes Among Canadian Academic Centres[17]	Jurisdiction	Canada
	Type of scan	MRI

Citation	Criteria	Description
	Brief description of recommendations	Based on survey of Canadian academic medical imaging departments, authors noted that great variation across facilities' hours of operation, request forms, and prioritization scales, and thus recommended: • Computerized order entry systems can require users to complete specific fields to submit form; also possible with PDFs • Standardize exam request forms; can consider customizing to specific clinical indications for high volume exams • Encourage facilities to share best practices and learn from others, such as standardized priority levels
	Assessment of effectiveness	NR

AI = artificial intelligence; NR = not reported.

Note that this table has not been copy-edited.

Table 4: International Implementation Plans and Recommendations

First author	Criteria	Description
Implementation plans		
NHS Lothian (2022) – Edinburgh Cancer Centre Capital Development[72]	Jurisdiction	UK
	Type of scan	CT, MRI; diagnostic imaging in general
	Brief description of strategy	States that their Radiology team will: • Focus on workforce planning • Submit business case for additional scanning time • Consider how to increase budget for postgraduate education • Review pathways to allow patients to be sent for immediate scanning when possible, and implement patient-focused booking when immediate scanning is not possible • Implement system to ensure referrals are received at the correct location in a timely manner Some recommendations related to reducing wait times for imaging: • Increase capacity by adding sessions on existing equipment • Commission additional and/or new imaging modalities • Improve reporting system (e.g., sends a computer alert when scans have been reported, rather than requiring staff to find the paper copy) • Improved communication between services
	Assessment of effectiveness	NR
Auckland District Health Board (2020) – 2020/21 Annual Plan[58]	Jurisdiction	New Zealand
	Type of scan	CT; radiology in general
	Brief description of plan	Radiology Action Plan states they plan to work with the Northern Region radiology work program to: • Identify current demand and capacity

First author	Criteria	Description
		• Improve waiting times and optimize capacity configuration • Plan for required replacement and additional assets • Develop and support sustainable workforce, including allowing international recruitment
	Assessment of effectiveness	Goal is that 95% of patients with accepted referrals for CT and 90% of patients with referrals for MRI will receive scan and their scans will be reported within 6 weeks
NHS Grampian (2020) – Service Transformation through digital: a Strategy 2020-2025[67]	Jurisdiction	UK
	Type of scan	Radiology in general
	Brief description of plan	Outline of digital transformation plan; steps specific to radiology: • 2020/21: general practitioners requesting imaging electronically • 2023: AI enters routine use in radiology
	Assessment of effectiveness	States that by 2025, will be using data to support continuous improvement of outcomes
Saolta University Health Care Group (2019) – An Options Appraisal for Saolta Model 4 Hospital Services in Galway[53]	Jurisdiction	Ireland
	Type of scan	CT, MRI; also other diagnostic imaging
	Brief description of plan	• Summarizes strategy and vision for an Ambulatory Cancer Care Centre to improve quality of care including reducing wait times • Plan includes setting up new Rapid Access Clinics which help to increase probability of early cancer diagnosis by providing patients direct access to consultants and diagnostic equipment (including CT and MRI) to diagnose and stage disease in one setting • Created based on suggestion that imaging should be done in an outpatient setting, separate from inpatient and emergency
	Assessment of effectiveness	NR

First author	Criteria	Description
Recommendations		
Doyle (2022) – Radiology and Te Whatu Ora – Health New Zealand in 2022. Why we should all care[57]	Jurisdiction	New Zealand
	Type of scan	CT, MRI; radiography in general
	Brief description of recommendations	Opinion article with recommendations to address increased demand for diagnostic imaging (exacerbated by COVID-19): • Increase local training for MRI technologists and radiologists, increasing clinical placements and encouraging graduates to train in MRI; an emphasis on "train to retain" principle • To increase capacity and improve access, set up mobile units • Upgrade IT systems with improved connectivity • Need equitable funding of publicly funded radiology services, independent of geography and demographic, using a coherent, consistent, and equitable national approach; need to agree on a national pricing model for contracting outsourcing • Ensure any increase in clinical activity is met by increased radiology resources; continue collaborative development of clinical pathways to encourage appropriate imaging
	Assessment of effectiveness	NR
Hofmann et al. (2021) – Visualizing the Invisible: Invisible Waste in Diagnostic Imaging[61]	Jurisdiction	First author's affiliations are in Norway (jurisdiction otherwise not reported)
	Type of scan	Radiology in general
	Brief description of strategy	Recommendations to reduce low-value scans (unnecessary scanning): • Avoid duplicates • Reduce retakes • Extend time intervals for repeat exams (where appropriate) • Halt exams without sufficient information • Stop low-value imaging, including screening with poor evidence

First author	Criteria	Description
		• Be cautious with incidental findings • Adapt measures for reducing low-value scans to specific context
	Assessment of effectiveness	NR
McKinsey & Company (2020) – Transforming healthcare with AI: The impact on the workforce and organisations[49]	Jurisdiction	European Union
	Type of scan	CT, MRI; diagnostic imaging in general
	Brief description of strategy	Overview of AI for health; some places where AI can be used to support care related to CT and/or MRI include: • Improve speed and accuracy of diagnostics (e.g., recognize complex patterns in imaging data, to help determine most appropriate imaging procedure, provide personalize radiation doses, analyze and review images, triage if require more imaging) • Handle administrative and repetitive tasks to allow health care staff to focus on other tasks (may help to reduce wait times) Recommendations regarding using AI in health care in general include: • Develop regional or national strategy with medium- and longer-term goals, initiatives, and performance indicators • Set data standards (e.g., quality, access, risk management) • Redesign workforce planning and clinical education • Provide incentives and guidance for collaboration in centres of excellence and innovation • Address issues like regulation, liability, and funding • Ensure funding and reimbursement mechanisms reflect innovation
	Assessment of effectiveness	Notes need to develop performance indicators
Auditor General for Wales (2018) – Radiology services in Wales[68]	Jurisdiction	UK – Wales
	Type of scan	CT, MRI; radiology in general

First author	Criteria	Description
	Brief description of recommendations	Highlights key challenges and recommendations to ensure radiology services will be able to keep up with growing demand; key themes for recommendations include: • Workforce (e.g., ensuring there are enough trainees for future demand, allowing support staff to contribute) • Equipment (e.g., recommends a national coordinated approach for replacing and purchasing new equipment with defined programs outlining priorities, requirements) • Demand (e.g., understanding demand to coordinate planning) • Information systems (e.g., systems should be efficient, reliable, and be able to produce management and performance information; allow appropriate sharing of patient information and images within and between health boards) • Management of services (e.g., allow for service improvements, referral guidance should provide sufficient information and be accessible to referring clinicians) • Quality (e.g., develop and implement common procedures codes, performance indicators, quality measures, monitoring arrangements)
	Assessment of effectiveness	Recommendations include that health boards should have action plans for how waiting times and targets will be achieved short-term and sustained, and the implementation of performance indicators and quality measures to allow for assessment and improvement
Parliament of Australia (2018) – Availability and accessibility of diagnostic imaging equipment around Australia[45]	Jurisdiction	Australia
	Type of scan	CT, MRI, diagnostic imaging in general
	Brief description of recommendations	Inquiry report regarding key issues related to diagnostic imaging services. Some recommendations related to CT and MRI that may assist with reducing wait times included: • Review the MRI referral pathway and reimbursement process • Investigate how data sharing measures between public hospitals can be improved to support teleradiology services, and implement these improvements as soon as practical

First author	Criteria	Description
		• Increase the number of radiologists trained each year based on consultation between the Department of Health and the Royal Australian and New Zealand College of Radiologists
	Assessment of effectiveness	NR
South Eastern Sydney Local Health District (2018) – St George Integrated Health Services Plan[46]	Jurisdiction	Australia
	Type of scan	Diagnostic imaging in general
	Brief description of recommendations	Recommends developing a purpose-built diagnostic imaging centre to meet future diagnostic imaging service demands and improve efficiencies; some details regarding the infrastructure include: • Physical location is in a new complex optimized for patient flow, works with other departments where imaging is critical component • All medical imaging modalities are located in the same centre • Should be located close to nuclear medicine to improve efficiencies in time; can share some facilities Other general recommendations: • Upgrade and expand capacity for medical imaging • Consider dedicated adult and pediatric MRI for patient flow • Ensure sufficient space for patient holding, preparation, and recovery, as well as patient parking
	Assessment of effectiveness	NR
Auditor General for Wales (2017) – Radiology service – Cwm Taf University Health Board[69]	Jurisdiction	Wales
	Type of scan	CT, MRI; radiology in general
	Brief description of recommendations	Recommendations included: • Develop an action plan outlining how wait time targets will be achieved short-term and sustained (e.g., use of locums, outsourcing exams) as well as manage backlogs (e.g., extended practice radiographers, outsourcing reporting)

First author	Criteria	Description
		• Develop and implement regular auditing of reported turnaround times and lost or late reports • Review appraisal and rates of nonclinical radiology staff • Review number of staff compliant with mandatory training and set target rate for compliance to be achieved in 1 and 2 years • Develop short-term strategy to address radiographer shortages • Develop strategy with referring specialties to identify changes that will impact radiology demand • Identify baseline capacity needed to meet radiology demand in a timely and safe way; use to develop a radiographer workforce plan • Identify staffing requirements to develop recruitment strategy
	Assessment of effectiveness	Recommends developing range of performance measures (e.g., equipment usage, report turnaround time) as well as workforce measures (e.g., staffing levels, vacancies)
Auditor General for Wales (2017) – Radiology service – Cardiff and Vale University Health Board[70]	Jurisdiction	Wales
	Type of scan	CT, MRI; radiology in general
	Brief description of recommendations	Recommendations included: • Develop action plan for sustainably managing backlogs (e.g., outsourcing while workforce and training plans are developed, ensuring trained radiographers are fully utilized, determine if more radiographers are needed and how to achieve this) • Increase appraisal rates for nonclinical radiology staff to level with other radiology staff • Increase mandatory training rates for all radiology staff • Work with referring clinicians when developing and reviewing referral guidance and ensure all referring clinicians know where to access current guidance • Develop radiology strategy with assessment of service, goals, and plans to achieve goals • Develop workforce plan to identify minimum capacity to meet

First author	Criteria	Description
		demand in a timely and safe way • Develop equipment replacement plan including assessment of priorities, requirements, and costs, and determining the risk if plan is not achieved on time
	Assessment of effectiveness	Recommends developing range of performance measures (e.g., equipment downtime, vacancy levels)
Auditor General for Wales (2017) – Radiology service – Abertawe Bro Morgannwg University Health Board[71]	Jurisdiction	Wales
	Type of scan	CT, MRI; radiology in general
	Brief description of recommendations	Provides several recommendations, particularly regarding how 2 separate radiology services in this jurisdiction should work together to: • Establish a joint action plan and achieve urgent parts as soon as resources are available • Identify how to reinforce need for communication from other services about provision of services • Review and address coordination of appointments to help reduce variation in waiting time • Examine costs and benefits of increased scanning hours and if appropriate develop a business case • Establish a joint radiology strategic plan that assesses resources, and sets out goals, plans, and impact on annual operational plans Also recommends the health board set up capital replacement plans and contingency plans for equipment with risk to service continuity and care
	Assessment of effectiveness	Recommends peer review of reporting quality aligns with professional standards

AI = artificial intelligence; NR = not reported.

Note that this table has not been copy-edited.

Table 5: Strategies to Address Wait Times

First author	Criteria	Description
Multidisciplinary or multiple interventions		
Dunne et al. (2022) – A Systematic Review of Interventions to Reduce Computed Tomography Usage in the Emergency Department[18]	Jurisdiction	First author's affiliations are in Canada; included studies were from Australia, Canada, China, Iran, Italy, Japan, Kenya, Lebanon, Netherlands, Qatar, Spain, Taiwan, Turkey, UK, US
	Type of scan	CT – ED
	Brief description of strategy	Systematic review to assess interventions to reduce CT usage in ED. Strategies that consistently reduced CT usage included providing clinicians with other options instead of a CT scan: • Diagnostic pathways • Alternative test availability • Specialist involvement • Provider feedback (e.g., quarterly reminders) Strategies that had a greater reduction effect: engaged multiple specialties during planning and implementation (compared to being coordinated or implemented by ED staff only). Strategies that did not consistently reduce usage: family/patient education, clinical decision support tools, passive guideline dissemination.
	Assessment of effectiveness	Review assessed number of CT scans
Bhullar et al. (2021) – Reducing the MRI outpatient waiting list through a capacity and demand time series improvement programme[59]	Jurisdiction	New Zealand
	Type of scan	MRI
	Brief description of strategy	• Assessed capacity and demand • Rostered staff so scanners were fully operational during working hours • Added patient care assistant to assist with paperwork, complete patient consent checklists, assist getting patients in and out of the

First author	Criteria	Description
		scanning room • Patients with excessive waiting times (~300 days) could be grouped into 5 main groups; allowed these patients to be booked into specific segmented lists and scheduled together for improved efficiency • Introduced late weekday sessions and weekend sessions, prioritizing patients with longest waiting times • Outsourced scans performed at a flat-rate fee by private providers; outsourcing decided based on longer duration and long waiting times; decreased use of outsourcing later • Redesigned MRI operational systems, including: ◦ modified referral vetting process to simplify and allow other staff to vet lower complexity scans ◦ refined booking template for greater efficiency ◦ senior medical officers rostered to cover MRI sessions to limit cancellations (previously booked patients according to the officer's subspecialty, which created issues if the officer was unable to do the session)
	Assessment of effectiveness	• From January 2019 to November 2020, waiting list fell from 1,954 to 413 • Number of patients waiting for > 42 days had also dropped, with the average waiting time falling by 73 days • Scanning hours per week more than doubled
Boldor et al. (2021) – Reforming the MRI system: the Israeli National Program to shorten waiting times and increase efficiency[54]	Jurisdiction	Israel
	Type of scan	MRI
	Brief description of strategy	Ministry of Health established a National Program with the aim of shortening wait time for ambulatory MRI exams to 14 days; components included: • Every hospital with an ED and existing CT device would have at least 1 MRI scanner

First author	Criteria	Description
		• Updated working hours where possible to 24 hours active over 6 days for regular exams and 24/7 for urgent testing • Established training course to train new radiographers, and allocated additional radiographer positions • Introduced the first Israeli radiology fellowship to train specialist radiologists and opened new radiologist posts • Established a computerized national database of MRI utilization to provide comprehensive data from all facilities • Introduced financial incentive to increase number of authorized and funded exams; modified later to incentivize reducing wait times
	Assessment of effectiveness	Study assessed average wait time for adult neurology MRI, which fell from 52 days prior to reform to 24 days a year later; in the following 2 years it had increased slightly again, up to 32 days.
Bor et al. (2021) – Increasing Patient Access to MRI Examinations in an Integrated Multispecialty Practice[83]	Jurisdiction	US
	Type of scan	MRI
	Brief description of strategy	A multidisciplinary project team gathered to design and implement improvements to MRI; general goals and strategies included: • Improve communication (e.g., daily huddle email, load-balancing management strategies) • Create structured work and effective documentation (created cross-functional care pathway) At the ordering phase: • Enhanced information presented to providers at order entry system to increase awareness of appropriate MRI At scheduling phase: • Converted predesigned schedule to open schedule (allowing patients to insert appointment time convenient for them, instead of picking predetermined blocks) • Reduced schedule holds (meetings, maintenance)

First author	Criteria	Description
		• Codified process for removing stat holds • Promoted collaboration among stakeholders • Reduced complexity of scheduling process • Created scheduler training program For medical imaging staff: • MRI protocol assignments codified by radiologists, MRI technologists trained to select protocols for most patients • Standardized imaging protocols across units • Radiologists eliminated nonessential sequences from protocols • Benchmarked imaging protocols (other facilities, literature) • Tasked lead technologists to shorten imaging times while maintaining high standards • Reduced number of long examinations • Standardized MRI protocols • Shifted maintenance to outside regular business hours • Created macros (code to run automated commands in a software) for radiologists to promote appropriate use of MRI and to efficiently report common findings • Utilized MRI vendor utilization software to optimize protocols • If order has an error, allow radiology staff (technologists) to change orders based on protocol (not require reaching out to provider) ◦ Instead of management overseeing entire process, secured analytics resources to evaluate improvements, created daily access awareness and notification strategy, secured resources for targeted weekend and after-hours staffing, communicated improvements to stakeholder
	Assessment of effectiveness	• Average wait time fell from 14.2 days to 5.8 days • Average imaging time fell from 27.7 minutes to 24.8 minutes • Total number of examinations increased • Increased patient satisfaction

First author	Criteria	Description
Dako et al. (2018) – Use of Value Stream Mapping to Reduce Outpatient CT Scan Wait Times[84]	Jurisdiction	US
	Type of scan	CT
	Brief description of strategy	• Performed baseline analysis of workflow for outpatient CT • Multidisciplinary team (scheduling, IT, film library and financial services, radiologists, technologists, consultants, senior radiology administrative leaders) had a 2-day value stream mapping session, a process aiming to eliminate sources of waste by identifying steps in a chain of processes and break them down into 3 categories: ◦ Value-added: activity that changes the form, fit, or function of a desired product ◦ Value-enabling: activity that does not directly add value but needed to realize value-added activity ◦ Non–value-added: all other actions and unwanted features; represents waste • Created high-level process map to understand key steps of throughput, categorized tasks, determined percentages of correctly completed (on first attempt) processes • Identified key problems and solutions along process map, with solution themes converted into actionable items • Actionable items were stratified using prioritization matrix on basis of ease of implementation and impact • Created an ideal process map minimizing waste • Identified key effectors of quality: order inaccuracies addressed at arrival, missing laboratory work, form redundancy, poor communication, and departmental ergonomics • Established site-level working groups to design solutions and activate change, and a site-level steering committee was formed to provide oversight, key decision approvals, and risk mitigation • Working groups and steering committee met regularly • Implemented solutions included:

First author	Criteria	Description
		◦ technologist reviewed pending cases 3 days before arrival ◦ daily summary of order defects for manager review, schedule, and scanner ◦ optimized and consolidated registration forms ◦ departmental renovations
	Assessment of effectiveness	• Average total wait time fell from 3.1 hours to 1.1 hours • Average number of outpatient CT scans performed daily increased from 37 to 44
Neal et al. (2018) – Improving Breast MR Wait Times: A Model for Transitioning Newly Implemented Diagnostic Imaging Procedures into Routine Clinical Operation[85]	Jurisdiction	US
	Type of scan	MRI
	Brief description of strategy	• Study team (breast imaging radiologist, chief health system MR manager, an MR supervisor, and lead breast MR technologist) reviewed breast MR wait times (time from breast MR order placement to time of third-available breast MR scheduling slot), scheduling grids, and staffing models (radiologist and technologist) to identify root causes, with wait times tracked biweekly • Identified 2 root causes of long wait times: ◦ only 3 MR technologists trained to perform breast MRI examination ◦ radiologists required to monitor examinations as needed • In response, developed countermeasures to remove requiring direct physician monitoring and train additional technologists • Developed at 16-item proficiency checklist for the new MR technologist trainees, and provided training; trainees were evaluated by MR supervisor using checklist to ensure proficiencies had been achieved before they began independent scanning • Over time, added weekends and weekday evenings to schedule

First author	Criteria	Description
	Assessment of effectiveness	• Wait time for routine breast MRI fell from 101 days to 5 days • Technical recall rate was 0.5%; no recall was performed for a technologist-related error or scan quality concern • Proportion of examinations with minor or major image quality impairments did not change statistically significantly
Barbour and Thakore (2017) – Improving door to CT scanner times for potential stroke thrombolysis candidates – The Emergency Department's role[73]	Jurisdiction	UK – Scotland
	Type of scan	CT – Emergency Department (ED)
	Brief description of strategy	Plan for patients with a stroke arriving at ED; had multiple cycles: 1. Increase staff awareness and evaluate problem areas that may not have been previously apparent 2. Use information from cycle 1 to ensure equal knowledge of procedures across staff (emails) 3. Further educate using formal presentations 4. Produce memory aid that can be seen by all staff to help streamline and standardize approach 5. Simplify paperwork filled by senior doctors
	Assessment of effectiveness	Previously, 20% of patients were having their scan in 20 minutes and 70% in 45 minutes; after the last cycle, 60% were having their scan in 20 minutes and 100% within 45 minutes; the variation around the mean also had declined
Beker et al. (2017) – Optimizing MRI Logistics: Prospective Analysis of Performance, Efficiency, and Patient Throughput[86]	Jurisdiction	US
	Type of scan	MRI
	Brief description of framework	Study that assessed MRI scanners over 2 weeks to examine delays' sources, impact, and frequency at each stage; authors state they plan to address the issues causing the most delays: • Issues with IV or port placement, required calling a nurse to help: plan to implement competency course, ensure each shift has a

First author	Criteria	Description
		highly skilled worker who can ease IV placement • Continuing education for scheduling, booking processes • Review patient scheduling 3 days ahead of appointment to identify potential issues; if any discrepancies identified, notify scheduling office (to implement change) and patient • Safety concerns reviewed with scheduling, with purchase and utilization of a new MRI safety database • Worked to schedule arrival of interpreters to prevent delays (e.g., to limit delays from waiting for interpreter to arrive)
	Assessment of effectiveness	NR
Loving et al. (2017) – Time Is Not on Our Side: How Radiology Practices Should Manage Customer Queues[82]	Jurisdiction	First author's affiliations are in the US (jurisdiction otherwise not reported)
	Type of scan	Radiology in general
	Brief description of strategy	Lists examples of strategies, including: • Identified bottleneck identified at the preauthorization stage: found many patients require insurance processing at time of appointment instead of in advance, and registration desk is understaffed and there is a hiring freeze; reassigned an administrative assistant to obtain insurance preauthorization before day of appointment • To address varying levels of demand for scans, can: acquire backup staff for demand spikes, separate priority queues, use predictive analytics for demand spikes • If customers request an extra scan, can deny extra requests, accommodate with extra staff, and tell patients only specifically ordered exams are allowed • To address patients who may have differing ability levels to perform a task and thus require more time for an exam, can screen patients during scheduling, provide patients information about the scan procedure before their appointment, and hire backup staff • To address lack of detailed history provided, can reward compliance and/or penalize noncompliance (e.g., reject orders with vague

First author	Criteria	Description
		histories), force compliance with decision support systems, hire extra staff to accommodate
	Assessment of effectiveness	NR
Roussos et al. (2017) – Optimizing computed tomography simulation wait times in a busy radiation medicine program[28]	Jurisdiction	Ontario, Canada
	Type of scan	CT
	Brief description of strategy	Improvement program for CT simulation scans involved several phases: Phase 1: Reviewed current booking guidelines and compared to current departmental practice Phase 2: Retrospective chart review of patients (randomly selected from each disease site) Phase 3: Added time for patient care and staff engagement Phase 4: Measured improvements in wait times Changes implemented included: • Time audit: measured current time per booking, then optimized, e.g., appointment time was overestimated, could be reduced from 60 minutes to 40 minutes, then added 5 minutes for unplanned issues • Removed unnecessary scanning accessories • Allocated 2 appointment times to ensure preprocedure preparations were performed correctly, patient counselling directly before scans
	Assessment of effectiveness	• Duration of each CT simulation was shortened for almost all disease sites by 22% to 33%, or 10 to 15 minutes per appointment (exceptions: sarcoma, pediatric, and palliative patients, as they require unique management approaches) • Reduced rescanning rates for patients with self-administered preparations • Overall net gain of 3,060 minutes, or 102 additional 30-minute appointment slots, per month

First author	Criteria	Description
Purchasing new scanners		
Manitoba Health (2022) – Manitoba Provides Update on the Diagnostic and Surgical Recovery Task Force[25]	Jurisdiction	Manitoba, Canada
	Type of scan	CT, MRI
	Brief description of strategy	Purchased and installed a new mobile CT unit and 2 new mobile MRI units for Winnipeg
	Assessment of effectiveness	NR; reported that the units will be able to deliver more than 11,600 CT scans and 7,200 MRI scans annually
Additional operating funding		
Ontario Ministry of Health (2022) – Ontario Expanding Access to MRI Services Across the Province[38]	Jurisdiction	Ontario, Canada
	Type of scan	MRI
	Brief description of strategy	Invested more than $20 million in operating funding to support 27 new MRI machines in hospitals
	Assessment of effectiveness	NR; reported that with more MRI services available, patients can be diagnosed and receive care quicker
Expanding operating hours		
Lawlor (2022) – 'The patients are so grateful' QEII COVID-19 Response Fund tackles wait times, reduces procedure backlogs for patients[41]	Jurisdiction	Nova Scotia, Canada
	Type of scan	CT, MRI, other scans
	Brief description of strategy	• Used funding from a COVID-19 Response Fund to hire additional technologists, sonographers, and appointment booking staff to expand operating hours • Appointments opened on weekends and up to 11 p.m. on weekdays
	Assessment of effectiveness	• In first month, more than 900 elective patients removed from backlog list

First author	Criteria	Description
		• Expected that backlog of CT will clear in 1 year and access to MRI should improve in next 14 to 16 months
Huizinga (2022) – Horizon Health working overtime in March to clear MRI, mammogram backlog[43]	Jurisdiction	New Brunswick, Canada
	Type of scan	MRI, other scans
	Brief description of strategy	• Employees working overtime to clear the backlog of medical imaging (caused by COVID-19) • States time will be used to improve imaging processes
	Assessment of effectiveness	NR
Using research MRI scanners for clinical scans		
Roifman et al. (2020) – Novel Combined Clinical and Research Protocol to Reduce Wait Times for Cardiac Magnetic Resonance[36]	Jurisdiction	Ontario, Canada
	Type of scan	MRI
	Brief description of strategy	Assessed intervention where both clinical and research cardiac MRIs were performed on a research MRI machine: • Research coordinator evaluated waitlist weekly to identify and contact potential patients (stable outpatients referred for indication of heart failure) • Participating patients had their "clinical" scan cancelled and rebooked at research centre (affiliated with hospital) to be scanned by their MRI machine; 4 patients scanned under the combined protocol per day (1 day per week) • Patients underwent an extended scan (standard clinical MRI sequences and additional research sequences) • Scans reported by radiologist or cardiologist assigned to imaging on scan day and billed in usual manner

First author	Criteria	Description
	Assessment of effectiveness	• Wait time at this institution for an outpatient cardiac MRI has decreased from 9 months to 5 months after 2 years • Number of patients on wait list decreased from 151 to 103 after 2 years
Outsourcing scans		
Olofsson et al. (2019) – The impact of contracts on outsourcing computed tomography[65]	Jurisdiction	Sweden
	Type of scan	CT
	Brief description of strategy	Study compared 2 outsourcing approaches between a hospital radiology department (in-house) and private external units: • Detailed, specific contract (with-contract) • No contract
	Assessment of effectiveness	• Total management time (from referral to when patient is informed of result and/or results been taken into consideration of treatment) was slightly shorter in with-contract group (37 days) than no contract group (43 days); in-house was 42 days • Patient waiting time did not differ significantly between with-contract and no contract • Compared to the no contract group, fewer exams needed re-interpretation for the in-house and with-contract group • Authors concluded that compared to the no contract group, CT examinations in the with-contract group were associated with shorter overall management time, patient waiting time
Changes to booking or scheduling processes		
Fraig et al. (2022) – Early experience of a local pathway on the waiting time for MRI in patients presenting to a UK district general hospital with suspected cauda equina syndrome[78]	Jurisdiction	UK
	Type of scan	MRI

First author	Criteria	Description
	Brief description of strategy	Assessed Salisbury Protocol for Assessment of Cauda Equina Syndrome for patients presenting with suspected cauda equina syndrome (CES); the protocol included: • All suspected cases referred to and reviewed by on-call orthopedic registrar • History and examination findings were documented • Immediately after clinical assessment, discussed case with on-call orthopedic consultant or the spinal surgeon (either was always available during working hours on weekdays) • After establishing urgency, immediately placed request electronically (if during working hours, discussed with duty radiologist) • Two dedicated daily slots allocated for CES; if these slots were full, or if more urgently needed, patient underwent MRI as soon as possible according to availability and other clinical priorities • MRI operational 7 days a week from 9AM to 8PM; patients requiring urgent scanning at night transferred to tertiary hospital by ambulance • Outside working hours, registrar discussed with on-call orthopedic consultant, who decided if an urgent opinion from a spinal specialist at the tertiary referral centre was needed; if needed, an electronic referral was completed, followed by a telephone discussion • On-call orthopedic registrar responsible for checking and documenting the scan outcome and discussing findings with the spinal surgeon or on-call orthopedic consultant
	Assessment of effectiveness	Although the number of referrals for MRI doubled, the median time from MRI request to scan decreased from 9.1 hours to 4.2 hours; the number of patients transferred to the regional hub hospital also decreased from 7 to 3
Watura et al. (2022) – Direct Access and Skill Mix Can Reduce Telephone Interruptions and Imaging Wait Times: Improving Radiology Service Effectiveness, Safety and Sustainability[79]	Jurisdiction	UK

First author	Criteria	Description
	Type of scan	CT
	Brief description of strategy	• Investigated nature of telephone interruptions by asking radiology registrars to make record of all incoming calls • Identified scans that do not routinely require discussion with radiologist (have clear guidelines regarding indications and acquisition protocols) but have frequent calls for radiologists • Created new flow diagrams for referrers and radiographers to enable radiographers to accept routine requests for specific CT scans directly, without requiring radiologist; radiologist contacted if radiographer or referrer has specific queries or concerns • Established awareness of new protocols to stakeholders, including radiologists, service leads and junior medical staff, in a variety of settings through in-person departmental meetings, emails to clinical leads and junior medical staff, and printouts in control rooms
	Assessment of effectiveness	Mean wait time between CT head request and scan completion pre- and post-intervention was 5.2 and 3.2 hours respectively (a 40% reduction)
Gyftopoulos et al. (2019) – The Use of an Emergency Department Expeditor to Improve Emergency Department CT Workflow: Initial Experiences[96]	Jurisdiction	US
	Type of scan	CT – ED
	Brief description of strategy	Implemented a new role, an ED expeditor, piloted over 3 months from 12PM to 8PM on weekdays (busiest time for the ED). This role was stationed in the ED patient area to facilitate easy communication with ED providers. Their main role was to coordinate workup for a patient cleared to undergo ED CT, with tasks depending on specific protocol but generally including calling for transport and checking: • Imaging protocol • Priority • Oral contrast order, administration and start time • NPO status

First author	Criteria	Description
		• Pregnancy test • Renal function • IV placement and gauge check • Contrast allergies • Isolation precautions • CT availability Expeditor was sent emails to describe the new role and function, and trained for 4 weeks before starting, to observe CT technologists and physician-led teams to understand CT workflow and role.
	Assessment of effectiveness	Decreased mean ordered to scheduled turnaround time (time between order placement and CT workup completion) and mean ordered to completed turnaround time (time between order placement and CT exam completion)
Luo et al. (2018) – A discrete event simulation approach for reserving capacity for emergency patients in the radiology department[47]	Jurisdiction	China
	Type of scan	CT – ED
	Brief description of strategy	• Simulation study based on having 1 CT scanner at the hospital, assessing the impact of developing an emergency reservation policy for stochastic arrivals of ED patients • If new emergency patients arrive, they are scheduled in earliest nonemergency occupied slots and must wait until all emergency patients before them are served; otherwise, they are booked and scheduled in earliest free slot
	Assessment of effectiveness	Simulation found that reserving capacity for emergency patients shortens the delay for nonemergency patients by 42% to 46%, based on the different simulated cases
Small et al. (2018) – Emergency Magnetic Resonance Imaging 3-Tiered Prioritization[97]	Jurisdiction	US
	Type of scan	MRI – ED

First author	Criteria	Description
	Brief description of strategy	Developed a 3-level tiered, unambiguous classification system (1: critical; 2: emergent; 3: urgent) of ED patients, with each tier having • Guiding consensus-driven clinical definitions • Specific target "order to imaging start time" • Defined safety expectations and requirements
	Assessment of effectiveness	• Overall waiting time decreased from 4.1 hours to 2.7 hours • Tier 1 turnaround was 1.1 hours, tier 2 was 2.3 hours, and tier 4 was 4.1 hours
Coordinated referral pathway		
Wu et al. (2020) – Does a Multidisciplinary Triage Pathway Facilitate Better Outcomes After Spine Surgery?[23]	Jurisdiction	Saskatchewan, Canada
	Type of scan	MRI
	Brief description of strategy	• Compared patients undergoing elective lumbar surgery triaged through multidisciplinary pathway (Saskatchewan Spine Pathway) versus conventional referral • Patients who fail to respond satisfactorily to primary care algorithms for pain may be referred to Saskatchewan Spine Pathway clinics, where appropriateness and need for further imaging and/or surgical consultation is triaged
	Assessment of effectiveness	Wait time for MRI was shorter for the Saskatchewan Spine Pathway group (16.8 days, versus 63.0 days), though wait time to see surgeon or for surgery did not differ statistically significantly
Common et al. (2018) – Reducing Wait Time for Lung Cancer Diagnosis and Treatment: Impact of a Multidisciplinary, Centralized Referral Program[40]	Jurisdiction	Newfoundland, Canada
	Type of scan	CT
	Brief description of strategy	• Assessed referral to Thoracic Triage Panel, a centralized referral program for patients with abnormal lung CT, including nurse navigation, weekly multidisciplinary meetings, and regular communication with primary care provider using standardized

First author	Criteria	Description
		forms; nurse navigator coordinates patient care and acts as contact person • Traditional process is led by the primary care provider
	Assessment of effectiveness	Time from first abnormal imaging to biopsy and treatment initiation were shorter for patients handled by the panel compared to traditional process
Chiarelli et al. (2017) – Evaluating wait times from screening to breast cancer diagnosis among women undergoing organised assessment vs usual care[30]	Jurisdiction	Ontario, Canada
	Type of scan	MRI (breast cancer screening; also includes mammograms)
	Brief description of strategy	• Ontario Breast Screening Program: organized assessment through Breast Assessment Centres, where an abnormal mammogram is followed by coordinated referrals using navigators for further imaging, biopsy, and surgical consultation as indicated • Compared to usual care (further diagnostic imaging is arranged directly from the screening centre and/or through their physician; results must be communicated to the physician who is responsible for arranging necessary biopsy and/or surgical consultation)
	Assessment of effectiveness	Screened patients with breast cancer, if assessed through Breast Assessment Centres (compared to usual care), were • More likely to be diagnosed within 7 weeks • More likely to have first assessment within 3 weeks of abnormal mammogram • More likely to have imaging or biopsy (vs consultation only) at first assessment visit • Overall, more likely to have shorter wait times to diagnosis
Artificial intelligence and/or machine learning		
Lee et al. (2022) – Emergency triage of brain computed tomography via anomaly detection with a deep generative model[64]	Jurisdiction	South Korea

First author	Criteria	Description
	Type of scan	CT – ED
	Brief description of strategy	Developed an anomaly detection algorithm with a deep generative model trained on brain CT images of healthy individuals to reprioritize radiology worklists and provides lesion attention maps for brain CT images with critical findings; conducted a clinical simulation test of an emergency cohort
	Assessment of effectiveness	• Median wait time was statistically significantly shorter postintervention (70.5 seconds, compared to 422.5 seconds) • Median radiology report turnaround time was also statistically significantly faster (88.5 seconds, compared to 445.0 seconds)
Mayberg et al. (2022) – Anisotropic neural deblurring for MRI acceleration[55]	Jurisdiction	First author's affiliations are in Israel (jurisdiction otherwise not reported)
	Type of scan	MRI
	Brief description of strategy	Proposed using a method of enhancing low-resolution brain MRIs using a trained network, so acquisition time can be shortened while still producing an image that can be used for diagnosis
	Assessment of effectiveness	NR; image quality was stated to be good quality as assessed by senior neuroradiologists
Monsour et al. (2022) – Neuroimaging in the Era of Artificial Intelligence: Current Applications[88]	Jurisdiction	First author's affiliations are in the US (jurisdiction otherwise not reported)
	Type of scan	MRI
	Brief description of strategy	Review highlighting some potential uses for AI in MRI, including: • Improve quality of neuroimaging • Predict wait times (may allow for more efficient patient scheduling and reveal areas of patient processing that could be changed) • Reduce need for repeat scans, determining if an MRI is usable clinically or unclear enough to require repetition • Speed up neuroimaging through algorithm(s) that reduce aliasing and improve resolution in compressed scans • Allow for reduced contrast dosages, which may help to prevent

First author	Criteria	Description
		allergic reactions (which may also lead to delays) • Assist triage, patient screening, providing a second opinion rapidly, shortening time needed for attaining a diagnosis • Quantify brain structures in neuroradiology (e.g., through MRI) for analysis of anatomy
	Assessment of effectiveness	NR
Moummad et al. (2021) – The Impact of Resampling and Denoising Deep Learning Algorithms on Radiomics in Brain Metastases MRI[50]	Jurisdiction	France
	Type of scan	MRI
	Brief description of strategy	Developed resampling and denoising deep learning models, evaluated their impact on radiomics from fast acquisition MRI brain images with metastases
	Assessment of effectiveness	Fast acquisition resulted in low-resolution images, but deep learning models restored parameters; authors suggested these findings indicate possibility of using deep learning-reconstructed MRI images of brain metastases for predictive radiomic model purposes
O'Neill et al. (2021) – Active Reprioritization of the Reading Worklist Using Artificial Intelligence Has a Beneficial Effect on the Turnaround Time for Interpretation of Head CT with Intracranial Hemorrhage[89]	Jurisdiction	US
	Type of scan	CT
	Brief description of strategy	Assessed commercially available machine learning algorithm that flags abnormal noncontrast CTs to detect intracranial hemorrhage; was implemented in 3 stages: 1. "Pop-up" widget on ancillary monitors and education 2. Marked examination ("flagged" studies) in worklists as positive 3. Worklists reprioritized based on positive flags

First author	Criteria	Description
	Assessment of effectiveness	• No difference found for queue size-adjusted wait time (interval between end-of-examination time stamp and initial report creation time stamp) for stages 1 and 2 • Reduced wait time for in phase 3 for flagged CTs (12.01 minutes) compared to negative CTs (16.45 minutes) and baseline (prior to intervention; 15.75 minutes)
University of British Columbia Cloud Innovation Centre (2021) – Vancouver Coastal Health MRI Project "CAN'T WAIT"[20]	Jurisdiction	British Columbia, Canada
	Type of scan	MRI
	Brief description of tool	• Goal: to improve MRI requisition process, reducing wait times and optimizing prioritization review for radiologists • Trained a machine learning system to recommend an accurate triage prioritization value for submitted requests • Built a rules-based algorithm using Natural Language Processing services, which uses the criteria on the submitted MRI requisition to help inform assigning the patient to the MRI site with the fastest turnaround time for their assigned priority or contrast
	Assessment of effectiveness	NR
Curtis et al. (2018) – Machine Learning for Predicting Patient Wait Times and Appointment Delays[87]	Jurisdiction	US
	Type of scan	CT, MRI; also included other imaging modalities
	Brief description of strategy	• Assessed various types of machine learning to predict waiting and delay times at scheduled radiology facilities • Found that elastic net model was best at predicting for all modalities, and identified more important predictors: ◦ patient queue length (current and most recent), ◦ examination queue length (number of examinations scheduled to be done before most recently arrived patient) ◦ order in which the most recent patient arrived, relative to other patients with the same appointment time

First author	Criteria	Description
		◦ median examination time of the 5 most recent examinations (particularly for MRI).
	Assessment of effectiveness	NR
Use of technology for scheduling		
Pang et al. (2022) – A dynamic sequential decision-making model on MRI real-time scheduling with simulation-based optimization[95]	Jurisdiction	First author's affiliations are in China and the US; for a real-world case experiment, assessed a hospital in the US
	Type of scan	MRI
	Brief description of strategy	Developed a model to based on real-time information (of the waiting patients and MRI scanners) which runs several simulations to estimate performance of several possible decisions, then select the best choice to reduce idle scanners and patient waiting times
	Assessment of effectiveness	Simulation produced decisions that appear better than real-world (i.e., reduced patient waiting time, increased MRI scanner utilization)
Yao et al. (2020) – Solving patient referral problems by using bat algorithm[66]	Jurisdiction	Taiwan
	Type of scan	MRI
	Brief description of strategy	Developed a simulation model using system simulation and a bat algorithm to calculate optimal value of daily referral patients
	Assessment of effectiveness	Model produced recommendations to increase the average total monthly MRI referral patients, which would reduce the wait time from 16 to 8 days
Arun and Panicker (2019) - Development of a Patient Scheduling System for a Radio Diagnosis Department[52]	Jurisdiction	India
	Type of scan	CT
	Brief description of tool	Developed a real-time, user-friendly patient scheduling tool in Microsoft Excel, which will provide a schedule based on input (scanning type, date preference)
	Assessment of effectiveness	NR

First author	Criteria	Description
Accelerated pathways		
Chang et al. (2021) – Impact of COVID-19 Workflow Changes on Patient Throughput at Outpatient Imaging Centers[90]	Jurisdiction	US
	Type of scan	MRI
	Brief description of strategy	Developed workflow changes due to COVID-19, including protocols to shorten MRI scanning protocols: • MRI committee took pandemic as opportunity to review MRI protocols to eliminate unnecessary sequences, optimize parameters (e.g., interecho spacing, taking full advantage of higher gradient strengths and slew rates on newer scanners, and introducing advanced pulse sequences) • Guideline for changes: cannot compromise imaging quality • Formed group including radiologists that interpret MRI and advanced practice technologist specialists to develop and test new sequences and parameters for image quality
	Assessment of effectiveness	Reported that implementation of accelerated imaging protocols resulted in an aggregated reduction of 9.7% in MRI exam times
Li et al. (2021) – The Feasibility of a Fast Liver MRI Protocol for Lesion Detection of Adults at 3.0-T[91]	Jurisdiction	US
	Type of scan	MRI
	Brief description of strategy	Tested the diagnostic capacity of a fast liver MRI exam protocol compared to conventional protocol
	Assessment of effectiveness	Compared to conventional protocol, the proposed fast liver MRI workflow: • had 96.4% concordance • was faster (without adjustment and waiting time, 4 minute and 28 seconds, compared to 6 minutes for the conventional protocol)

First author	Criteria	Description
Shakeel et al. (2021) – Wait times in the management of non–small cell lung carcinoma before, during and after regionalization of lung cancer care: a high-resolution analysis[29]	Jurisdiction	Ontario, Canada
	Type of scan	CT
	Brief description of strategy	Assessed wait times for patients with non–small cell lung carcinoma before and after regionalization of lung cancer care in Ontario
	Assessment of effectiveness	• Noted that 5 years after regionalization, patients had shorter wait times between first physician visit to CT scan, and time from abnormal CT scan to first surgeon visit, compared to before regionalization; however, they had longer wait times at other parts of the pathway between symptom onset to first treatment, resulting in a longer total wait time • A more streamlined diagnostic process was adopted after regionalization through implementing clinical decision-making models (diagnostic pathways) developed by Cancer Care Ontario for primary care providers, which may have contributed to the decrease in time to CT
Buell et al. (2019) – Expediting the management of cauda equina syndrome in the emergency department through clinical pathway design[77]	Jurisdiction	UK
	Type of scan	MRI – ED
	Brief description of strategy	Developed a pathway aiming to reduce time needed to diagnose or exclude cauda equina syndrome (CES) by MRI in the ED: • Surveyed ED staff to assess barriers, then developed new clinical pathway to address identified barriers • Pathway ensured early ED consultant assessment of patients suspected of CES, empowered ED consultants to order MRIs prior to neurosurgery review; they could then call the radiology team to communicate the result, and the patient would be referred to neurosurgery based on the MRI result

First author	Criteria	Description
		• If ED consultant not on-duty, can be done by ED registrar with neurosurgeon reviewing patient within the hour
	Assessment of effectiveness	In study of 17 patients: • Time from arrival to ED and MRI preliminary report fell from 8 hours 17 minutes to 5 hours 17 minutes • Proportion of patients who underwent MRI remained constant
Rudder et al. (2019) – Effects of an MRI Try Without program on patient access[92]	Jurisdiction	US
	Type of scan	MRI
	Brief description of strategy	Program to reduce usage of sedation or anesthesia for pediatric MRI: • Identified children at least 4 years old and had a single order for a specific MRI scan (brain, face, neck, orbit, spine, extremity, or MR elastography; excluded chest or abdominal as motion artifacts are more prominent for these) and invited patients' caregiver to schedule an MRI Try Without appointment • Patients and families met with a child life specialist who prepared them for the MRI (e.g., using videos and pictures of the environment and equipment, demonstrating with a mock scanner and dolls) • Child life specialist assisted technologist in moving patient to MRI room; patient would watch a movie or listen to music during scan • If knew patient needed IVs for contrast before the scan, IV was placed in a separate room before the patient came into the scanner room, and child life specialist provided support during IV placement
	Assessment of effectiveness	• Average number of days between order placement and exam completion was 15.4 days, while the third-available appointment with sedation or anesthesia was 46.2 days • Authors stated this reduced waiting time for an MRI, but did not report waiting time without this program
Bargnoux et al. (2018) – Point-of-care creatinine testing in patients receiving contrast-enhanced computed tomography scan[51]	Jurisdiction	France

First author	Criteria	Description
	Type of scan	CT – ED
	Brief description of strategy	As renal function must be assessed before contrast-enhanced CT (due to risk for an acute kidney injury), this study aimed to evaluate the implementation of a rapid point-of-care creatinine test for patients at the ED for a CT
	Assessment of effectiveness	Point-of-care creatinine test had good agreement with central laboratory methods, and was faster (results were available in approximately 0.52 hours, compared to 1.95 hours), which led to a reduced waiting time for CT (1.73 hours, versus 2.57 hours)
Farrell et al. (2018) – Acute appendicitis in childhood: oral contrast does not improve CT diagnosis[93]	Jurisdiction	US
	Type of scan	CT
	Brief description of strategy	Assessed impact of conducting CT without oral contrast for suspected appendicitis in children, compared to using oral contrast
	Assessment of effectiveness	• Patients who did not use oral contrast had a shorter mean CT turnaround time (43.8 minutes) compared to patients who used oral contrast (137.4 minutes) • No difference in diagnostic accuracy
Ma et al. (2018) – Fast 3D Magnetic Resonance Fingerprinting (MRF) For a Whole Brain Coverage[94]	Jurisdiction	US
	Type of scan	MRI (Magnetic Resonance Fingerprinting)
	Brief description of strategy	Assessed an accelerated acquisition of 3-D magnetic resonance fingerprinting scan (total acceleration factor of 144, compared to Nyquist rate)
	Assessment of effectiveness	Accelerated scan showed good agreement with standard values with high image quality in less than 5 minutes
Al Kadhi et al. (2017) – A renal colic fast track pathway to improve waiting times and outcomes for patients presenting to the emergency department[74]	Jurisdiction	UK

First author	Criteria	Description
	Type of scan	CT – ED
	Brief description of tool	• Nurse-led fast-track pathway for patients with ureteric or renal colic to streamline patient flow • Patients screened on arrival to ED by a checklist, determined if eligible for fast-track pathway; if met criteria, directed to analgesia, fast-track noncontrast CT, and review by urology clinician
	Assessment of effectiveness	Time to radiologist-reported imaging was shorter in the fast-track group (99.9 minutes) than non–fast-track group (148.9 minutes)
Rapid and walk-in clinics		
Paulino Pereira et al. (2022) - Superfast Magnetic Resonance Imaging-based Diagnostic Pathway for Prostate Cancer[56]	Jurisdiction	Netherlands
	Type of scan	MRI
	Brief description of strategy	Assessed a superfast (< 36 hours) diagnostic pathway for patients at risk of prostate cancer (prostate-specific antigen levels between 3 and 50 ng/mL, and/or abnormal digital rectal exam): • Repeat prostate-specific antigen blood test, MRI, urology consultation, and if indicated prostate biopsies done in the morning, with diagnosis and telephone consultation by next day afternoon
	Assessment of effectiveness	• Authors reported that time from referral to histopathology diagnosis of prostate cancer can take several months, and introduction of prebiopsy MRI has also added to time to diagnosis; this superfast pathway is comparably faster • From sample of 48 patients who underwent biopsy, 73% diagnosed with prostate cancer (86% clinically significant) • Low rate of last-minute cancellation due to illness or no-show (4%)
Bhuva et al. (2019) – MRI for patients with cardiac implantable electronic devices: simplifying complexity with a 'one-stop' service model[80]	Jurisdiction	UK
	Type of scan	MRI

First author	Criteria	Description
	Brief description of strategy	Set up a 'one-stop' service model for patients with cardiac implantable electronic devices (require additional steps for MRI): • Surveyed hospitals to understand service and clinicians' awareness, and patients for their experience • Trained team of administrators, physicians, cardiac physiologists, and radiographers; developed standard booking protocol to prevent unnecessary request refusals and delays (scheduling and during scanning) • Organized bookings into preallocated scanning sessions, allowing all necessary staff to be present at scan, and specific individuals could be trained to perform the service • Over time, adjusted pathways to improve patient experience
	Assessment of effectiveness	Waiting time fell from 60 days to 15 days; no adverse events from MRI scans despite cardiac devices
Gulak et al. (2019) – Implementing a one-day testing model improves timeliness of workup for patients with lung cancer[31]	Jurisdiction	Ontario, Canada
	Type of scan	MRI; also assessed others
	Brief description of strategy	Multidisciplinary team created a "Navigation Day," a single-day visit for patients with lung cancer including nurse-led teaching, social work, smoking cessation counselling, symptom control, and dedicated test slots for integrated PET-CT, pulmonary function tests, and MRI of the brain
	Assessment of effectiveness	Wait time for brain MRI fell from 16.0 days to 10.2 days
van Sambeek et al. (2018) – The success of walk-in-computed tomography in practice[60]	Jurisdiction	Netherlands
	Type of scan	CT
	Brief description of strategy	• Assessed implementation of walk-in CT for all outpatients and emergency patients • Limited appointments available for inpatients and outpatients who

First author	Criteria	Description
		require special preparation or patients who request an appointment • Patients using a contrast agent can also walk in
	Assessment of effectiveness	Authors concluded that walk-in CT functions better than an entirely appointment-based one by nearly eliminating access time and increasing satisfaction among staff, physicians, and patients
Alternative exams or pathways		
Alhowimel et al. (2021) – Development of a Logic Model for a Programme to Reduce the Magnetic Resonance Imaging Rate for Non-Specific Lower Back Pain in a Tertiary Care Centre[62]	Jurisdiction	Saudi Arabia
	Type of scan	MRI
	Brief description of tool	• Proposed model to reduce unnecessary MRIs by providing early physiotherapy for lower back pain • Patients will be screened; those who have no red flags will be referred to physiotherapy rather than straight to MRI
	Assessment of effectiveness	Expect to see reduced MRI referrals (estimated 25% reduction after 6-month pilot); also plan to assess time to access the service
Cock et al. (2021) – Adapting a 2-week-wait colorectal service in the pandemic using the quantitative faecal immunochemical test[75]	Jurisdiction	UK
	Type of scan	CT
	Brief description of strategy	• Due to COVID-19, developed a temporary procedure to introduce quantitative fecal immunochemical test (qFIT); patients' investigations were deferred for 2 weeks if result was negative (<10) • Reviewed strategy, identified some cancers in negative population • Have modified procedure: still perform qFIT to triage, patients with qFIT < 10 referred to their general practitioner for further review, streamlining referral process and increasing probability of being investigated by the correct specialty

First author	Criteria	Description
	Assessment of effectiveness	Some patients who had a qFIT < 10 were later determined to have cancer; however, this may help to triage and prioritize patients if there is lack of staff and/or capacity for a CT
O'Donohoe et al. (2021) – COVID-19 recovery: tackling the 2-week wait colorectal pathway backlog by optimising CT colonography utilisation[76]	Jurisdiction	UK
	Type of scan	CT
	Brief description of strategy	Retrospective review; assessed patients who underwent CT colonography to determine appropriateness
	Assessment of effectiveness	Found that only 13% of CT colonography procedures met guidance, and some should have undergone a colonoscopy instead; this may be a method of addressing the backlog of CT resources
Kandiah et al. (2020) – Reducing the Volume of Low-Value Outpatient MRI Joint Examinations in Patients ≥55 Years of Age[21]	Jurisdiction	British Columbia, Canada
	Type of scan	CT, MRI arthrogram
	Brief description of strategy	Assessed if referring to X-ray to evaluate concomitant osteoarthritis could reduce inappropriate MRI and CT arthrogram use, for patients scheduled for outpatient MRI (who did not have red flags)
	Assessment of effectiveness	Resulted in statistically significantly fewer number of low-value protocoled MRIs and CT arthrogram examinations
Law et al. (2020) – Computed tomography-based diagnosis of occult fragility hip fractures offer shorter waiting times with no inadvertent missed diagnosis[63]	Jurisdiction	Singapore
	Type of scan	MRI
	Brief description of strategy	Retrospective review of scans for occult fragility hip fractures, comparing CT and MRI

First author	Criteria	Description
	Assessment of effectiveness	• Compared to MRI, CT group had a shorter mean waiting times (29 hours; MRI: 44 hours); surgical delay was not statistically significantly different (CT: 82 hours; MRI: 128 hours) • No readmissions for fracture 12 months after negative scan • Suggests modern CT may be comparable to MRI for detecting occult fractures, may be suitable alternative (in absence of cancer history) if MRI wait times are long or is contraindicated
Patient education interventions		
Dawdy et al. (2018) – Developing and Evaluating Multimedia Patient Education Tools to Better Prepare Prostate-Cancer Patients for Radiotherapy Treatment (Randomized Study)[32]	Jurisdiction	Ontario, Canada
	Type of scan	CT
	Brief description of strategy	Educational tools for patients provided prior to appointment, with a reminder 1 to 3 days before their appointment to review the provided tools: • Multimedia education: educational video and pamphlet • Pamphlet only
	Assessment of effectiveness	Both treatment groups had a lower rescan rate (24% of patients requiring a rescan) compared to the historical control (76%)
Physician education interventions		
Zarrabian et al. (2017) – Improving spine surgical access, appropriateness and efficiency in metropolitan, urban and rural settings[34]	Jurisdiction	Ontario, Canada
	Type of scan	MRI
	Brief description of strategy	• Assessed impact of Inter-professional Spine Assessment and Education Clinics (ISAEC) on patients with persistent or recurrent low back pain meeting surgical referral criteria • Authors noted MRI has been shown to be unreliable for detecting pathology that should be managed with surgery, but it is common practice for spine surgeons in Canada to request MRI upon referral

First author	Criteria	Description
	Assessment of effectiveness	At ISAEC locations, referral MRI usage decreased by 31%
Appropriate use checklist and guidance		
Madani Larijani et al. (2021) – Combined lumbar spine MRI and CT appropriateness checklist: a quality improvement project in Saskatchewan, Canada[24]	Jurisdiction	Saskatchewan, Canada
	Type of scan	CT, MRI
	Brief description of strategy	Developed and adopted evidence-based lumbar spine MRI and CT combined checklist into radiology requisition process, based on a systematic literature search; tested at 2 sites
	Assessment of effectiveness	Mixed results: • At 1 site, saw decrease in monthly number of lumbar spine MRI requisitions but no change in CT • At another site, saw increase in MRI and decrease in number of CT requests – possibly due to physicians switching from CT to MRI, which may be more appropriate for some indications
Xu et al. (2020) – Reduction in inappropriate MRI knee studies after implementation of an appropriateness checklist: Experience at a tertiary care centre[35]	Jurisdiction	Ontario, Canada
	Type of scan	MRI
	Brief description of strategy	Developed knee MRI appropriateness checklist with mandatory adherence from referring physicians; presence of moderate or greater osteoarthritis on reports was marker for inappropriate MRIs
	Assessment of effectiveness	• Proportion of knee MRIs of moderate or greater grade osteoarthritis decreased significantly, particularly severe osteoarthritis • Number of knee MRIs performed fell by 48% • Wait times for knee MRIs fell from 23.3 days to 17.4 days though this was not statistically significant
Mettias and Lyons (2019) – Magnetic resonance imaging for vestibular schwannoma: cost-effective protocol for referrals[81]	Jurisdiction	UK

First author	Criteria	Description
	Type of scan	MRI
	Brief description of strategy	Based on previously published guidelines, developed MRI referral criteria, and compared before and after to assess impact of using a referral protocol
	Assessment of effectiveness	Reported that after implementing referral criteria: • percentage of appropriate referrals increased • percentage of resources wasted decreased • wait times decreased
Tan et al. (2017) – Breast magnetic resonance imaging: are those who need it getting it?[39]	Jurisdiction	Quebec, Canada
	Type of scan	MRI
	Brief description of strategy	1. Conducted audit and institution of breast MRI exams being performed to classify indications 2. Organized a multidisciplinary half-day session for the breast team: presented an informal review of literature about MRI use for breast cancer staging, high-risk screening, and other indications, then developed an institutional consensus-based modified radiology form to reflect accepted indications for MRI; also took steps to ensure the document was easily accessible to all clinicians
	Assessment of effectiveness	• Wait time for estimated next nonurgent breast MRI fell from 320 days to 176 days (after 1.5 years) • From 6 months after consensus implementation to 1.5 years after, proportion of requests exceeding wait time decreased
Improved communication		
Huang et al. (2022) – Emergency department treatment process planning: a field research, case analysis, and simulation approach[48]	Jurisdiction	First author's affiliations are in China (jurisdiction otherwise not reported)
	Type of scan	CT – ED

First author	Criteria	Description
	Brief description of strategy	• Simulation study to assess bottlenecks in treatment time at ED and propose an optimized management strategy • Authors suggest it is necessary to establishing effective communication channels between the ED with administrative, clinical, and medical technical departments to improve the efficiency of CT use and reduce patient waiting times
	Assessment of effectiveness	NR

AI = artificial intelligence; DI = diagnostic imaging; ED = emergency department; ISAEC = Inter-professional Spine Assessment and Education Clinics; MR = magnetic resonance.
Note that this table has not been copy-edited.