

Combined lumbar spine MRI and CT appropriateness checklist: a quality improvement project in Saskatchewan, Canada

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Abstract

Background: As rates of advanced imaging for lower back pain (LBP) continue to increase, there is a need to ensure the appropriateness of imaging.

Objective: The goal of this project was to reduce the number of inappropriate magnetic resonance imaging (MRI) and computed tomography (CT) requests for LBP patients and facilitate appropriate imaging by developing a combined imaging appropriateness checklist for lumbar spine MRI and CT.

Methods: In prior work, we developed and adopted individual evidence-based lumbar spine MRI and CT checklists into the radiology requisition process. In the current project, a combined checklist was developed and trialed in one of the former Saskatchewan health regions (Five Hills) beginning in May 2018. Using statistical process control, control charts compared the monthly number of imaging requests pre-checklist implementation and post-checklist implementation from May 2017 to February 2020. The monthly number of lumbar spine MRI and CT requisitions in the nearby former Saskatchewan Regina Qu'Appelle Health Region, in which the combined checklist was not trialed, was also plotted and compared as a balancing measure.

Results: In Five Hills, a shift (decrease) was observed in the monthly number of lumbar spine MRI requisitions 7 months following the implementation of the combined checklist. However, the monthly number of lumbar spine CT requisitions did not change significantly. In the Regina Qu'Appelle Health Region, there was a shift (increase) in the monthly number of lumbar spine MRI requisitions, while the monthly number of lumbar spine CT requests decreased after the implementation of the combined checklist.

Conclusions: The combined checklist with evidence-based indications for lumbar spine MRI and CT imaging in LBP patients appeared to reduce the complexity associated with two previous individual checklists and facilitate imaging appropriateness. Accountable benefits may include the reduction of radiation exposure as a result of unnecessary and repeated imaging and reduction in wait times for CT and/or MRI.

Key words: lower back pain, checklist, computed tomography, magnetic resonance imaging, imaging order appropriateness, quality improvement

Introduction

Lower back pain (LBP) is one of the most common health problems in primary care in Canada [1]. The literature shows that 50–80% of the adult population experience spine-related illnesses (e.g. LBP) in their lifetime [2]. Diagnostic imaging—including magnetic resonance imaging (MRI) and computed tomography (CT)—is commonly used in the assessment of LBP opposed to clinical practice guideline recommendations [3]. However, inappropriate diagnostic imaging for LBP is an increasing problem within the Canadian healthcare system, and it has been reported that approximately 30% of LBP imaging is inappropriate [2, 4]. A Canadian study on patients with degenerative spine disease showed that over 60% of MRIs and 100% of CT scans were unnecessary,

leading to an additional cost of approximately \$24 million dollars per year [5]. The significant number of CT and MRI requisitions has generated an enormous economical, personal and societal burden to the healthcare system of Canada [6, 7].

Although MRI and CT are helpful tools for informing the clinical management of LBP, unnecessary and inappropriate imaging requests increase radiation exposure (in the case of CT imaging), lead to further avoidable tests and surgeries and increase wait times for those who may benefit most from imaging [8–10]. Efforts to increase the number of MRI and CT scanners without instituting methods to encourage the appropriate use of imaging has not resulted in proportionate reduction in wait times for diagnostic imaging [2].

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To address the problem of unnecessary tests, treatments and procedures, the Saskatchewan Ministry of Health developed the provincial Appropriateness of Care Program (ACP). As part of the ACP team's mandate, a Clinical Development Team (CDT) was formed in 2015. The CDT developed and implemented two individual evidence-based checklists to promote the appropriateness of lumbar spine MRI and CT requisitions [11]. This team included orthopedic surgeons, neurosurgeons, radiologists, family physicians, a chiropractor and a patient family advisor. In a prior study, two checklists were adopted into the radiology requisition process for both lumbar spine MRI and CT in four former health regions of Saskatchewan [11]. In the current study, a single combined checklist was developed and trialed in one of the former Saskatchewan health regions (Five Hills Health Region) for 3 months from May to July 2018. In addition to the former Five Hills Health Region, the checklist has now been implemented in the former Cypress Health Region and has been partially implemented in the former Saskatoon and Regina Qu'Appelle Health Regions (the two largest health regions in the province by population served). Implementation in the rest of the province was planned for early 2020 but has been postponed due to COVID-19. The former health regions are now amalgamated to form one health authority for the province called the Saskatchewan Health Authority [12]. This quality improvement project was conducted by the CDT to facilitate the process of ordering appropriate lumbar spine MRI or CT imaging and to reduce unnecessary MRIs and CTs for adult outpatients with LBP.

Employing checklists in the previous study improved the appropriateness of imaging orders and reduced inappropriate and repeated imaging requests [13]. However, using two separate individual checklists to order lumbar spine CT and/or MRI imaging resulted in confusion and increased complexity among referring physicians and medical imaging booking staff. For this quality improvement project, we developed a combined lumbar spine MRI and CT checklist to reduce inappropriate imaging orders for adult patients with LBP who were nonemergent and outpatient. With the inclusion of clinical indications and guidelines for both lumbar spine MRI and CT in a single document of a combined checklist, our aim was to facilitate the determination of imaging appropriateness and its practice and submission process. We studied the impact of the combined checklist on the number of MRI and CT requisitions submitted to the former Five Hills Health Region in Saskatchewan, Canada, from May to July 2018. We also studied the number of MRI and CT requisitions submitted over the same time period to the nearby Regina Qu'Appelle Health Region, which did not trial the new combined checklist and which shares workload with the Five Hills Health Region, as a balancing measure. Since the Regina Qu'Appelle Health Region is adjacent to the Five Hills Health Region, there is some overlap in the patient population served, and patients in the Five Hills Health Region may travel to the Regina Qu'Appelle Health Region for imaging and vice versa.

Methods

Development of combined lumbar spine MRI and CT checklist

The CDT reviewed the data retrieved from the Radiology Information System (RIS) repository and collected feedback

from referring physicians and booking staff after the implementation of the individual lumbar spine MRI and CT checklists. This review revealed complexities in the process of submitting two individual lumbar spine MRI and CT checklists and confusion among physicians and booking staff about employing two separate checklists. A decision was made by the CDT to combine the lumbar spine CT checklist with the MRI checklist. Stakeholders involved in the use of both checklists determined that developing a combined CT/MRI checklist for imaging requisitions for patients with LBP would serve as a better tool for decision-making when both modalities are available. The combined checklist with clinical indications for both MRI and CT would also be better positioned to reduce duplicate or serial imaging.

A combined checklist was developed through the steps described in detail in our prior study [11]. These steps comprised a systematic search of peer-reviewed literature, clinical guidelines and other decision support tools for LBP imaging to draft the checklist, multiple reviews of the draft by the CDT and finally refining and pilot-testing the checklist. This process took approximately 6 months prior to the trial of the combined checklist. The developed combined checklist was trialed in the former Five Hills Health Region for 3 months from May to July 2018. The combined checklist was considered part of the requisition process for adult outpatients, meaning that referring physicians must submit the completed checklist to order a lumbar spine CT or MRI (Appendix 1). It was implemented into the regular ordering practice of all urgent, semi-urgent and elective lumbar spine MRI and CT requests (excluding emergent requests).

Data collection and analysis

The RIS collects all provincial CT and MRI information, including all imaging requests sent to hospitals and all CT and MRI requests received by private imaging facilities contracted by the Saskatchewan Health Authority (SHA) [14]. Imaging requisitions, including lumbar spine MRIs and CTs collected from the RIS were reviewed by medical imaging staff according to an algorithm (Figure 1). This algorithm was created by the CDT for the determination of the appropriateness of imaging orders [11].

The number of lumbar spine MRI and CT requisitions received were used as a proxy to measure the effect of the combined checklist's implementation on the appropriateness of lumbar spine imaging. Monthly volumes of lumbar spine MRI and CT requisitions were studied and compared pre-intervention and postintervention by using control charts. The number of lumbar spine MRI and CT requisitions in the Regina Qu'Appelle Health Region were plotted and compared as a balancing measure. In a quality improvement project, a balancing measure determines whether an improvement in one part of the system does not negatively affect other parts of the system [15]. Given that the MRI centers in Regina Qu'Appelle and Five Hills are relatively close to each other, they refer their patients to each other's sites if the workload is more than their capacity. Displaying the Regina Qu'Appelle data points as a balancing measure helps to explore the impact of the combined checklist from a different dimension to determine and explain any improvement in the Five Hills Health Region.

The pre-checklist data were collected from May 2017 to April 2018, and post-checklist data from August 2018 to

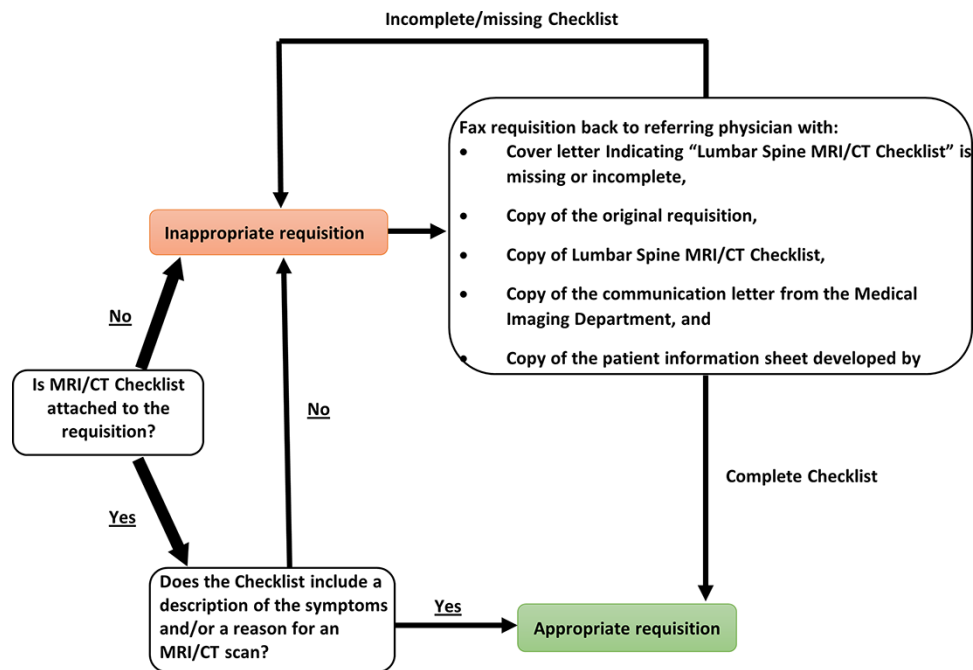


Figure 1 Algorithm in determining appropriateness for lumbar spine MRI and CT requisitions.

Table 1 Number of monthly average MRI and CT requisitions in Five Hills and Regina Qu'Appelle preimplementation (May 2017–April 2018) and postimplementation (August 2018–February 2020) of the combined checklist

Imaging in Saskatchewan health regions		Average number of requisitions per month (May 2017–April 2018)	Average number of requisitions per month (August 2018–February 2020)	Relative percentage of change
MRI	Five Hills	31.2	26.3	–16%
	Regina Qu'Appelle	189.9	202.6	+7%
CT	Five Hills	2	1.7	–19%
	Regina Qu'Appelle	38.5	29.4	–24%

February 2020. The 'pre-checklist' period does include the postimplementation period of the individual MRI and CT Checklists in the Five Hills and Regina Qu'Appelle Health Regions. Based on the prior study [11], the individual MRI Checklist was initially implemented in the Regina Qu'Appelle and Five Hills Health Regions in November 2015 and January 2016, respectively. Following the MRI Checklist implementation, the individual CT Checklist was developed and implemented in the Regina Qu'Appelle and Five Hills Health Regions in May and April 2017, respectively [11]. The number of requisitions received for lumbar spine MRI and CT exams were collected for 21 months after the intervention. Control charts were plotted with a 32-month timespan to capture any changes in the number of imaging requisitions. The most recent 20–30 data points are recommended to develop a control chart to monitor changes in the number of imaging requisitions over time [16].

The number of lumbar spine MRI and CT requisitions received each month were plotted on Individual (I) control charts. The baseline monthly average number of MRI or CT requisitions in each site was determined from May 2017 to April 2018 (before the implementation of the combined checklist in Five Hills). Control limits were defined to be

± 3 SDs from the baseline mean. Special cause variations in control charts were defined by five rules: (i) a run of eight or more points either all above or below the mean (shift), (ii) two out of three consecutive points near (outer one-third) a control limit; (iii) a single point outside the control limits; (iv) six consecutive points increasing or decreasing (trend); and (v) fifteen consecutive points close (inner one-third of the chart) to the mean [17].

Results

The results are reported according to the Revised Standards for Quality Improvement Reporting Excellence [18]. The average numbers of lumbar spine MRI requisitions in the Five Hills and Regina Qu'Appelle Health Regions were 31.2 and 189.9 requisitions per month, respectively, from May 2017 to April 2018 (Table 1). For the same period, the average numbers of lumbar spine CT requisitions were 2 and 38.5 requisitions per month in Five Hills and Regina Qu'Appelle. Postimplementation analysis shows that the monthly average number of MRI requisitions decreased to 26.3 (–16%) in Five Hills and increased to 202.6 (+7%) in Regina Qu'Appelle. However, the monthly average number of CT requisitions

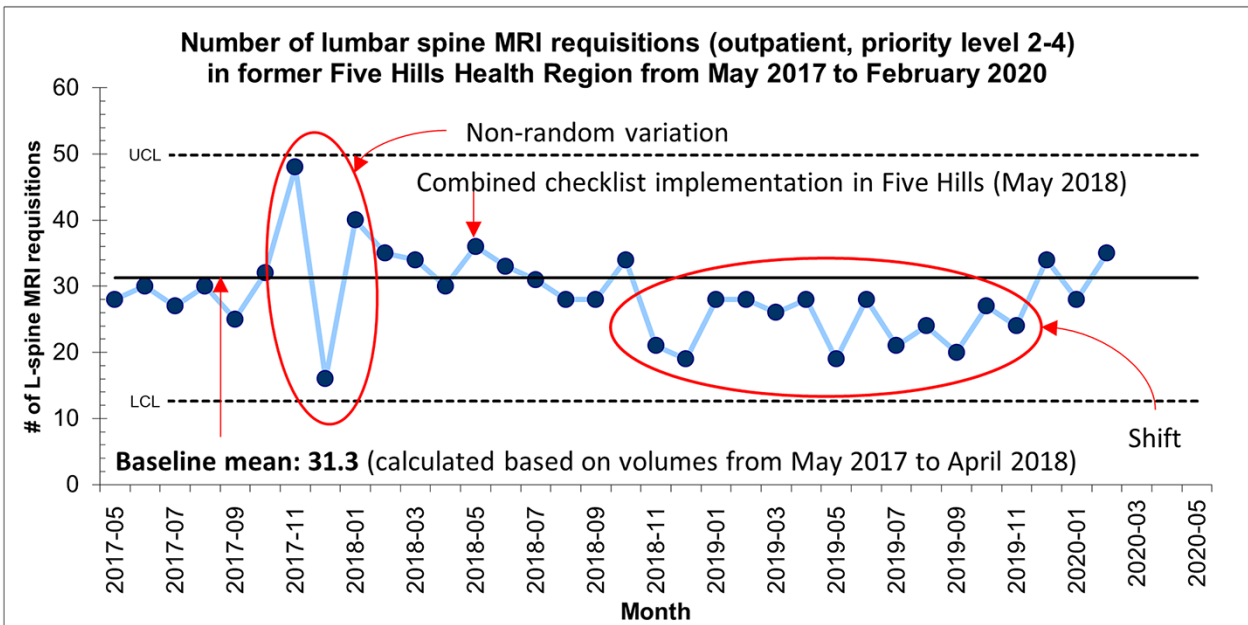
decreased in both sites (-19% in Five Hills and -24% in Regina Qu'Appelle; Table 1).

In the former Five Hills Health Region, there is a shift (reduction) in the number of lumbar spine MRI requisitions 7 months after the implementation of the combined checklist, which lasted until November 2019. In the Regina Qu'Appelle Health Region, a shift (increase) was observed in the number of lumbar spine MRI requisitions around the time the combined checklist was trialed in the

Five Hills Health Region. The increase lasted for 9 months (Figure 2).

In Five Hills, no shift was observed after the implementation of the combined checklist in the number of lumbar spine CT requests (Figure 3). In Regina Qu'Appelle, special cause variation (shift) is observed 3 months after the trial. The shift (decrease) in the monthly volume of lumbar spine CT requisitions lasted for 11 months in Regina Qu'Appelle (Figure 3).

(a)



(b)

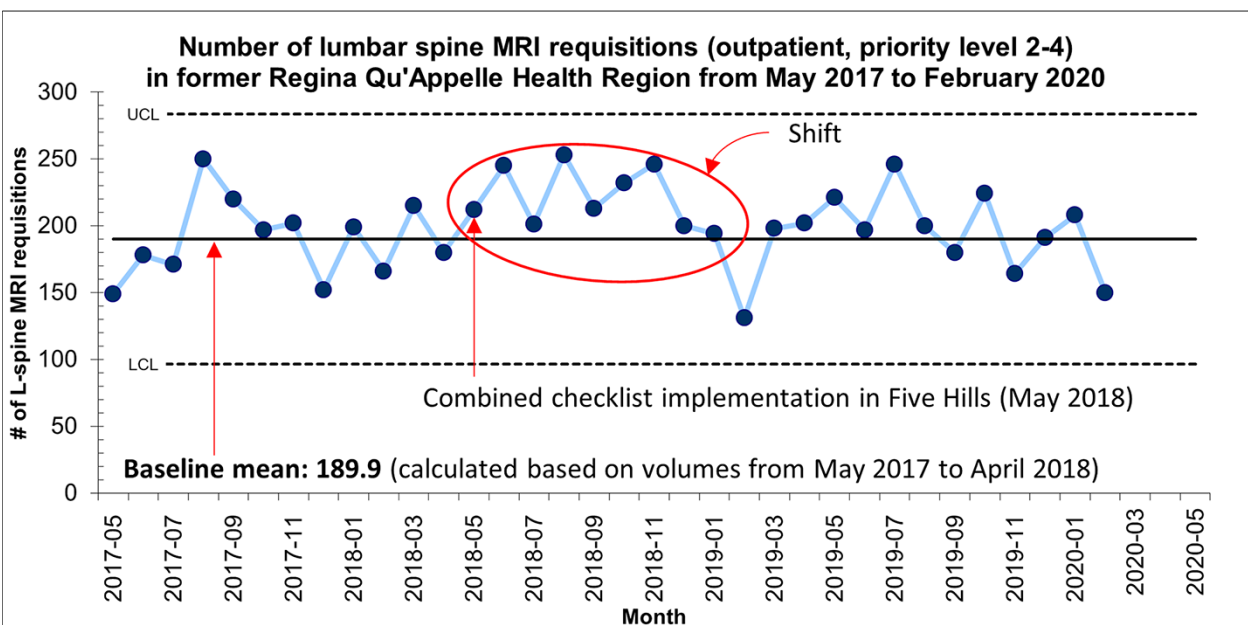
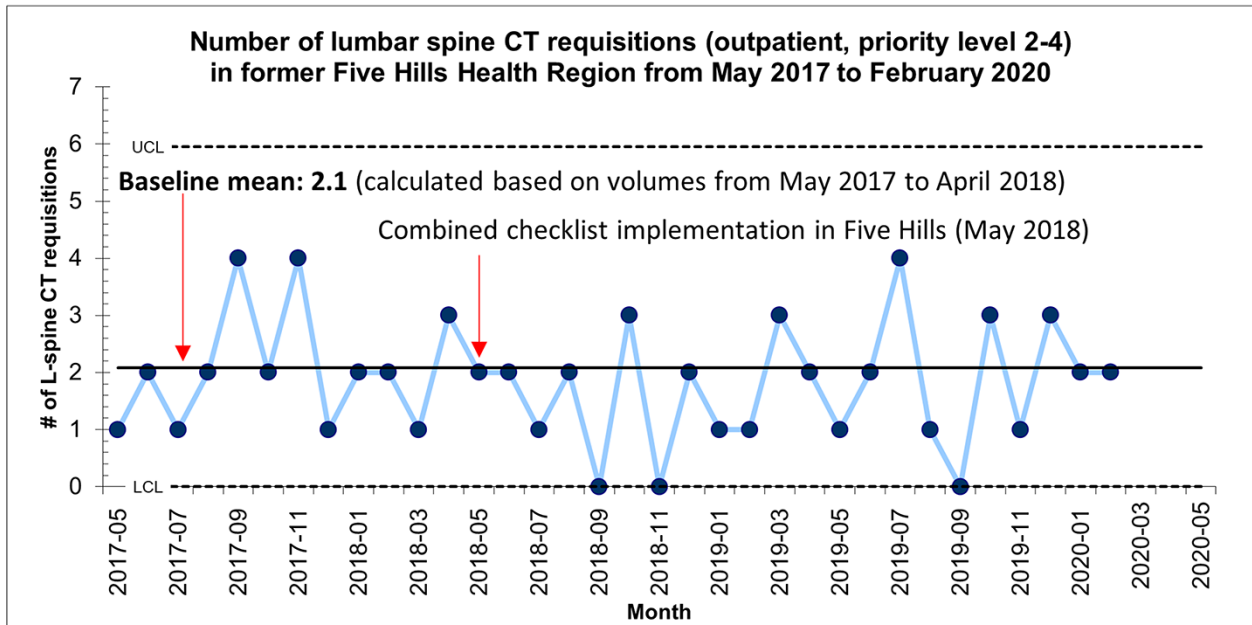


Figure 2 Number of lumbar spine MRI requisitions in former Five Hills and Regina Qu'Appelle Health Regions (Priority Level 2: urgent; Level 3: semi-urgent and Level 4: elective).

(a)



(b)

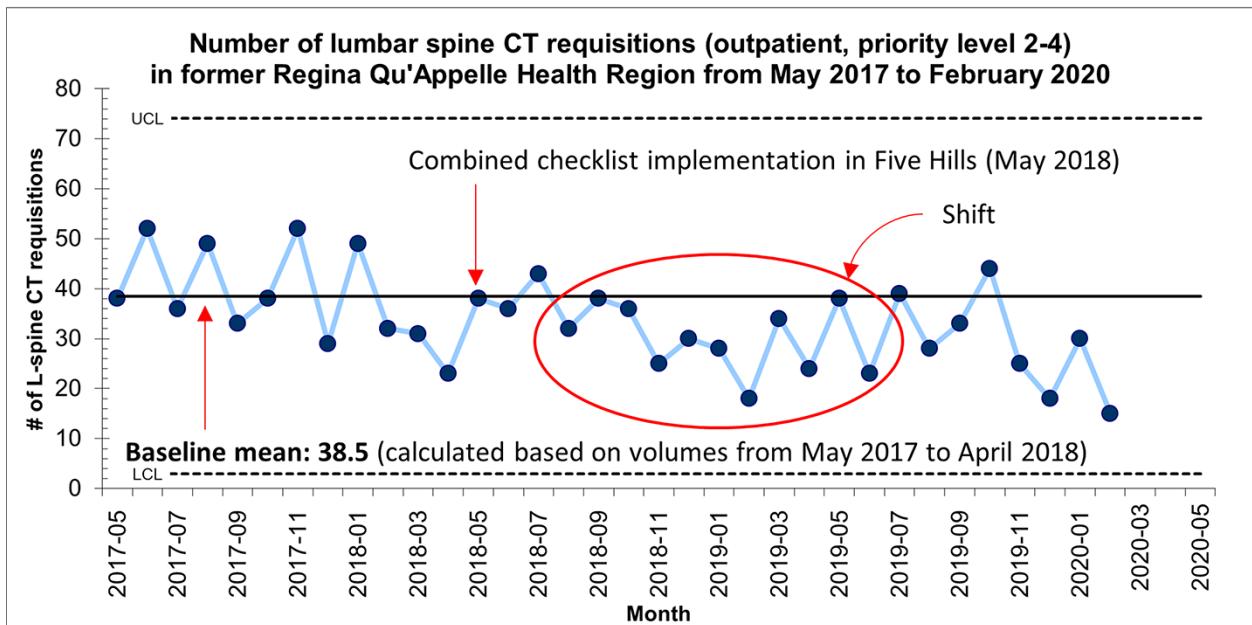


Figure 3 Number of lumbar spine CT requisitions in former Five Hills and Regina Qu'Appelle Health Regions (Priority Level 2: urgent; Level 3: semi-urgent and Level 4: elective).

Discussion

Statement of principal findings

Our findings suggest a continued improvement in the appropriateness of imaging requests after trialing a combined lumbar spine MRI and CT checklist in Saskatchewan. Similar to the initial intervention of employing two individual lumbar spine checklists (described in our prior study [11]), the combined checklist reduced the monthly average number of MRI and CT requisitions in Five Hills and that of CT requisitions

in Regina Qu'Appelle. However, the monthly average number of MRI requisitions in Regina Qu'Appelle increased slightly after the implementation of the combined checklist.

In the Five Hills Health Region, there was a special cause variation (increase) in the monthly number of MRI requisitions before the trial of the combined checklist (November 2017). One explanation of this variation is that the MRI requisitions were coming more before the slowdowns and holiday time in December. However, due to the nature of

the RIS database, we could not explore what exactly caused the variation. Although the individual lumbar spine CT and MRI checklists were implemented in Five Hills prior to the combined checklist trial, the number of monthly MRI requisitions decreased 7 months after the implementation of the new checklist. This may demonstrate that the requisition process in Five Hills had the potential for more improvement in receiving appropriate lumbar spine requests. There is, however, no shift in the number of lumbar spine CT requisitions in Five Hills after the implementation of the combined checklist. This may be due to very low monthly volumes (average two requisitions per month) that makes it difficult to observe a significant change in the requisition process.

In the Regina Qu'Appelle Health Region, the number of lumbar spine CT requisitions decreased after the combined checklist was trialed in Five Hills. However, when we look at the monthly number of lumbar spine MRI requisitions in the Regina Qu'Appelle Health Region for the same time period (after implementation of the combined checklist), we see an increase in the number of MRI requisitions. This increase may be due to physicians modifying their imaging ordering practices from CT to MRI imaging, which may be more appropriate for some clinical indications.

This quality improvement project provides evidence on the positive impact of the combined checklist. Overall, the combined checklist reduced the number of lumbar spine imaging requests while seizing the opportunity to equip healthcare providers with a clinical decision support tool to improve the delivery of appropriate care for patients with LBP. As a result, a provincial implementation plan to spread the combined checklist across all remaining CT and MRI sites in Saskatchewan was proposed to the SHA in August 2018.

Interpretation within the context of the wider literature

There is a high rate of inappropriate imaging for the assessment of LBP in Canada, including in Saskatchewan [11, 14, 19]. Evidence shows that active decision aids appear more promising than passive dissemination of educational material, including guideline dissemination, practitioner education and audit and feedback of imaging practices [13, 20]. Clinical decision support interventions (e.g. targeted reminders to primary care doctors, a modified referral form in a hospital setting and checklists with evidence-based clinical guidelines) have shown positive impact in addressing imaging overuse for LBP [21, 22]. In medical education settings, appropriateness checklists are employed either as evaluation tools for comprehensive assessment or as a common and easy means of communicating a set of guidelines regarding effective performance [13]. Checklists remove ambiguity, increase the reliability of care processes and facilitate rapid decision-making. They disseminate best evidence-based clinical practices for a wide range of complications and care processes [13].

Strengths and limitations

This quality improvement project has a few limitations. Given its design as a quality improvement project with the statistical process control evaluation method, we could not control for confounding factors and determine what other elements

(such as other appropriateness of care activities, including Choosing Wisely training and workshops) are associated with the reduction in the number of lumbar spine MRI and CT requests. As the observed shifts in the control charts were not stable to the end of the project period, there may be other factors influencing the flow of incoming requisitions (e.g. an increase in the number of LBP patients) that are out of the control of this project. For the preimplementation period of the combined checklist, there is no timeframe that we can capture with no checklist integrated into the requisition processes. The individual MRI and CT Checklists had been developed and trialed in Five Hills prior to our current quality improvement project and the individual MRI Checklist was integrated into the requisition process since the MRI scanner started operating in Five Hills (January 2016). The use of individual checklists had impacted imaging order practices and contributed to the decreases in the number of MRI and CT requisitions prior to the current quality improvement project. Considering the small size of this quality improvement project and its trial in one of the former Saskatchewan health regions, the results may not be generalizable to other Saskatchewan health regions or provinces. This limitation is significant in the vast majority of quality improvement work that is not conducted at multiple institutions. However, following the guidelines on the reporting of quality improvement projects [22], both the quality improvement process and intervention (the combined checklist) is described in detail in order to assist with understanding the specific context of the Five Hills Health Region and customizing the process and intervention for replication at other health regions or provinces. Another limitation is related to the use of the number of requisitions as a proxy for the appropriateness of imaging orders. Due to the nature of the RIS database, there is a lack of valid clinical information to confirm if the decreased number of requisitions has increased the appropriateness of imaging. However, the requirement of employing the combined checklist to order imaging and the clinical indicators in this checklist has likely improved the appropriateness of received lumbar spine MRI and CT requisitions.

Implications for policy, practice and research

The combined lumbar spine MRI and CT checklist is likely to have a positive impact on reducing unnecessary imaging in Saskatchewan. However, future research is required to test the effectiveness of the combined checklist in other provinces and to evaluate its impact on reducing radiation exposure (in the case of CT imaging) and additional costs associated with overimaging. A qualitative research approach could provide important insights into how the combined checklist can best be incorporated into referring clinicians' practices and could provide additional data regarding barriers to implementation and root causes of unnecessary imaging.

Conclusion

In conclusion, the combined checklist with evidence-based indications of lumbar spine MRI and CT imaging for LBP patients may be an opportunity to equip primary care physicians with decision-support tools to improve the appropriateness of their imaging decision requests. Compared with two previous individual checklists, the combined checklist appeared to facilitate the appropriateness of imaging orders,

reducing the complexity and confusion associated with usage and submission of two separate checklists.

Acknowledgements

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Contributorship

G.G., as a member of the CDT, made substantial contributions to the design of the work and development of the checklist. A.A. was involved in the design and implementation of the combined checklist as well as the collection, analysis and interpretation of data. M.M.L. drafted the manuscript, with editing from A.A., T.C., S.J.A. and G.G. All authors critically revised the draft, gave final approval of the version to be published and are accountable for all aspects of the work.

Ethics and other permissions

According to the University of Saskatchewan Research Ethics Board (REB), this quality improvement project is exempt from the requirement of REB review and approval.

Data availability

The data underlying this article will be shared on reasonable request to the corresponding author.

Disclaimer

This study is based on de-identified data provided by the Saskatchewan Ministry of Health. The interpretations and conclusions contained herein do not necessarily represent those of the Government of Saskatchewan or the Saskatchewan Ministry of Health.

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Appendix 1. Combined lumbar spine MRI and CT checklist



Saskatchewan Lumbar Spine MRI and CT

Decision Making Tool and Checklist

Please complete the checklist for all adult (18+) outpatient lumbar spine requisitions and include this checklist with the requisition.

Patient's Information

First Name:

Last Name:

HSN:

Please note that imaging tests like X-rays, CT scans and MRIs are not helpful for recovery or management of acute or recurring low back pain unless there are signs of serious pathology.

Indication

Investigation

Red Flags

(If present, immediately call Spine Service/Neurosurgery on Call if these services are available. If not, call Radiologist)

- Neurological: diffuse motor/sensory loss, progressive neurological deficits, cauda equina syndrome (i.e. urinary incontinence, urinary retention)
- Infection: fever, IV drug use, steroid use, immune suppressed, osteomyelitis, discitis
- Tumor: hx of cancer, unexplained weight loss, significant unexpected night pain, severe fatigue, suspected cancer, including metastasis

Urgent MRI

MRI

MRI

Mechanical Back Pain

(with symptoms persisting or worsening despite conservative management for at least 6 weeks)

- Low back pain for at least 6 months (Pattern 1 [Disc Pain] & 2 [Facet Joint Pain])
- Radiculopathy for at least 6 weeks (Pattern 3 [Compressed Nerve Pain])
- Spinal stenosis symptoms for at least 6 weeks (Pattern 4 [Neurogenic Claudication])
- Patient has abovementioned MRI indications, but lumbar spine MRI is contraindicated (e.g. claustrophobia, heart pacemaker, intracranial metal clips).

MRI

MRI

MRI

CT

Suspected or Known Conditions

- Fracture: trauma, osteoporosis risk/fragility fracture
- Tumor of vertebra or bone (known malignancy with lumbar pain, follow-up primary or metastatic bone tumor, new or worsening pain at site, periodic assessment, new onset scoliosis or kyphosis)
- Intradural tumor (hyperreflexia, LE weakness, spasticity, bladder/bowel dysfunction, sensory loss, new onset scoliosis/kyphosis, spastic gait, radiculopathy, localized spine tenderness, pain, CSF positive for malignant cells—with or without history of cancer)
- Arachnoiditis
- Spinal dysraphism (open or closed)
- Preprocedure kyphoplasty
- Evaluation of scoliosis (preoperative assessment, any neurologic findings, atypical curve pattern, congenital scoliosis, neurofibromatosis, Marfan's syndrome)
- Postoperative collections (soft tissue or fluid)
- Treatment fields for radiation therapy
- Evaluation of prior lumbar surgery in terms of follow-up, type of surgery and presence of hardware
- Evaluation of prior lumbar surgery in terms of hardware complications

CT

MRI with Specialist referral

MRI with Specialist referral

MRI with Specialist referral

MRI with Specialist referral

MRI with Specialist referral

MRI with Specialist referral

MRI with Specialist referral

MRI with Specialist referral

MRI with Specialist referral

CT with Specialist referral

Inflammation/Spondyloarthropathy

- Inflammation: chronic low back pain >3 months, age of onset <45, morning stiffness >30 minutes, improves with exercise, disproportionate night pain

Imaging test pending on rheumatology consultation

If there is other indication for ordering MRI or CT, please specify here:

What medical imaging test are you ordering?

L-Spine MRI

L-Spine CT

Information useful for physicians to help patients manage their symptoms through conservative management is available at the Saskatchewan Spine Pathway (<http://spinepathwaysk.ca>) and Choosing Wisely Canada (<https://choosingwiselycanada.org/>) websites.