

Research

Reducing Inappropriate Imaging Orders for Lower Back Pain Using MRI and CT Checklists: A Quality Improvement Study in Saskatchewan, Canada

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ABSTRACT

Purpose: The objectives of this quality improvement study were: a) to develop Checklists for healthcare professionals to improve appropriateness of lumbar spine imaging orders and referrals in concordance with Choosing Wisely recommendations and guidelines; and b) to trial the Checklists, assessing their impact on reducing inappropriate imaging orders in Saskatchewan, Canada.

Methods: A Clinical Development Team developed and adopted evidence-based lumbar spine magnetic resonance imaging (MRI) and computed tomography (CT) Checklists (quality improvement interventions) into the radiology requisition for both lumbar spine MRI and CT in Saskatchewan. Using a pre-post study design, data were obtained from the Radiology Information System (RIS). Control charts compared monthly number of imaging requests pre- and post-Checklists from June 2014 to August 2017.

Results: Results showed a 23% reduction in the monthly average number of MRI requisitions one year after implementation of the lumbar spine MRI Checklist. On average, monthly volumes of lumbar spine CT requests decreased by 27% after implementation of the lumbar spine CT Checklist.

Conclusions: Implementation of the two Checklists with evidence-based clinical indications and guidelines to order imaging may reduce volume of inappropriate urgent to elective MRI and CT requisitions for adult outpatients. Our results may help the design of other local and national quality improvement studies (e.g., appropriate ordering of knee MRI imaging), by replicating the integration of a Checklist into the ordering process to mitigate inappropriate imaging requests.

Keywords: Lower back pain, Checklist, Computed tomography, Magnetic resonance imaging, Appropriateness of imaging order.

How This Fits in with Quality in Primary Care

What do we know?

- The high rate of inappropriate and unnecessary imaging for patients with low-back pain has become an increasingly recognized problem.
- Effective interventions that support primary care physicians to appropriately order lumbar spine imaging are needed.

What does this paper add?

- The lumbar spine MRI and CT Checklists demonstrate an opportunity to equip primary care physicians with decision-support tools to improve appropriateness of their imaging decision requests.

Introduction

Lower back pain (LBP) has been identified as a major health problem in primary care in Canada [1]. One out of five Canadian patients has LBP [1]. Up to 30 % of patients with LBP have at

least one unnecessary imaging test [2,3]. The significant rate of computed tomography (CT) scan and magnetic resonance imaging (MRI) use for LBP patients has caused considerable overuse in the healthcare system. In addition, inappropriate MRI and CT scans for LBP increases radiation exposure, leads

to further avoidable tests and surgery, and increases wait times for those who genuinely need these imaging [5-7].

Lumbar spine CTs and MRIs are often performed in LBP patients, although clinical practice guidelines recommend imaging only in the presence of specific symptoms (the so called red flags) such as infections, tumors, fractures, cauda equina syndrome, or neurological deficits [8]. Despite the fact that approximately 90% of patients presenting with non-specific symptoms, the utilization of diagnostic imaging in Canada has increased markedly [9]. The Canadian Institute of Health Information reports that in 2011-2012, 1.7 million MRI scans and 4.4 million CT scans were performed on Canadian patients, representing an 8.7% and 2.7% annual increase, respectively [10]. According to the Radiology Information System (RIS) data, the annual number of MRI and CT orders including knee, head, etc. has been rising in Saskatchewan [11]. In 2013, there were 66,584 CT requisitions which increased to 93,535 by 2014. Similarly, the number of MRI requisitions increased from 19,731 in 2013 to 33,544 in 2014 [11]. The RIS collects all provincial CT and MRI information, including information provided by private facilities contracted to the publicly funded Saskatchewan Health Authority [12]. Although lumbar spine MRI/CT imaging accounts for a small proportion of all imaging requisitions, they play a major role in the management of LBP patients [11].

Given increasing rate of MRI and CT requisitions reported in the literature including Saskatchewan, there is a pressing need to find clinical practice guidelines to improve the appropriateness of ordering imaging. Choosing Wisely (CW) initiatives were designed to change the culture of medical care, which historically supported overuse of unnecessary tests, treatments, and procedures considered to be of low-value [13]. Currently, there are twelve provincial and territorial campaigns in Canada including Saskatchewan, all sharing the common goal of tackling the medicine overuse problem within Canada's unique health care systems [14]. The College of Family Physicians of Canada, the Canadian Association of Radiologists, and the Canadian Rheumatology Association have each developed recommendations lists for the Choosing Wisely Canada campaign for LBP imaging [15-17]. All recommend that imaging should not be routinely conducted in patients with LBP without red flags indicating a potential pathological cause [8,9].

To improve appropriateness of care throughout the health system, the Saskatchewan Ministry of Health (MOH) developed a provincial Appropriateness of Care Program (ACP) [18]. Through collaborative efforts of the ACP team, MOH policy makers, Saskatchewan Health Quality Council (HQC) researchers, and Quality Improvement (QI) experts, a Clinical Development Team (CDT) was formed in 2015 to conduct a quality improvement study. The CDT included orthopedic surgeons, neurosurgeons, radiologists, family physicians, a chiropractor, and a patient family advisor. The study aim was to develop and implement lumbar spine imaging Checklists guiding healthcare professionals to improve the *appropriateness of lumbar spine MRI and CT orders*.

Methods

Lumbar spine MRI and CT Checklists development:

Schmutz and colleagues described clear and reproducible steps of a robust development process of valid appropriateness

checklists that can be adapted by different health care communities in many clinical scenarios [19]. These steps include: (a) professional experience, (b) primary literature sources and/or peer reviewed guidelines, and (c) the consensus of experts in the field of interest [19]. Following these steps, the ACP team, HQC researchers, and QI experts conducted a systematic search of peer-reviewed literature, clinical guidelines, and other decision support tools for LBP imaging in the following electronic databases: CINAHL, MEDLINE, EMBASE, PubMed, Science Direct and Cochrane Library. The search was limited to the English language publications from 2004 to 2015 and the emphasis was on systematic reviews, meta-analysis, randomized controlled clinical trials, and cross-sectional studies. Google Scholar was used to identify relevant gray literature and the resources. Then, the ACP team, HQC researchers, and QI experts initially drafted an MRI Checklist that was sent to the CDT for review.

To produce the final draft, the CDT conducted multiple review rounds through regular meetings until consensus was achieved. After the MRI Checklist was refined by the CDT, it was pilot-tested in the Saskatoon Health Region for four months and the Regina Qu'Appelle Health Region for three months in the fall 2015. During the trial, the ACP team collected data/feedback on the Checklist as a final development step and shared them with the CDT. Through the trial of the MRI Checklist, ambiguity in the order and grouping of the contents were identified. The Checklist (Appendix A) was implemented provincially in May 2016. The content validity (the extent to which the MRI Checklist includes all relevant items) was also assessed through a detailed discussion with physicians and patient representatives of the CDT.

The HQC team studied the RIS data during the trial, indicating 8.5% of patients receiving lumbar spine MRIs having also received a previous lumbar spine CT over a year period [11]. This evidence prompted a retrospective review of lumbar spine CT ordering practices. A review of 300 retrospective CT requests from six former health regions of Saskatchewan (Regina Qu'Appelle, Saskatoon, Sunrise, Prince Albert Parkland, Prairie North, and Five Hills) revealed that 58% of lumbar spine CT requisitions may not have been ordered for the most appropriate clinical indication [11]. The existing issue of duplicate testing between lumbar spine MRIs and CTs, large number of inappropriate CT requisitions, as well as uncertainty about lumbar spine CT indications while using the lumbar spine MRI Checklist in practice, led the CDT to develop the CT Checklist (Appendix B). The CT Checklist was also trialed in four former health regions of Saskatchewan (Regina Qu'Appelle, Saskatoon, Prairie North, and Five Hills) from April to November 2017.

Lumbar spine MRI and CT Checklists implementation:

The MRI Checklist was the first to be implemented into regular ordering practice of all urgent, semi-urgent, and elective lumbar spine MRI requests (excluding emergent requests) in the two largest Saskatchewan regions housing MRI machines in Saskatchewan: Saskatoon and Regina Qu'Appelle from October 2015 and November 2015 to January 2016, respectively (**Figure 1**). During the trial period, the ACP research team worked directly with the MRI booking staff in both regions to integrate the MRI Checklist into the requisition intake process, while

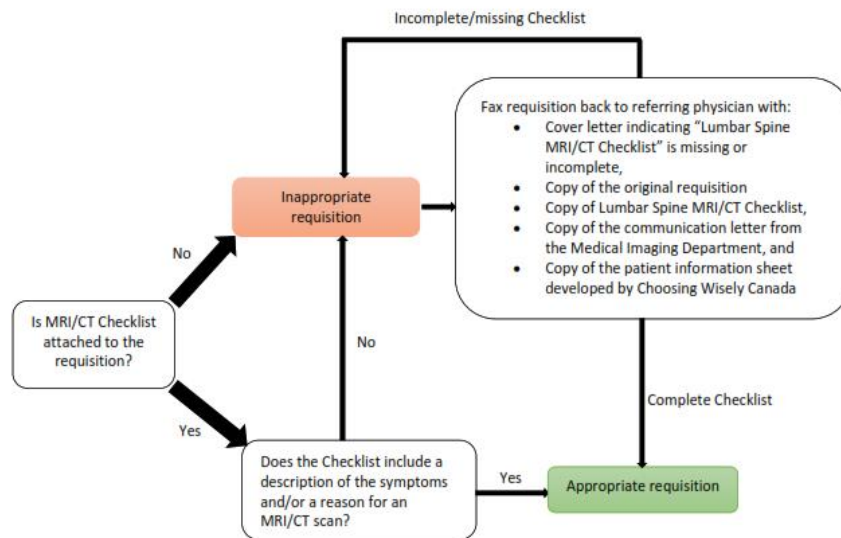


Figure 1: Algorithm in determining appropriateness of lumbar spine MRI and CT requisitions.

the ACP team provided additional support to the top referring physicians. Incoming requests were also monitored to ensure completion of the Checklist and requisition forms. Post-trial period, the MRI Checklist was used in the regular ordering of LBP MRIs and monitored for two months.

Data collection and analysis:

Retrospective request volume data were collected from the RIS for each segment of the study from regions involved in the trial. Figure two outlines the pre- and post-implementation data for MRI and CT Checklists: for the MRI Checklist, pre-implementation data were collected for the period of October 2014 to September 2015 and post-implementation data for the period of October 2015 to September 2016; and for the CT Checklist, data were collected from April to November 2016 prior to implementation and from April to November 2017 post implementation of the Checklist (Figure 2). Monthly volumes of lumbar spine MRI and CT requisitions in the study regions were analyzed using individual control charts (Figures 3-6). Each control chart presents a plot of the data (number of lumbar spine MRI and CT requisitions) over time (per month) with three additional lines: the centre line demonstrates monthly average number of MRI or CT requisitions in each site; and the upper and lower control limit show three standard deviations from the mean. Significant changes are defined by five rules; a) a run of eight or more points either all above or below the mean, (b) two out of three consecutive points near (outer one-third) a control limit; (c) a single point outside the control limits; (d) six consecutive points increasing or decreasing; and (e) fifteen consecutive points close (inner one third of the chart) to the mean [20].

Results

Results of lumbar spine MRI Checklist:

Comparing one year before and after the implementation of the MRI Checklist, the RIS data indicated that the number of lumbar spine MRI requisitions reduced from 4606 to 3559 (23% reduction). Regina Qu’Appelle reduced the average number of MRI requisitions by 39.8% and Saskatoon by 9.0%. The reduction in volumes lasted 13 months in Regina Qu’Appelle,

however when the lumbar spine CT Checklist was introduced, volumes of MRI started to increase (Figure 3). In Saskatoon, the monthly volume of MRI requisitions did not change significantly post MRI Checklist implementation. However, the number of lumbar spine MRI requisitions decreased after the implementation of the CT checklist.

Results of lumbar spine CT Checklist:

The RIS data showed a 27% decrease in the monthly average number of lumbar spine CT requests in the four sites in a year period after the CT Checklist implementation compared to one-year period before the implementation. One year before and after implementation indicated that the monthly average number of lumbar spine CT requisitions decreased by 76.2%, 45.5%, 15.6% and 11.6% in Five Hills, Prairie North, Saskatoon, and Regina Qu’Appelle, respectively (Figure 4).

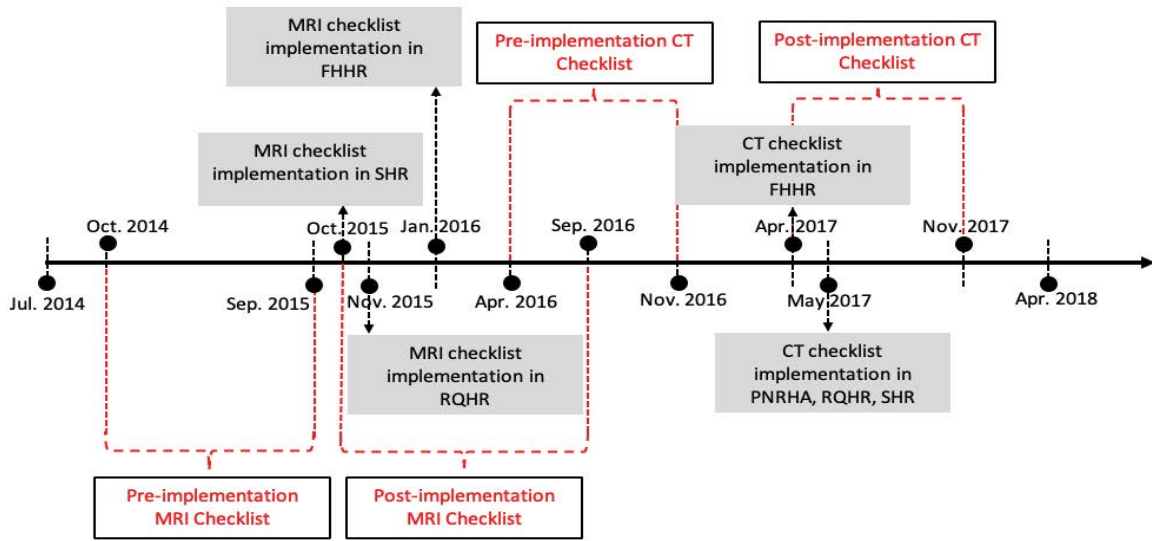
In Five Hills, the decrease in the monthly number of lumbar spine CT requisitions started 11 months before the implementation of the CT Checklist and was sustained after implementation. In Prairie North, the requisitions decreased after the implementation and lasted 11 months. There was no change after the implementation in Saskatoon. There was a shift (decrease) six months after the implementation in Regina Qu’Appelle (Figure 4).

The impact of CT Checklist on MRI requisitions:

After introducing the MRI Checklist, the number of lumbar spine MRI requisitions decreased and was sustained for 16 months in Saskatoon and Regina Qu’Appelle health regions. However, after the CT Checklist implementation, that shift disappeared. Post CT Checklist, a new shift (increase) in the count of MRI requisitions appeared (Figure 5).

The impact of MRI Checklist on CT requisitions:

After the implementation of MRI Checklist, there was not an immediate impact on the number of CT requisitions in the four health regions (Figure 6). However, after implementation of CT Checklist implementation there was a shift (decrease) in the number of lumbar spine CT requisitions.



Abbreviations:

- FHHR: Five Hills Health Region
- PNRHA: Prairie North Regional Health Authority
- SHR: Saskatoon Health Region
- RQHR: Regina Qu'Appelle Health Region

Figure 2: Study timeline.

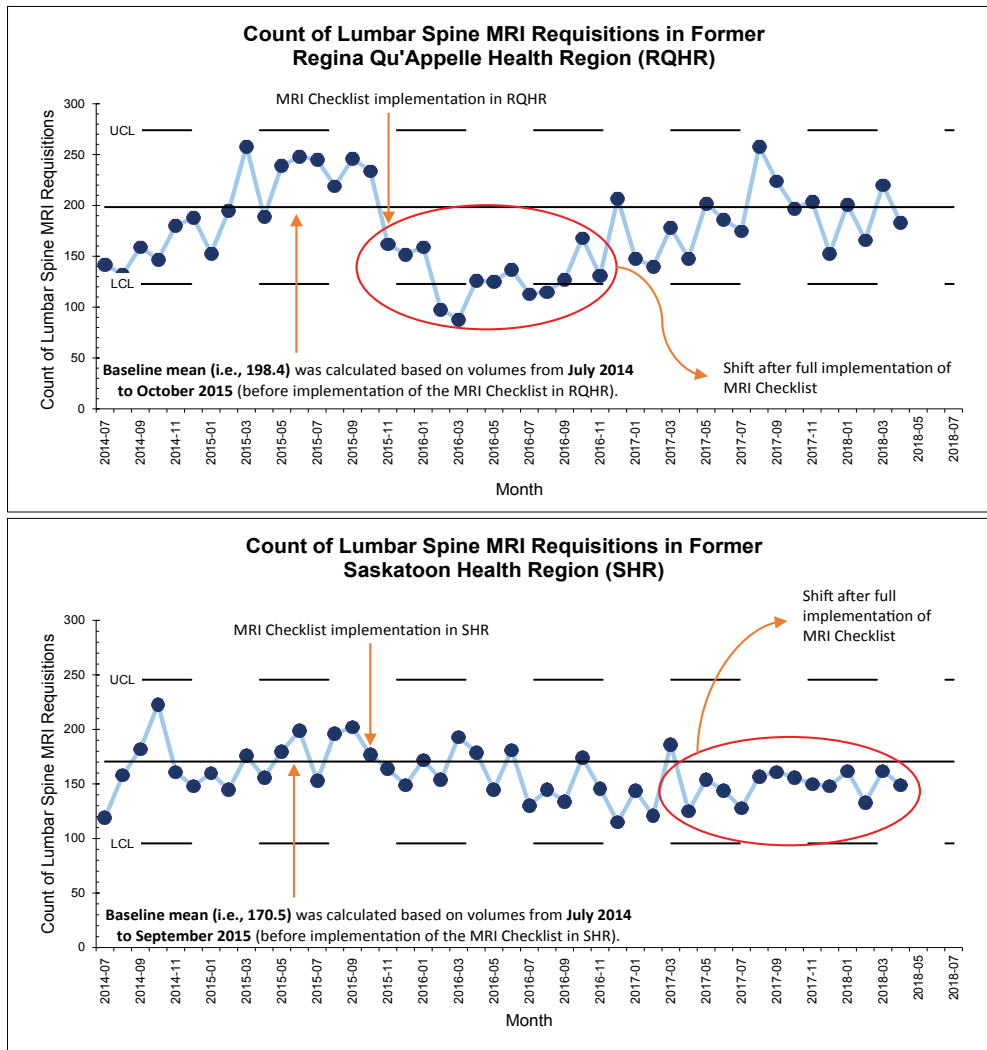


Figure 3: Control charts of monthly number of urgent, semi-urgent, and elective lumbar spine MRI requisitions in the two former health regions in Saskatchewan.

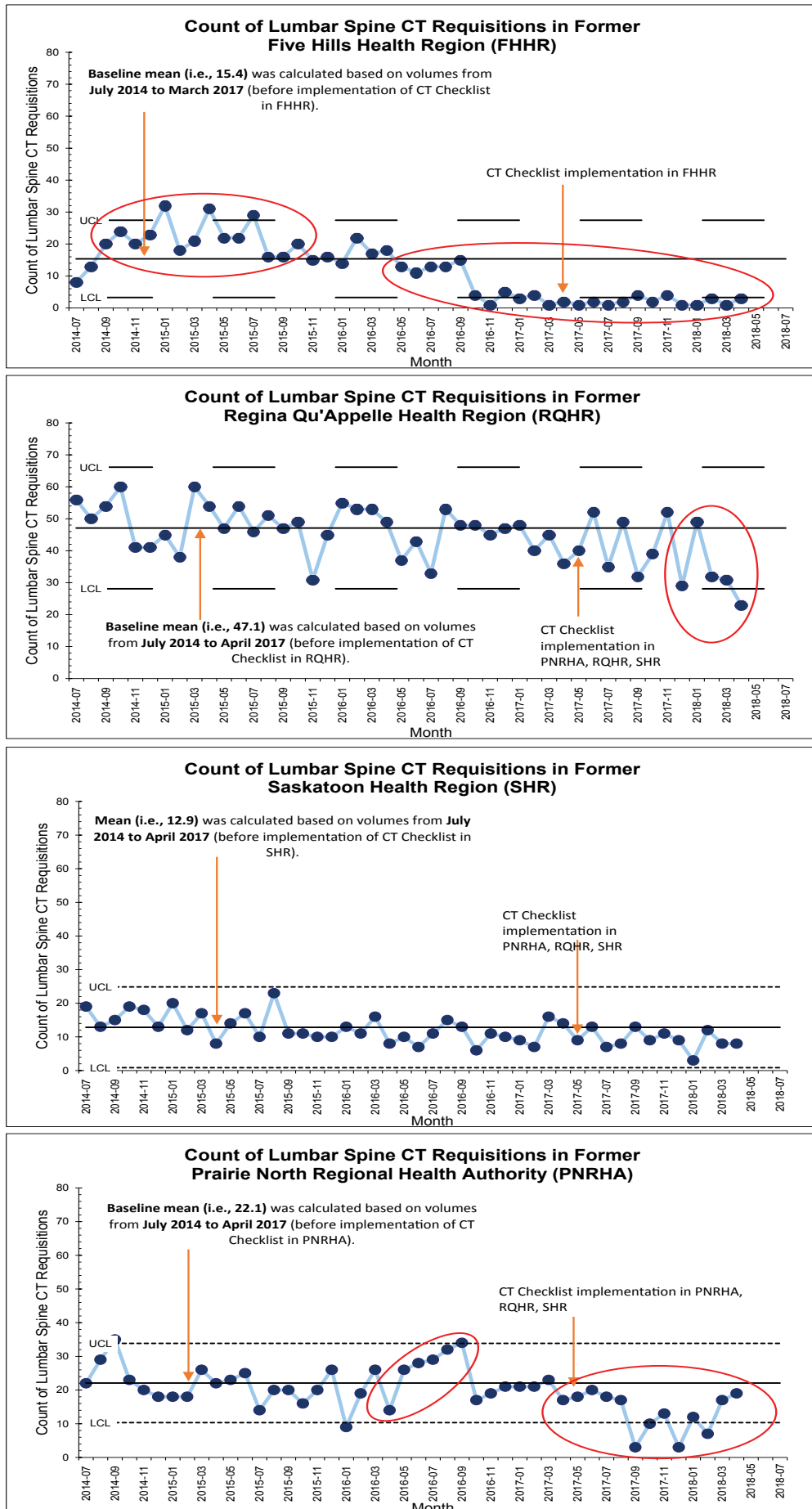


Figure 4: Control charts of monthly number of urgent, semi-urgent, and elective lumbar spine CT requisitions in the four former health regions in Saskatchewan from July 2014 to April 2018.

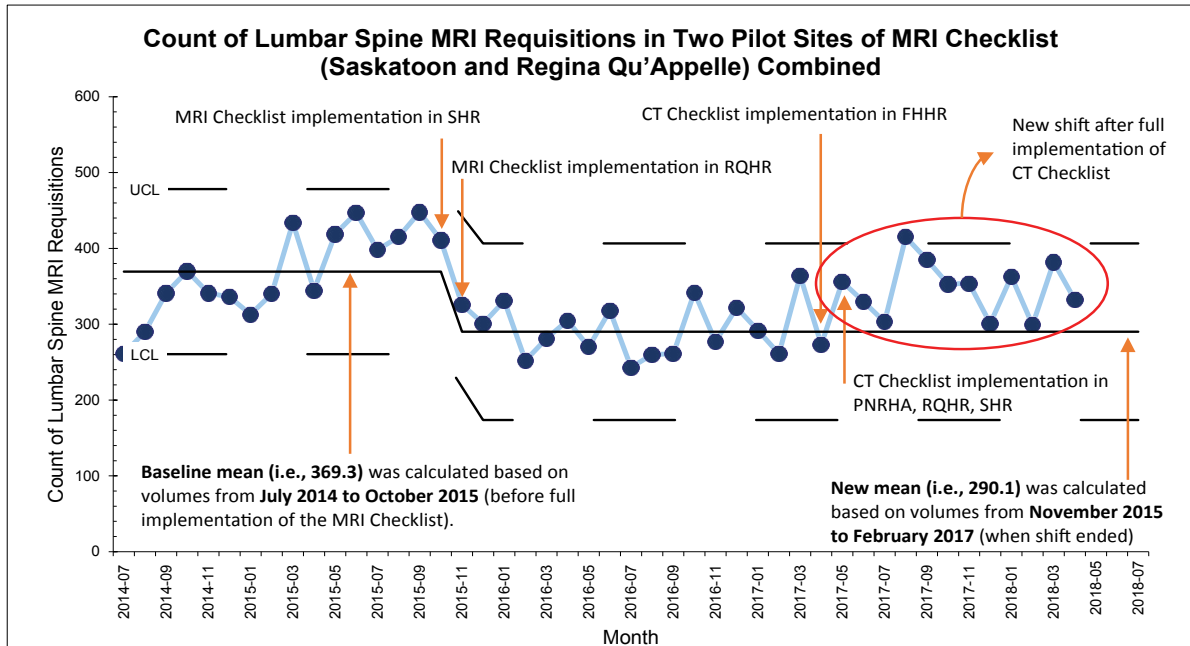


Figure 5: The impact of CT Checklist on the number of lumbar spine MRI requisitions.

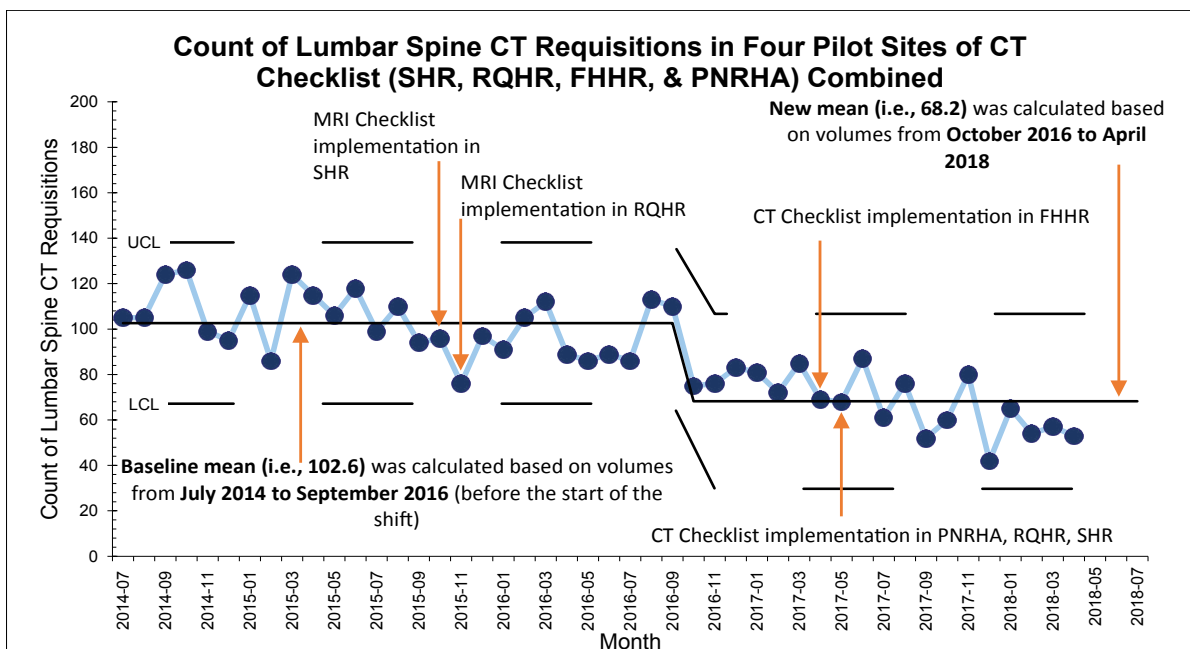


Figure 6: The impact of MRI Checklist on the number of lumbar spine CT requisitions.

Discussion

Inappropriate use of imaging for LBP patients has become an increasingly recognized problem [21]. To reduce inappropriate imaging orders for LBP, the ACP, CDT, and HQC teams conducted a quality improvement study. For this study, MRI and CT Checklists were developed to provide health professionals with ordering guidelines and indications to optimize urgent to elective imaging requests for adult outpatients. Our results showed 23% and 27% reductions in the monthly average number of lumbar spine MRI and CT requisitions, respectively, comparing a year before and after the implementation of the Checklists. The study findings indicate that the Checklists assisted physicians and general practitioners to appropriately order lumbar spine imaging matching CW recommendations

and provided an effective way to present important patient information and reasons for when to order imaging.

Decision support tools for LBP imaging have been developed and implemented with increasing frequency. There is a paucity of literature on the effectiveness of decision support tools in reducing inappropriate utilization [22]. Prior studies focused on the factors increasing number of imaging and have demonstrated increasing rate in imaging utilization [21,23,24]. However, in this study, we report a significant decrease in MRI and CT requisitions through Checklists based on locally derived evidence-based clinical indications and guidelines.

This study revealed requests for lumbar spine MRIs declined following the MRI Checklist introduction. Similarly, after full implementation of the CT Checklist, there was a decreasing

shift in the number of lumbar spine CT requisitions. However, monthly volumes of MRI requisitions increased above average after introducing the CT Checklist. That could be because inappropriate CT requisitions were not accepted and appropriate lumbar spine MRIs were ordered instead. Having said that, without access to the clinical indications of the requisitions, we cannot confirm if a requisition was appropriate or inappropriate based on the data coming from the RIS.

The CDT developed the lumbar spine CT Checklist to tackle the large number of inappropriate CT requisitions and duplicate rates of imaging between MRIs and CTs. A 2013 Canadian study indicated that 8% of patients have undergone repeat imaging [23]. The potential factors related to test substitution and duplication of imaging have been reported: (a) patient demand for diagnostic testing; and (b) long wait lists for patients awaiting non-urgent MRIs [25-28]. We also believe that different contexts and policies in two former health regions (Regina Qu'Appelle and Saskatoon) may contribute to the duplication of MRIs and CTs [29]. For example, while specialists and general physicians are allowed to order lumbar spine MRI in Regina Qu'Appelle, only specialists are allowed to do so in Saskatoon. This policy may lead some general physicians to order inappropriate lumbar spine CTs instead of MRIs. This variation in the ordering policy also may explain the reason that monthly volume of MRI requisitions did not change significantly in Saskatoon post MRI Checklist, opposed to Regina Qu'Appelle.

Only a few studies have evaluated the efficacy of LBP decision support tools [22]. Similar to the Checklist, a modified hospital referral form and targeted reminders to primary care doctors of appropriate indications for imaging, have contributed to successful and significant decreased use of LBP imaging by 36.8% and 22.5%, respectively [30,31]. These interventions could considerably decrease medical expenditures associated with inappropriate imaging [31]. This analysis of the Checklist impact provides a starting point for further study of the intervention's influence on reducing costs, wait times, and harms to patients.

Our quality improvement study requires further evaluation. First, limits of the pre- and post-intervention design restricts the ability to draw conclusions on the Checklists can effectively improve healthcare provision to LBP patients and whether other factors (such as change in local policy) contributed to these improvements. Second, we did not account for variations among the health regions, given they had different ordering policies. Third, control charts provided an understandable overview that allows monitoring whether Checklists reduce inappropriate imaging requests. However, there was a lack of post-hoc review of imaging requisitions after Checklist implementation due to the nature of the RIS database. This review could help to explore if there were other indications to receive or not receive imaging.

Control charts provide an understandable and up-to-date overview that allows detection of runs of good or bad outcomes and can encourage local investigation and learning. Control charts display details of the history of outcomes at a particular hospital and in many cases, learning actions could be instigated based on the plot itself without using thresholds; for example, the abrupt appearance of a downward slope as in **Figure 3**.

Conclusions

Two key features make this study novel. First, it describes the development of lumbar spine MRI and CT Checklists that could be employed to prevent inappropriate imaging orders, potentially reducing costs, shortening wait times, and improving patient safety. Our results may help the design of other local and national quality improvement studies (e.g. appropriate ordering of knee MRI imaging), by replicating the integration of a Checklist into the ordering process to mitigate inappropriate imaging requests. Second, the developed Checklists may evaluate appropriateness of imaging requests, standardize the process of imaging requisition intakes, and improve appropriateness of lumbar spine imaging in the province. These Checklists can represent important advancement in the quality of care provided to LBP patients, if the appropriate imaging order is sustained over time. Future research might identify other factors that are effective in Checklists implementation. Work is also needed to determine harms and costs with a relative attenuation in the rate of imaging utilization. Future studies could assess the sustainability of appropriate ordering of LBP imaging.

Ethical Approval

According to the ethics committee by the University of Saskatchewan Research Ethics Board, this study is exempted from the requirement of Research Ethics Board (REB) review and approval.

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Declaration of Interest Statement

The authors declare that they have no competing interest.

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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