Reducing the MRI outpatient waiting list through a capacity and demand time series improvement programme

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ABSTRACT

INTRODUCTION: A capacity and demand improvement initiative commenced in January 2019 with the goal of reducing the growing outpatient waiting list for magnetic resonance imaging (MRI) at Counties Manukau District Health Board (CMDHB). Initial work showed that the capacity (MRI machines and staff) actually outstripped demand, which challenged pre-existing assumptions. This became the basis for interventions to improve efficiency in the department. Interventions undertaken can be split into three distinct categories: (1) matching capacity to demand, (2) waiting list segmentation and (3) redesigning operational systems.

METHODS: A capacity and demand time series during 2019 and 2020 was used as the basis for improving waiting list and operational systems. A combination of the Model for Improvement and Lean principles were used to embed operational improvements. Multiple small tests of change were implemented to various aspects of the MRI waiting list process. Staff engagement was central to the success of the quality improvement (QI) initiatives. The radiological information system (RIS) provided the bulk of the data, and this was supplemented with manual data collection.

RESULTS: The number of people waiting for an MRI scan decreased from 1,954 at the start of the project to 413 at its conclusion—an overall reduction of 75%. Moreover, the average waiting time reduced from 96.4 days to 23.1. Achieving the Ministry of Health's (MoH) Priority 2 (P2) target increased from 23% to 87.5%.

CONCLUSION: A partnership between Ko Awatea and the radiology department at CMDHB, examining capacity and demand for MRI and using multiple QI techniques, successfully and sustainably reduced the MRI waiting list over a two-year period. The innovative solutions to match capacity to demand may be instructive for other radiology departments, and other waiting list scenarios.

In 2018 an additional magnetic resonance imaging (MRI) machine was purchased, bringing the Counties Manukau District Health Board (CMDHB) total to three. This increase in physical capacity had not reduced the waiting list as expected and, despite outsourcing 60 scans per week to private providers, the backlog and waiting times for MRI scans were increasing.

At the start of the project, 1,954 patients were on the waiting list, and only 23% had MRI scans performed within six weeks—the Ministry of Health (MoH) Priority 2 (P2) target. The perception was that a lack of medical radiology technicians (MRTs) was the significant factor preventing the department from meeting demand.

In December 2018 the radiology department requested assistance from Ko Awatea (CMDHB's centre for innovation and improvement) to improve the performance of the MRI service, particularly to reduce the waiting list.

Stakeholders agreed that a demand and capacity study would be undertaken

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to identify and realise opportunities to increase activity.

Method

Staff engagement

All staff groups involved with the MRI process participated in its improvement (ie, clerical booking staff, nursing, MRTs and radiologists). Regular meetings were held with staff groups, both separately and collectively, to identify perceived roadblocks; from this a framework for improvement was developed. Meetings continued regularly: mapping progress, identifying issues and defining action plans.

This initiative used Lean tools[1] and the Model for Improvement.[2] Lean aims to reduce waste in a system; waste is defined as anything that does not add value (eg, waiting for a test). These tools were used in several ways to: value-stream map the process, observe how the system actually worked and listen and work with front-line staff. The Model for Improvement uses small tests of change: Plan-Do-Study-Act (PDSA) cycles to rapidly trial different ways of working.

The Model for Improvement asks three crucial questions that guided the overall initiative:

1. What are we trying to achieve?

The aim of this study was to optimise the available capacity to better match MRI outpatient demand, reduce the waiting list to less than 500 and meet the MoH's P2 national target of 85% of scans completed within six weeks.

2. How will we know that a change is an improvement?

Not all change produces improvement—this question requires the definition of measures to confirm improvement:

- Number of people on the waiting list (measured every Tuesday).
- Number of patients waiting in each segment (<42 days, 42–90 days, 91–120 days, 121–150 days, 151–180 days, >180 days).
- P2 compliance rate—percentage of patients scanned within 42 days from the date of referral (measured weekly).
- Average waiting time (measured monthly).
- Scanning hours utilised per week.

It was important to measure demand, capacity, backlog and activity in the same units for the same period of time, and to have clear definitions of key metrics (Figure 1).

Figure 1: Definitions of terms.[3]

1. Demand: What the service is being asked to do
2. Capacity: What the service could be doing with its resources used optimally
3. Activity: What the service actually did
4. Backlog: What the service should have done but haven't

3. What changes can we make?

All improvement requires change and being specific about the primary drivers in managing the MRI waiting list was important. Change interventions (Figure 2) can be split into three distinct categories:

1. matching capacity to demand
2. waiting list segmentation
3. redesigning the operational systems.

Interventions were trialled in small tests of change (PDSA cycles) in each of the three areas.

Matching capacity to demand

The first action was to establish the relationship between departmental capacity (equipment and staff), incoming demand (referrals) and activity (completed and reported scans).

Demand and activity data were generated through the radiology information system (RIS) reports, which displayed the number and types of scans being referred and completed in chronological order. As the reports did not record the time each scan took, this was added manually.

Although the MRI machine capacity was apparent (ie, three MRI machines available 24 hours per day), the productive output was also dependent on the availability of MRTs. Capacity data, in the form of staffing rosters by scanner, were translated into available daily staffing hours.

In reviewing this capacity and demand information, it became clear that there was sufficient capacity to meet demand (Figure 3). In fact, the daily available capacity of staff was greater than incoming demand by 2.5–3 times.

Demand was outstripping activity, even though it was not exceeding the actual capacity of the unit. Understanding this became the basis for interventions to increase activity and reduce the waiting list.

Demand fluctuated throughout the week, with Mondays and Fridays being the busiest. The MRT roster was unbalanced and not matched to demand; many part-time MRTs were not rostered on Mondays or Fridays, resulting in more MRT capacity than scanner availability midweek, and insufficient capacity to run the scanners on the busiest days (Figure 4).

The 80th percentile of the variation in the number of hours of incoming demand was chosen to be the minimum number of hours that were required. This meant that a minimum of 18.5 MRT-hours per day (over the three machines) would be required every weekday to meet demand. Staff were rostered to be more evenly spread across the working week to ensure that each scanner was fully operational within working hours.

Historical staffing patterns for each MRI machine were also reviewed. When there were two MRI machines in different locations, each machine was staffed with two MRTs. When the new machine arrived and co-located with the one in the department, this staffing model continued until the staff identified that we could test a ‘2+1 model’. This utilised one MRT per scanner and a ‘floating MRT’ shared between two rooms, with the focus of ensuring an efficient flow of patients. This minimised the non-scanning dwell time between patients, as the floating MRT could ensure upcoming patients were prepped and ready to be scanned as previous diagnostic tests concluded.

A patient care assistant (PCA) was also added to the staffing roster—this role was tasked to assist with paperwork, completing patient consenting checklists and assisting MRTs in getting patients in and out of the scanning room. The efficiency of the stand-alone scanner increased from a nadir of less than 20% to over 99% (Figure 5).

Scanning list segmentation

Initial work aimed to decrease the downtime between scans by grouping scans of the same body part (eg, head, shoulder), avoiding the need to change MRI coils between scans and allowing more scans to be completed in a list.

Patients with excessive waiting times could be grouped into five main groups (Figure 6). The average waiting time for this type of patient was close to 300 days.

Figure 2: Driver diagram for MRI optimisation.

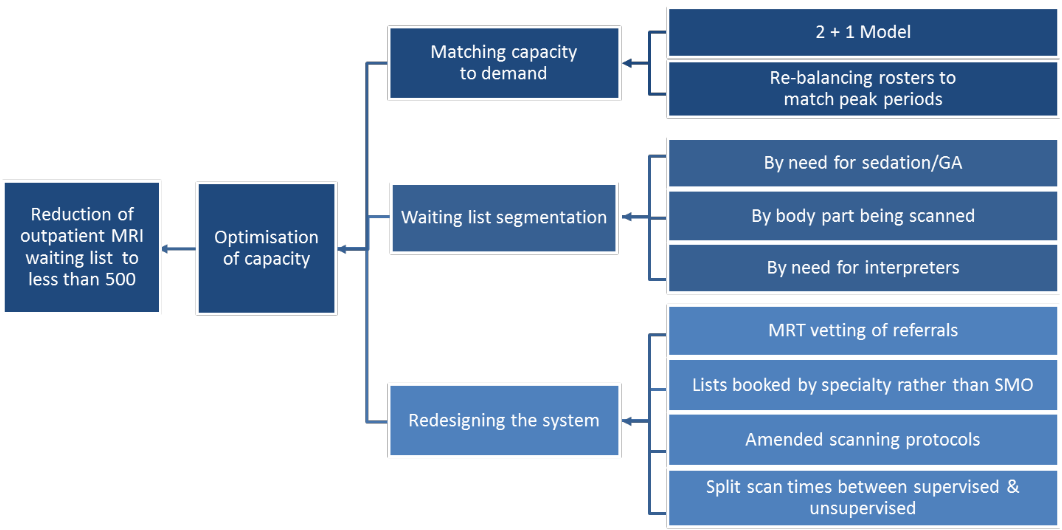


Figure 3: Demand and capacity measures over six months.

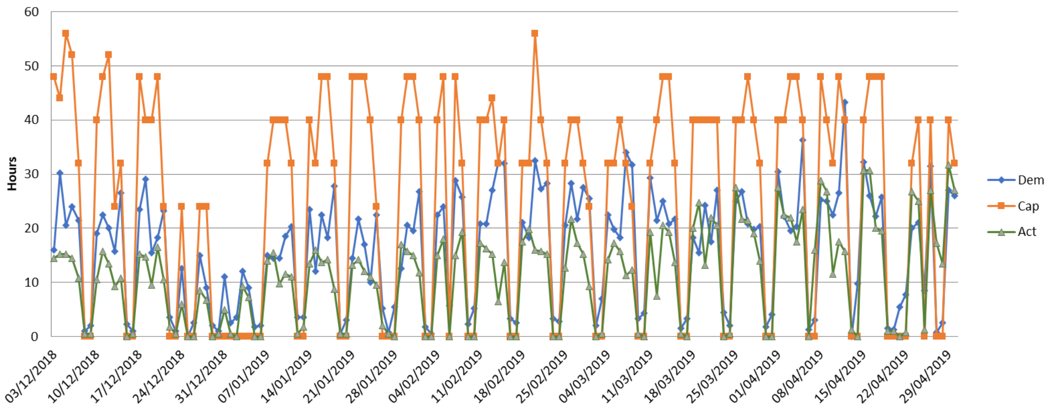


Figure 4: Capacity and demand in cumulative hours by weekday.

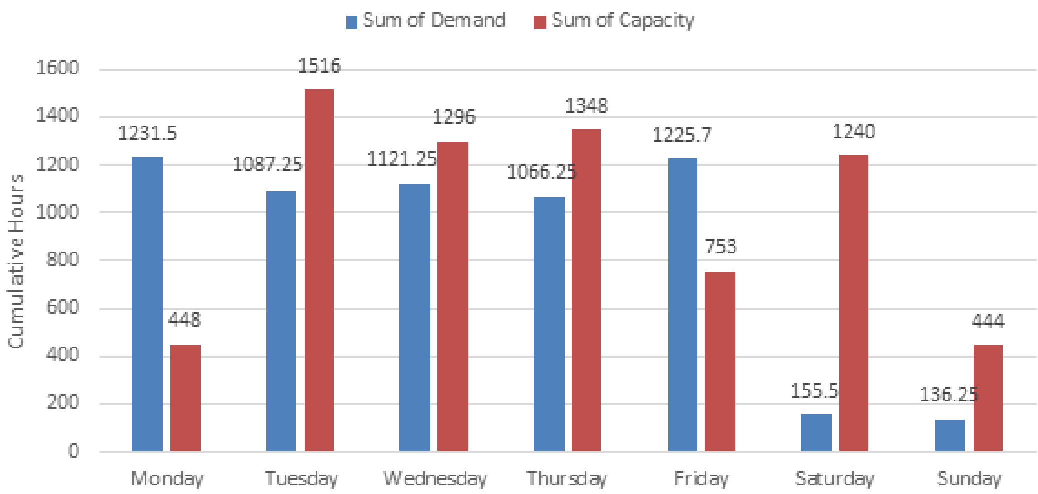
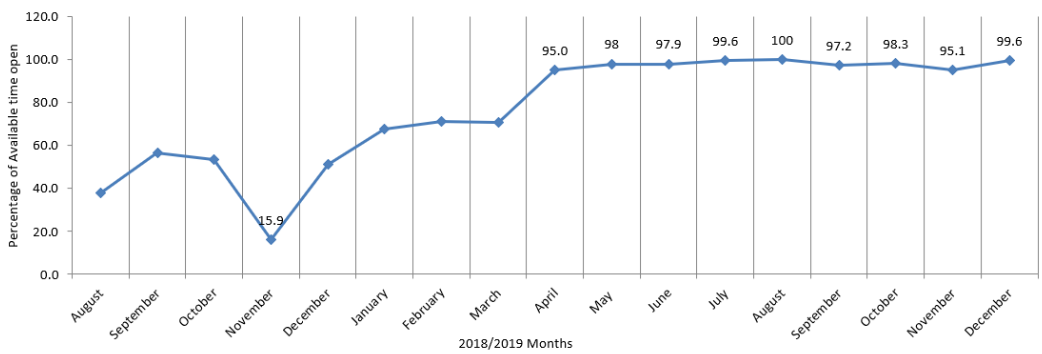


Figure 5: Standalone MRI (Building 58) utilisation.



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This knowledge enabled such patients to be booked onto specific segmented lists. Patients requiring sedation or general anaesthetic were scheduled together to enable the anaesthetic workforce to be used efficiently. Likewise, patients requiring the same interpreter language were grouped and scanned in the same list. The system now has alerts to notify schedulers if certain patients are being held up due to one of these characteristics.

In March 2019, the service introduced late weekday sessions, increasing scanning by two hours per day. At the same time, weekend sessions were started. Weekend sessions prioritised those patients who had been waiting the longest. Pending scans over 180 days were targeted as a priority, with cascading importance being placed on subsequent bandings. The waiting list was also segmented to utilise scanners before radiologists started work. Unsupervised scans were booked at the beginning and end of each day in one-hour blocks, enabling full utilisation of MRT capacity.

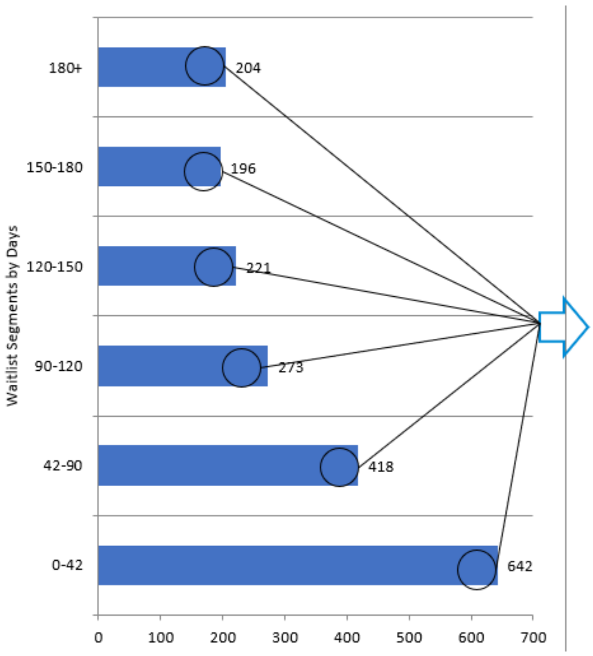
As outsourced scans were performed at a flat-rate fee by private providers, the decision matrix for outsourcing was amended to more equally distribute longer duration scans in addition to the oldest on the waiting list. This extracted better value from the contractual arrangement. The outsourcing contract was decreased from 60 scans per week to 15 in July 2019 as part of DHB cost-saving initiatives.

Redesigning MRI operational systems

A series of interventions targeted operational processes, enabling more efficient processes.

The first intervention was to modify the referral vetting process that was creating a bottleneck to workflow. This process was manual, completed by two senior medical officers (SMOs) and utilised significant administrative staff time (printing electronic referrals for SMOs and scanning referrals back into the RIS once vetting was completed). Referrals that could be vetted by the Grade MRT were identified. The SMOs' workload was reduced by redirecting lower-complexity scans while enabling the Grade MRT to perform at an expanded scope. Furthermore, the Grade MRT used the electronic system to vet referrals, speeding up the process; this encouraged the SMOs to vet electronically, which in

Figure 6: Waiting list segmentation.



Function Types	Number of cases	Average days waited
Sedations	304	298
Interpreter	209	258
Paediatric General Anaesthetic	259	247
IR Arthrogram	56	283
Prisoners	19	300

turn reduced the workload for administrative staff.

Another operational reform refined the booking template that dictated the duration of scanning appointments. The original template was provided by the MRI vendor. However, over time, clinical protocols had been updated, as had regional and collegiate standards, and these updates were not reflected in the booking template. A revised template that accurately reflected up-to-date standard scanning times was introduced, allowing the scheduler to accurately book based on scan duration times. This resulted in efficient booking practices.

The allocation of SMOs to MRI sessions was also changed. Initially, when SMOs were allocated to work in MRI, the administrative team booked patients according to the sub-specialty interest of the SMO (eg, head and neck patients). This created issues if the SMO was unable to do the session, resulting in patients being postponed and re-booked and wasted scanning capacity. Instead, a patient-focused template was developed enabling sessions to be allocated by patient referral requirement, and SMOs were rostered to cover the sessions. This allowed the roster co-ordinator to allocate an alternate SMO should the allocated SMO be unavailable. This markedly reduced the number of cancellations and changes to patient bookings.

Results

The waiting list decreased from 1,954 in January 2019 to 413 in November 2020 (Figure7), and the target compliance for P2 scans increased from 23% to 87.5%, close to the MoH's 90% target.

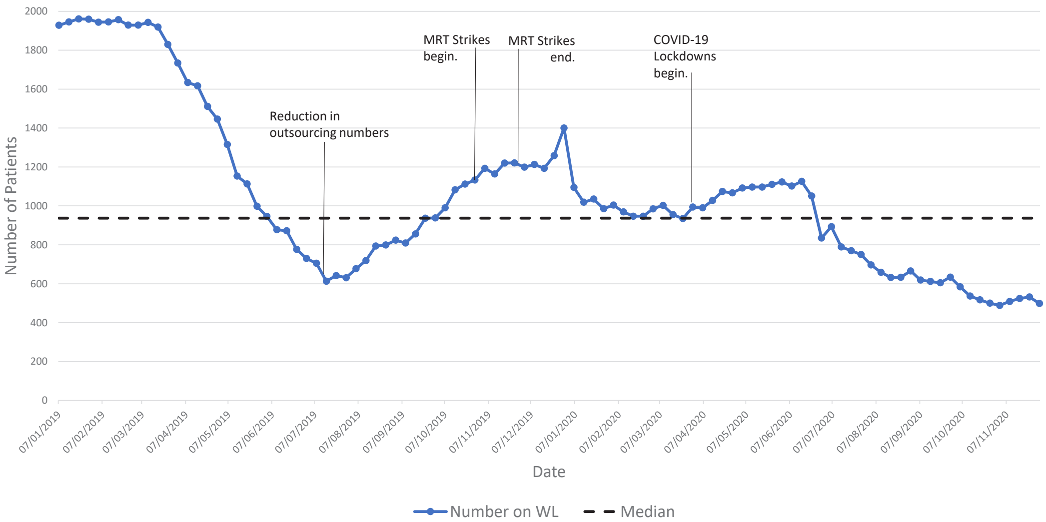
Within the overall backlog reduction, significant improvements have been made in the number of patients waiting in excess of 42 days (Figure 8). At the commencement of the project, 1,312 patients had waited over 42 days; by the end there were 48, and the whole waiting list shifted to the left. The most dramatic reduction was in the longest wait category, with 204 patients waiting more than 180 days for a scan at the start of the study, and zero by the end.

Associated with this change, patients received MRI scans in a timely manner, with 73 days being removed from the average waiting time. Simultaneously, scanning hours per week more than doubled (55.38 to 136.50)—see Table 1.

Discussion

At the start of this study, the radiology department had a limited understanding

Figure 7: Number of patients on waiting list, January 2019–November 2020.



of their capacity and demand for MRI. In fact, the department believed more resources were required, particularly MRTs, to meet the demand. The collaborative effort between Ko Awatea and the radiology department, through this capacity and demand study, showed that in fact there was sufficient capacity to meet the demand, but that it was not organised optimally.

Through nine interventions covering three major areas—matching capacity to demand, list segmentation and redesigning operational systems—the department sustainably reduced the number of people waiting for MRI scans (from 1,954 to 413), shortened the average waiting time (from 96 days to 23 days) and decreased the number of patients with excessively long waits (from 1,312 to 48). By-products of this 'shift to the left' were an improvement in the MoH target for P2 patients (from 23% to >85%) and the exposure of the radiology department to QI methodologies and their enthusiasm to continue improvement efforts.

The use of data to drive improvement challenged several long-standing practices (eg, MRTs' expanded scope to vet referrals electronically released SMO time and encouraged SMOs to adopt electronic vetting). Likewise, understanding the characteristics of the long waits enabled specified lists for those patient groups, reducing the long waiting list tail.

This attention to detail is not common in waiting list management in New Zealand healthcare. However, understanding the principles of Lean thinking (eliminating waste and increasing value for customers) has the potential to improve many waiting lists. Adopting such manufacturing tools is not always appropriate in medicine,[4] but radiology is perhaps peculiarly suited to this production planning model, as it is a series of well-defined technical processes.

New Zealand as a whole has relatively few public MRI machines per head of population. In Counties Manukau Health, there are three for a population of 600,000 (~5 machines per million). It is not clear how many is optimal; internationally numbers range from 55 per million in Japan to 2.65 in Mexico.[5] Given the constrained resources, it is important for New Zealand to be innovative and apply the appropriate

Figure 8: Changes in waiting list numbers by waiting time segments, December 2018 to November 2020.

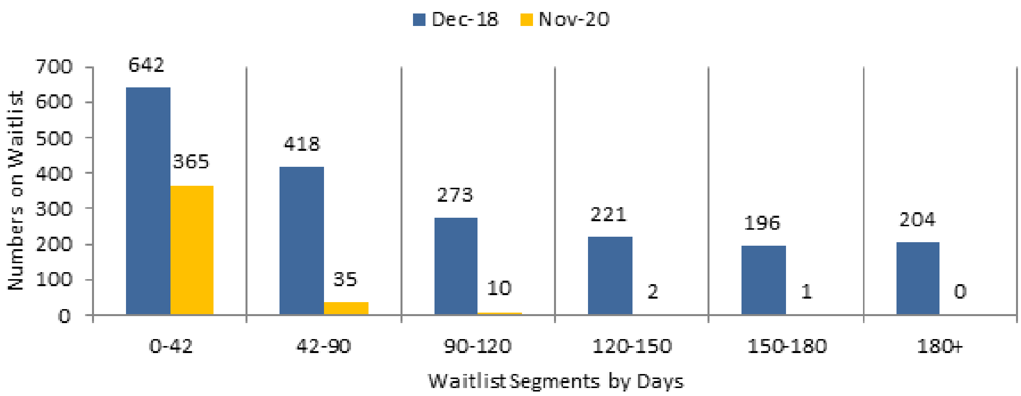


Table 1: Waiting list descriptive characteristics.

Descriptive stats	December 2018	November 2020
Total number of patients on waiting list	1954	413
Average number of days waiting	96.4	23.1
Range of days waiting	0-308	0–170
Scanning hours per week	55.38	136.50

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improvement methodologies to optimise resources.

A similar approach was used by Canterbury District Health Board (CDHB)[6] when they faced increased waiting times for imaging. Using the principles of Lean, production planning and constraint theories, they worked with in-house production planning engineers to improve waiting times. In this case, the main constraint was limited radiologist hours, which was improved by rationalising and delegating some tasks traditionally undertaken by radiologists. As in Counties Manukau Health, having visibility of the gap between capacity and demand allowed several improvements in the process.

A systematic review of the application of Lean and Six Sigma (which aims to decrease defects to one in a million) approaches in radiology was published in 2016 and concluded that these methodologies had the potential to reduce errors and cost, and improve quality.[7] The five studies that looked at reducing waiting times were not representative of Counties Manukau Health's situation; starting from a much shorter baseline: decreasing the waiting time from 25 days to one. A review of MRI waiting lists in Canada[8] in 2009 noted that most centres routinely used scanners at the weekend, but only 3% were utilised on a 24/7 basis, and median scanning hours per week was 93.5, whereas our work increased this to 136.50.

There are some limitations to this study. It was neither feasible nor sensible to conduct a randomised controlled study as the team were examining the whole department and MRI process pathway. Learning and adjusting hypotheses based on small tests of change, a central tenet of most QI methods, meant that this was an iterative process with multiple tests—some sequential, some in parallel—so it is unclear which initiative had the biggest impact. Therefore, generalising results to other jurisdictions is not possible. However, the process of understanding a given department's data on capacity and demand is generalisable. Most radiology departments in New Zealand will be facing similar constraints, especially in the face of the COVID-19 lockdowns.

A further constraint is that ethnicity of each patient on the waiting list is not captured in the RIS, and it is therefore not possible to comment on any inequity in waiting times. In future it would be beneficial to conduct this work through an equity lens and, if inequity were to be identified, to use patient experience and co-design methodologies to uncover the reasons for this disparity.

The team faced several constraints that threatened the sustainability of improvements. The first challenge was the impact of national industrial action that occurred through the third and fourth quarters of 2019, severely affecting the availability of MRT staff and directly increasing the waiting list. At the same time, the outsourcing contract for 60 scans per week was reduced to 15 in July 2019, increasing demand. A further compounding factor in 2020 was COVID-19, which significantly reduced the availability of outpatient scans, particularly during the first lockdown in April 2020—consequently the backlog during this period increased.

Conclusion

Although the original premise for the long waiting times for MRI was a lack of capacity, this study showed that existing capacity was sufficient, but inefficiently matched to demand. Acting on detailed data of the causes of this inefficiency and employing Lean thinking principles and the Model for Improvement methodology, a number of innovative changes were made in the process of care, leading to a dramatic reduction in waiting times. There are lessons for other waiting lists in the healthcare system, particularly in building capability in capacity and demand analysis and other QI tools, which will be important for the New Zealand health system as it faces a future of fiscal constriction.

Competing interests:
Nil.
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