ONLINE EXCLUSIVE

Cost-Effectiveness Analysis of a Reduction in Diagnostic Imaging in Degenerative Spinal Disorders

Analyse coût-efficacité d'une réduction de l'imagerie diagnostique pour les troubles dégénératifs de la colonne vertébrale

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Abstract

Background: Advanced imaging technologies such as computed tomography (CT) and magnetic resonance imaging (MRI) are highly sensitive, but often non-specific, diagnostic tools. Despite this, CT and MRI are overutilized in degenerative spinal disorder diagnosis. From the perspective of the Ministry of Health, we evaluated against usual care the cost-effectiveness of a hypothetical triage program for non-emergent spinal disorders that reduces unnecessary imaging uses.
Methods: Diagnostic and surgical data were prospectively collected on 2,046 outpatients who received consultation with the senior surgical author at Toronto Western Hospital, University Health Network, between September 2005 and April 2008. Using these data, we modelled an evidence-based diagnostic triage program wherein spine-focused clinical assessments and plain X-ray imaging would be applied prior to CT and MRI. Incremental costs were the incurred expenses from additional consultations and plain X-rays less the cost savings from the eliminated CT and MRI scans, expressed in 2009 Canadian dollars. Outcomes were expressed as the number of surgical candidates identified per MRI used in diagnosis, reflecting the efficiency of diagnostic imaging.
Results: The triage program incurred $109,720 from additional consultations and plain X-rays and saved $2,117,697 from eliminated CT and MRI scans, resulting in net cost savings of $2,007,977 for the 31 months of the study period, or $777,282 per year. In usual care, 0.328~0.418 surgical candidates were identified per MRI whereas in the triage program, 0.736~0.885 surgical candidates were identified per MRI, resulting in over a twofold improvement in MRI efficiency. The triage program was therefore dominating. Applying to high-volume spine surgeons in Ontario, we estimated that the implementation of the triage program would save the province $24,234,929 per year.
Interpretation: Based on the assumptions made in our modelling, eliminating unnecessary imaging in spinal disorder diagnosis can save healthcare significant resources.

Résumé

Contexte : Les technologies d'imagerie de pointe, telles que la tomographie par ordinateur (TO) et l'imagerie par résonance magnétique (IRM), sont très sensibles mais constituent souvent des outils de diagnostic à caractère non spécifique. Malgré cela, la TO et l'IRM sont surutilisées pour le diagnostic des troubles dégénératifs de la colonne vertébrale. Sous l'angle du ministère de la Santé et des Soins de longue durée de l'Ontario, nous avons évalué le rapport coût-efficacité d'un programme hypothétique de triage pour les cas de troubles non émergents de la colonne, en comparaison aux soins habituels. Ce programme hypothétique prévoyait une réduction de l'emploi non nécessaire de l'imagerie.
Méthode : Des données diagnostiques et chirurgicales ont été recueillies de manière prospective auprès de 2046 patients externes qui ont visité, pour consultation, l'auteur chirurgien principal du Réseau universitaire de santé de l'hôpital Toronto Western, entre septembre 2005 et avril 2008. Ces données ont été appliquées à un programme modèle de triage diagnostic

fondé sur les données probantes dans lequel l'évaluation clinique des problèmes de colonne vertébrale et l'imagerie par rayons X étaient utilisées avant de procéder à la TO ou à l'IRM. Les coûts différentiels étaient calculés en fonction des dépenses engagées par les consultations et l'imagerie par rayons X additionnelles moins les dépenses épargnées grâce à la suppression de la TO et de l'IRM, en dollars canadiens 2009. Les résultats sont exprimés en fonction du nombre de candidats pour la chirurgie obtenus par IRM employée pour le diagnostic, reflétant l'efficacité de l'imagerie diagnostique.
Résultats : Le programme de triage a engagé 109 720 dollars en consultations et radiographies additionnelles et a permis d'épargner 2 117 697 dollars par la suppression de TO et d'IRM, ce qui équivaut à une économie de coûts nets de 2 007 977 dollars au cours des 31 mois de l'étude, soit 777 282 dollars par année. Pour les soins habituels, 0,328~0,418 candidats à la chirurgie ont été obtenus par IRM alors que dans le cas du programme de triage, 0,736~0,885 candidats ont été obtenus par IRM, ce qui équivaut à une amélioration deux fois plus grande de l'efficacité de l'IRM. Le programme de triage est donc plus efficace. Étant donné la grande quantité de chirurgiens de la colonne vertébrale en Ontario, nous estimons que la mise en application du programme permettrait à la province d'économiser 24 234 929 dollars par années.
Interprétation : Selon les hypothèses tirées de notre modèle, l'élimination des imageries non nécessaires pour le diagnostic des troubles de la colonne vertébrale peut permettre d'économiser d'importantes ressources dans les services de santé.

Technology innovation is a major driver of rapidly rising healthcare costs (Newhouse 1992; Bodenheimer 2005; Laupacis and Evans 2005). Advanced imaging technologies such as computed tomography (CT) and magnetic resonance imaging (MRI) are now routinely employed in the diagnosis of common chronic conditions such as headaches and back pain. From 1993 to 2005, the annual numbers of CT and MRI scans performed in Ontario increased threefold and sixfold, respectively (Iron et al. 2003; Laupacis et al. 2005). The number of spinal MRIs, the second largest use of MRI after brain MRIs, has grown the fastest, from 10,523 in 1994 to 75,984 in 2005 (Laupacis et al. 2005), with back pain as its most frequent indication (You et al. 2008).

While MRI offers the finest imaging, its use in spinal disorder diagnosis must be exercised with caution for two reasons. First, it is significantly costlier than plain X-ray imaging or CT. Second, for degenerative spinal disorders, MRI exhibits a high prevalence of non-correlative, incidental "abnormalities" in both symptomatic and asymptomatic individuals (Jensen et al. 1994; You et al. 2008), suggesting a lack of clinical effectiveness in its usage (Larson et al. 1980; Chou et al. 2009). This finding is in contrast to the use of MRI in headaches, for which negative imaging tests typically eliminate possibilities of life-threatening lesions. In the 2001 Ontario guidelines for clinical management of back pain, spinal MRI was recommended only for persisting back pain after clinical assessments and alternative imaging techniques have been

performed (Deyo and Weinstein 2001; Institute for Clinical Systems Improvement 2010; Iron et al. 2004). Although a high level of physician compliance with these guidelines has been suggested (Iron et al. 2004), additional reports indicate otherwise (Staiger et al. 1999; Schers et al. 2000; Miller and Pinnington 2003; Cassidy et al. 2005; Kovacs et al. 2006; Dahan et al. 2008; Corbett et al. 2009; You et al. 2009), highlighting inconsistency in clinical practice.

In this study, we investigated whether stronger adherence to the 2001 Ontario guidelines would reduce CT and MRI usage in spinal disorder diagnosis and be cost-effective from the perspective of the Ministry of Health. We designed and compared to usual care an alternative triage program in which patients were first diagnosed from their clinical assessments and plain X-rays prior to CT or MRI.

Methods

Data

We used data from a single spine surgeon's practice at an urban academic hospital in Ontario. The study cohort consisted of all outpatients with non-emergency back pain who were referred to the senior surgical author between September 2005 and April 2008. From their referral information, 2,165 patients were deemed either potential surgical candidates or in need of further testing and scheduled for consultation with the spine surgeon. Three patients failing to attend their consultation were excluded from the study. The diagnosis and candidacy for spine surgery for the remaining 2,162 patients were clinically determined and prospectively coded by the spine surgeon at the time of consultation. Among them, 116 were missing diagnosis data in their charts and were excluded from the study. The remaining 2,046 patients represented approximately two-thirds of all referred patients (senior surgical author's practice). The other one-third, an estimated 1,023 patients, were deemed non-surgical from their referral information and did not receive consultation with the spine surgeon.

Demographic data were extracted from patient charts and coded by a third-year medical student. Patients were categorized into 14 different spinal diagnoses (Table 1). Surgical candidates were defined as patients whose clinical symptoms and structural abnormalities would likely have been amenable to surgical intervention at some point during their clinical course. Of the 2,046 patients who received consultation with the spine surgeon, 1,008 patients were identified as surgical, 763 were non-surgical, and 275 needed further testing (Table 1).
For our analysis, we created three distinct scenarios, allocating the 275 undetermined cases to (a) surgical cases, (b) surgical and non-surgical cases based on the distribution of known cases or (c) non-surgical cases as the high, medium and low estimates, respectively (Table 2).

TABLE 1. Patient diagnosis and candidacy for spine surgery

Code	Diagnosis	Diagnosable by	# patients	Surgical candidacy		
				Yes	No	Undetermined
1	Lumbar disc herniation / sciatica / radiculopathy	MRI	623	421	119	83
2	Lumbar spinal stenosis / claudication	MRI	228	166	27	35
3	Degenerative spondylolisthesis	X-ray	87	75	7	5
4	Isthmic spondylolisthesis	X-ray	103	85	11	7
5	Cervical radiculopathy / herniated nucleus pulposus	MRI	139	73	45	21
6	Cervical myelopathy / stenosis	MRI	26	20	5	1
7	Axial back pain / DDD* / stenosis / facet osteoarthritis	CA**	470	94	293	83
8	Axial neck pain / DDD* / spondylosis	CA**	58	5	48	5
9	Coronal deformity / scoliosis	X-ray	50	17	21	12
10	Sagittal deformity / kyphosis	X-ray	19	11	5	3
11	Tumour / infection	MRI	18	10	6	2
12	Inflammatory / rheumatoid arthritis / ankylosing spondylitis	MRI	11	6	3	2
13	Myofascial / multifactorial / chronic / regional pain syndrome	CA**	134	5	125	4
14	Miscellaneous	MRI	80	20	48	12
	Total		2,046	1,008	763	275

Data provided by the senior surgical author, Division of Orthopaedic Surgery, Musculoskeletal Health and Arthritis Program, Toronto Western Hospital, University Health Network, Toronto, ON, Canada.
* DDD, degenerative disc disease.
** CA, clinical assessment.
Shaded, diagnosable by clinical assessments or plain X-ray imaging.

TABLE 2. Outcome analysis

	Usual care			Triage program		
	# surgical candidates	# diagnostic MRIs	Outcome (candidates identified/ MRI)	# surgical candidates	# diagnostic MRIs	Outcome (candidates identified/ MRI)
High*	1,283	3,069	0.418	1,087	1,228	0.885
Medium*	1,162		0.379	1,038		0.845
Low*	1,008		0.328	904		0.736
Outcome difference**	0.467 (High*), 0.466 (Medium*), 0.408 (Low*)					

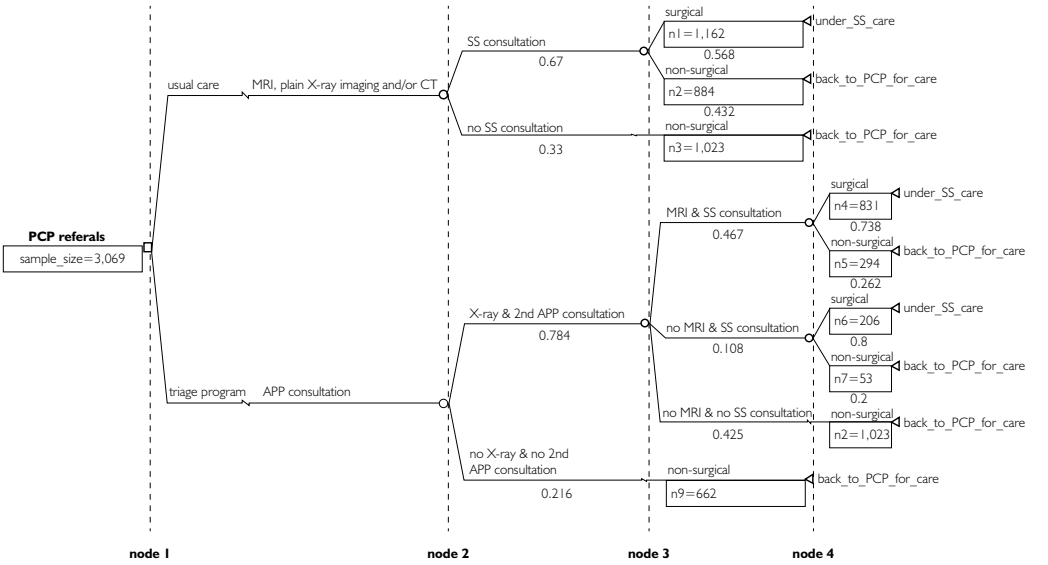
* Undetermined cases were allocated into: 1) surgical cases (High); 2) surgical and non-surgical cases based on the distribution of known cases (Medium); or 3) non-surgical cases (Low).
** Outcome difference = $\text{Outcome}_{\text{triage program}} - \text{Outcome}_{\text{usual care}}$

Decision modelling

All 3,069 patients underwent MRI, ordered by their primary care providers (PCPs), prior to referral. Of the 2,046 patients who received consultation with the spine surgeon, 493 and 869 had also obtained plain X-rays or CTs, respectively. However, the 1,023 patients who did not

receive consultation and cases with codes 3, 4, 7–10 and 13, as reported in Table 1, were diagnosable by clinical assessments, plain X-rays or both (senior surgical author's practice). From this information and the relative ratios of the diagnoses, a decision tree was constructed using the TreeAge Pro 2004 software, and the probabilities of each decision node determined (Figure 1).

FIGURE 1. Decision tree and probabilities for usual care and triage program for spinal disorder diagnosis



In usual care, all patients referred to the spine surgeon (SS) by their primary care providers (PCPs) underwent imaging prior to consultation. In the triage program, clinical assessments by an advanced practice physiotherapist (APP) and plain X-ray imaging were employed prior to determining whether MRI was required. The nodes refer to decision points. The numbers below each branch refer to probabilities. The n# values refer to the number of patients in the subgroups. Surgical candidacies from the "medium" estimates are shown. See Methods for details.

In usual care, all 3,069 patients referred to the spine surgeon by their PCPs (node 1, Figure 1) underwent diagnostic imaging. From their referral information, 1,023 patients were deemed non-surgical by the spine surgeon (node 2, Figure 1) and returned to their PCPs for care. The remaining 2,046 patients received consultation with the spine surgeon, and their surgical candidacy was determined (node 3, Figure 1). Surgical candidates fell under the spine surgeon's care. Non-surgical patients were returned to their PCPs for care. Modelling for post-consultation care is described in Appendix 1.

Building on the Ontario experience with hip and knee triage (Ontario Wait Time Strategy 2009), we hypothesized that an advanced practice physiotherapist with direct clinical training under a spine surgeon would be qualified to assume a triage clinician position. In the triage program, all 3,069 patients received consultation with the triage clinician prior to any imaging. From clinical assessments at consultation, 662 cases of axial pain (codes 7, 8 and 13 in Table 1) were identified as non-surgical (node 2, Figure 1). The remaining 2,407 patients underwent X-ray imaging and subsequent consultation with the triage clinician, and from

this, the 1,023 patients who did not receive consultation with the spine surgeon in usual care were identified as non-surgical (node 3, Figure 1). Of the remaining 1,384 patients, 259 cases with conditions readily identifiable on plain X-rays (codes 3, 4, 9 and 10 in Table 1) were diagnosed and referred to the spine surgeon without MRI (node 4, Figure 1). The outstanding 1,125 cases underwent MRI and were referred to the spine surgeon (node 4, Figure 1). Surgical candidates fell under the spine surgeon's care, and non-surgical patients were returned to their PCPs for care. Modelling for post-consultation care is described in Appendix 1.

Cost analysis

Incremental cost components between usual care and the triage program included MRIs, plain X-rays, CTs, consultations, post-consultation care and associated administration and overhead fees. In the triage program, some MRIs were replaced with plain X-rays; all CTs were eliminated; and consultations with the triage clinician were added and those with the spine surgeon reduced. The number of patients requiring post-consultation care from their PCPs or spine surgeon also differed between usual care and the triage program.

The cost components were quantified from the decision tree (Figure 1). Unit costs were drawn from the Ontario Case Costing Initiative (OCCI) for the fiscal year 2007/2008 or 2009 Ontario Health Insurance Plan Schedule of Benefits (SoB) and described in detail in Appendix 2. The OCCI costing was inflated from year 2007 to year 2009 using the annual average growth rate of per capita healthcare expenditure at 5.75%, computed with the 2004 ($4,123.50) and 2009 ($5,452.40) data from the Canadian Institute for Health Information (2009).

Outcome analysis

The outcome of the study was expressed in efficiency units of spinal MRI usage as the number of surgical candidates identified per MRI performed from the three scenarios for surgical candidacy created above (Table 2). The number of MRIs needed for diagnosis was determined from the decision tree (Figure 1; Table 2). In usual care, all 3,069 patients underwent MRI. In the triage program, MRI was needed for the 1,125 patients who could not be comprehensively diagnosed by clinical assessments with or without plain X-rays. In addition, of the 206 surgical candidates diagnosed through plain X-rays in the triage program, those who proceeded with surgery required MRIs for surgical planning. Because typically about half of surgical candidates proceed with surgery (senior surgical author's practice), an additional 103 MRIs were assumed needed for the triage program, indicating a total of 1,228 MRIs.

Incremental cost-effectiveness ratio

The incremental cost-effectiveness ratio (ICER) was computed as the incremental costs over the difference in MRI efficiency between usual care and the triage program and reflected cost implications of an improvement in MRI usage, in which each additional MRI scan identifies one surgical candidate.

Provincial implications

We obtained from the hip and knee triage study (Ontario Wait Time Strategy 2009) the tally and breakdown of spine surgery practices in Ontario into different classes that reflect the scope of practice (Table 3).

TABLE 3. Scope of practice among orthopaedic surgeons and neurosurgeons in Ontario

# surgeries/year*	# surgeons*	# orthopaedic surgeons**	# neurosurgeons**
25–49	11	6	5
50–74	12	7	5
75–99	8	4	4
>100	31	17	14

* Previous findings from Ontario Wait Time Strategy (2009).

** Computed with findings from Bederman et al. (2009).

TABLE 4. Cost analysis

	Usual care					
Incremental cost component	MRIs	Plain X-rays	CTs	Consultations	Post-consult care	
				SS*	SS*	PCP**
Quantity (Q)	3,069	493	869	2,046	1,155	11,223
Unit Cost (UC) in CAD****	$804.00	$91.58	$476	$76.30	$24.00	$42.35
UC in 2009 CAD	$899.05	$91.58	$532.27	$76.30	$24.00	$42.35
Cost (QxUC)	$2,759,185.09	$45,148.94	$462,545.68	$156,109.80	$27,720.00	$475,294.05
Total cost	$3,926,003.55					
Cost difference*****	–$2,007,977.47					

TABLE 4. Continued

	Triage program					
Incremental cost component	MRIs	Plain X-rays	Consultations		Post-consult care	
			APP***	SS*	SS*	PCP**
Quantity (Q)	1,228	2,407	5,476	1,384	1,817	5,747
Unit Cost (UC) in CAD****	$804.00	$91.58	$30.14	$76.30	$24.00	$42.35
UC in 2009 CAD	$899.05	$91.58	$31.87	$76.30	$24.00	$42.35
Cost (QxUC)	$1,104,033.66	$220,433.06	$200,966.72*****	$105,599.20	$43,608.00	$243,385.45
Total cost	$1,918,026.09					
Cost difference*****	–$2,007,977.47					

* SS, spine (orthopaedic) surgeon.

** PCP, primary care provider.

*** APP, advanced practice physiotherapist.

**** Drawn from 2007/2008 OCCI data or 2009 SoB.

***** Includes the one-time $25,000 training fee inflated to 2009 Canadian dollars.

****** Cost difference = $\text{Cost}_{\text{triage program}} - \text{Cost}_{\text{usual care}}$

The 31 surgeons performing >100 spine surgeries per year are likely to have a scope of practice similar to that of the senior surgical author. According to Bederman and colleagues (2009), of the 6,128 surgeries performed for degenerative disease of the lumbar spine in Ontario between April 1, 1995 and December 31, 2001, 2,687 were by neurosurgeons and the rest by orthopaedic surgeons. Assuming that neurosurgeons and orthopaedic surgeons perform comparable numbers of surgery, we partitioned the 31 surgeons into 14 neurosurgeons and 17 orthopaedic surgeons. Using this information and from the analysis on the two types of spine surgeons (Tables 4 and 5), province-wide cost implications of the triage program were estimated.

TABLE 5. Cost analysis using different professions in the triage program

	PCP* as triage clinician	Neurosurgeon for SS** consultation
Cost of usual care in CAD	$3,926,003.55	$4,024,594.35
Cost of triage program in CAD	$2,086,567.27***	$1,990,931.29
Cost difference****	–$1,839,436.29	–$2,033,663.07

* PCP, primary care provider.

** SS, spine surgeon.

*** Includes the one-time $25,000 training fee inflated to 2009 Canadian dollars.

**** Cost difference = $Cost_{triage\ program} - Cost_{usual\ care}$

Sensitivity analysis

The 2007/2008 OCCI data yielded an estimate of the unit cost of an MRI scan as $804, with a minimum of $45 and maximum of $9,241. The minimum might reflect the cost of a missed appointment, and the maximum might include non-MRI costs associated with an entire procedure. We performed sensitivity analyses to identify the effect of varying the unit cost of an MRI scan on the total cost difference between the triage program and usual care (Figure 2). In addition, because not all patients underwent plain X-ray imaging or CT in usual care, we tested scenarios in which varying proportions of the patients had undergone either test prior to referral (Tables 6 and 7; Figure 3).

Results

Patient descriptions

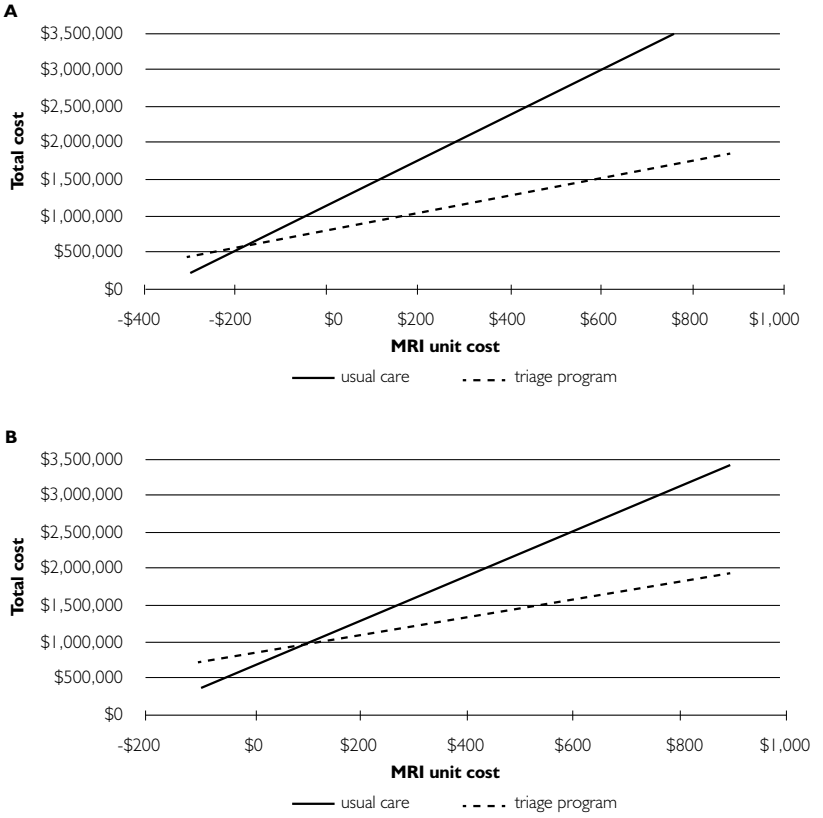
Of the 2,046 patients who received consultation with the senior surgical author between September 2005 and April 2008, 1,062 (51.9%) were male. Age, available for 2,034 patients, ranged from 18 to 98 years, with an average of 57.1±15.6 (SD) years and a median of 57 years. The most common conditions were lumbar disc herniation/sciatica/radiculopathy and the least common inflammatory/rheumatoid arthritis/ankylosing spondylitis (Table 1).

Cost analysis

The incremental cost components between usual care and the triage program are shown in Table 4. The triage program relative to usual care would generate $2,007,977 in savings over

the study period, equivalent to annual savings of $777,282. The major contributors to the cost savings were the 60% reduction in MRI usage and the elimination of CT scans.

FIGURE 2. Sensitivity analyses using various unit costs of an MRI scan



Varying the unit cost of an MRI scan shows that the total cost of usual care always exceeded that of the triage program irrespective of the MRI unit cost (A). If no plain X-rays or CTs had been utilized in usual care, the total costs of usual care and the triage program would be identical if an MRI scan cost $84.12 (B). Below this unit cost, the triage program would cost more; above this, it would generate cost savings.

TABLE 6. Sensitivity analysis using various proportions of patients with X-rays in usual care

	Costs with differential X-ray usage					
Proportion of patients with X-rays	0%	16% (Usual care)	25%	50%	75%	100%
Quantity	0	493	767.25	1,534.5	2,301.75	3,069
Unit cost in 2009 CAD	$91.58					
Cost of X-rays to usual care	$0	$45,148.94	$70,264.76	$140,529.51	$210,794.26	$281,059.02
Total cost of usual care	$3,880,854.61	$3,926,003.55	$3,951,119.37	$4,021,384.12	$4,091,648.88	$4,161,913.63
Cost difference*	–$1,962,828.53	–$2,007,977.47	–$2,033,093.28	–$2,103,358.04	–$2,173,622.79	–$2,243,887.55

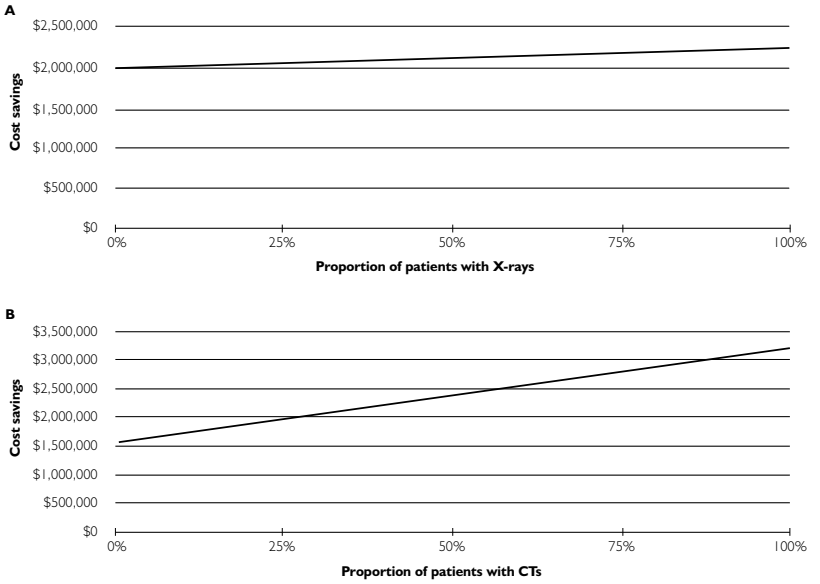
* Cost difference = $Cost_{triage\ program} - Cost_{usual\ care}$

TABLE 7. Sensitivity analysis using various proportions of patients with CTs in usual care

	Costs with differential CT usage				
Proportion of patients with CTs	0%	28% (Usual care)	50%	75%	100%
Quantity	0	869	1,534.5	2,301.75	3,069
Unit cost in 2009 CAD	$532.27				
Cost of CTs to usual care	$0	$462,545.68	$816,773.70	$1,225,160.54	$1,633,547.39
Total cost of usual care	$3,463,457.88	$3,926,003.55	$4,280,231.57	$4,668,618.42	$5,097,005.27
Cost difference*	–$1,545,431.79	–$2,007,977.47	–$2,362,205.49	–$2,770,592.34	–$3,178,979.18

* Cost difference = $Cost_{triage\ program} - Cost_{usual\ care}$

FIGURE 3. Sensitivity analyses using various proportions of patients with plain X-rays or CTs in usual care



Varying the proportion of patients who obtained plain X-rays (A) or CTs (B) in usual care from 0 to 100% shows that the total cost savings from the triage program would increase with increasing proportions.

Outcome analysis

The outcomes of usual care and the triage program are shown in Table 2. The triage program would identify a slightly lower number of surgical candidates because patients diagnosed with codes 7, 8 and 13 would be deemed non-surgical, whereas in usual care, 104 of these patients would be identified as surgical, likely based on other confounding clinical factors (Table 1). In usual care, approximately three MRIs are needed to identify one surgical candidate. More than a twofold increase in the efficiency of MRI usage would be achieved under the triage program.

Incremental cost-effectiveness ratio

The ICER was computed from the $2,007,977 in savings over the 0.408~0.467 additional surgical candidates identified as $4,299,737~4,921,513 saved from an improvement in MRI usage that leads to each additional MRI scan identifying one surgical candidate. The triage program would be dominating over usual care.

Alternatives for triage program

While we designated an advanced practice physiotherapist as the triage clinician, the task could be performed, with training, by PCPs and chiropractors alike. Similarly, surgical consultations could be performed by a neurosurgeon instead of an orthopaedic surgeon. The cost analysis was repeated with the alternatives of hiring a PCP as the triage clinician (chiropractors would result in similar costs to physiotherapists) or providing neurosurgery consultations (Table 5). The triage program would still be dominating over usual care.

Provincial implications

We expanded our findings to the province of Ontario, assuming 14 neurosurgeons and 17 orthopaedic surgeons in total (Table 3). Province-wide savings from the triage program were estimated at $62,606,900 (= 17 x $2,007,977 [Table 4] + 14 x $2,033,663 [Table 5]) for the study period of 31 months, yielding annual savings of $24,234,929.

Sensitivity analysis

The savings from reduced MRI usage was a major driver of the total cost savings from the triage program, suggesting that our result would be most sensitive to the unit cost of an MRI scan. However, even with a varying unit cost of MRI, the triage program always resulted in cost savings relative to usual care (Figure 2A). If we assumed that no plain X-rays or CTs had been obtained in usual care, the triage program no longer generated cost savings if the unit cost of each MRI scan was $84 or less (Figure 2B). Since this unit cost is implausible, the triage system was likely to generate cost savings.

In usual care, at least 16% and 28% of all referred patients underwent plain X-ray imaging or CT, respectively. The triage program would still generate cost savings even if no X-ray imaging or CT were assumed (Tables 6–7; Figure 3), demonstrating the robustness of our model.

Interpretation

Summary of findings

In this study, we modelled in an evidence-based manner (Iron et al. 2004; Institute for Clinical Systems Improvement 2010) a triage program for spinal disorder diagnosis that would reduce advanced imaging usage by first employing clinical assessments and plain X-ray imaging. Our study showed that 100% of CTs and 60% of MRIs performed in the study cohort were not necessary. The sequential model of diagnosis and the use of a triage clinician instead of the spine surgeon in the triage program minimized the unnecessary use of advanced imaging and the cost of

extra consultations needed, respectively, and in turn maximized the cost savings. The triage program was more efficient than usual care at identifying surgical candidates while saving resources, and if implemented throughout the province, could generate over $24 million per year in savings.

Implications

Reducing wait times for CT and MRI is one of the top healthcare priorities in Ontario as well as in other parts of Canada (Emery et al. 2009; Wait Times Alliance 2009). To the best of our knowledge, no comprehensive economic evaluation has been conducted to investigate the potential cost savings and resource utilization from eliminating unnecessary CT and MRI usage in spinal disorder diagnosis. Because patients referred to spine surgeons represent a subset of all patients presenting to PCPs with back pain, and because non-referred patients may also obtain unnecessary imaging, the potential cost savings are likely even greater.

While the proposed triage program is a simple, minimalist model, the cost savings generated could be used to augment the program for realistic implementation. For instance, the savings should be used in hiring more personnel and promoting team-based approaches across different professions to facilitate the diagnostic process. Current wait times for surgical consultation span several months to over a year in some areas (Braybrooke et al. 2007; Hurlbert et al. 2008; Simon et al. 2009). According to a recent survey, the majority of patients assessed by a spine-trained nurse practitioner did not want to wait an additional six months to see a spine surgeon (Sarro et al. 2010). The triage program could also be accompanied by education components that improve general knowledge of spinal disorders, limitations of imaging tests and self-management strategies. The importance of such education programs for the public was highlighted in a recent study in which physicians reported patient pressure as a determinant in ordering MRI (You et al. 2009). The triage program could be offered in existing specialist centres or in new multidisciplinary spine centres that could be established with reallocation of the province-wide cost savings from reduced imaging.

Limitations

Our study was subject to significant limitations.

First, we used a single tertiary care and academic surgeon's data. While we could not directly generalize our findings, data from the Institute for Clinical Evaluative Sciences (You et al. 2010) and other studies (Power et al. 2006; Bederman et al. 2009) reported lower rates of surgery uptake among spine surgical candidates compared to ours, suggesting that our study represented a conservative estimate for the economic evaluation.

Second, our data set included charts for only the 2,046 patients who received consultation with the senior surgical author, and not for the referrals that were not seen. Therefore, the exact number of the latter patients was unknown, and whether these patients obtained MRIs, plain X-rays or CTs could not be confirmed. However, if we assumed that none of these patients obtained MRI scans, there would still be 818 MRIs in total and $421,258 per year saved by the triage program.

Third, post-consultation care was estimated from provincial administrative data and carries many assumptions (Power et al. 2006). However, the costs of post-consultation care in usual care and the triage program were not significant drivers of the total cost savings and would not change the conclusions drawn from our study.

Fourth, we performed macro costing using publicly available data from OCCI and SoB. While there is potential for errors in our costing, our sensitivity analyses consistently demonstrated the robustness of the model.

Conclusion

Based on the assumptions made in our model, reducing unnecessary CT and MRI usage and providing subspecialty diagnostics with the proposed triage program would improve the efficiency of diagnostic imaging and result in significant savings in resources. Future studies are warranted to test our model against additional surgeons' data as well as the larger population of patients suffering from spinal disorders who typically see only a PCP or a non-surgical specialist and also to apply to other diagnostic tests.

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Appendix 1: Post-Consultation Care

For post-consultation care in usual care, the rate of return visits to the spine surgeon or PCPs was calculated from the findings of Power and colleagues (2006). In Canada, each patient with back pain for the fiscal year of 1998/1999 made 2.2 medical visits per year, 18.3% of which were made to specialists and the rest to PCPs (Power et al. 2006). These findings translate into 5.7 visits per patient for our study period of 31 months, thereby yielding in aggregate 17,493 (= 3,069 x 5.7) total visits. Of these, 3,201 (= 17,493 x 0.183) visits were estimated to have been made to specialists, assumed to be the spine surgeon in our case, and 14,292 (= 17,493 – 3,201) to PCPs. The 3,069 patients in our study cohort initially contacted their PCPs, and 2,046 of them received consultation with the spine surgeon. Therefore, we estimated that post-consultation care would have consisted of 11,223 (= 14,292 – 3,069) return visits to PCPs and 1,155 (= 3,201 – 2,046) return visits to the spine surgeon.

For post-consultation care in the triage program, identical to that in usual care, we assumed that the study cohort made 17,493 total visits, 3,201 to the spine surgeon and 14,292 to PCPs. This was a conservative estimate because every patient in the triage program received consultation with the triage clinician, likely lessening patient demand for additional consultations. The 3,069 patients in the triage program initially contacted their PCPs and received consultation with the triage clinician. Of them, 2,407 patients received another consultation with the triage clinician, and 1,384 patients received consultation with the spine surgeon. Therefore, we estimated that post-consultation care would have consisted of 5,747 (= 14,292 – 3,069 – 3,069 – 2,407) return visits to PCPs and 1,817 (= 3,201 – 1,384) return visits to the spine surgeon.

Appendix 2: Sources of and Codes for Costing

The unit cost of an MRI scan of the spine without enhancement (OCCI code: 3SC40WA), the most common procedure for spinal disorder diagnosis, was determined from OCCI categorized under ambulatory care in the University Health Network. The average total cost included direct (e.g., machine use) and indirect (e.g., hospital administration) fees.

The unit cost of a plain X-ray was assigned from SoB. Cases of scoliosis and kyphosis (codes 9 and 10 in Table 1) were clinically visible and required two or more views of the entire spine (SoB code: X031, 69 patients), whereas cases of spondylolisthesis (codes 3 and 4 in Table 1) necessitated four or five views of the lumbar or lumbosacral spine (SoB code: X205, 190 patients). The rest of the X-ray cases (1,125 patients) would also obtain the more comprehensive X205 because their conditions were not clinically visible. The unit cost of an X-ray, which included technical, professional and facility fees, was determined as the weighted average of SoB X031 and X205.

The unit cost of a CT scan of the spine without enhancement (OCCI code: 3SC20WA), the most common procedure for spinal disorder diagnosis, was determined from OCCI categorized under ambulatory care in the University Health Network. The average total cost included direct (e.g., machine use) and indirect (e.g., hospital administration) fees.

For consultation with the spine surgeon, the general fee-for-service rate for consultation in orthopaedic surgery (SoB code: A065) was used, which included direct (e.g., physician salary) and indirect (e.g., hospital administration) costs. For consultation with the triage clinician, a rate was obtained from the previous study on hip and knee triage (Ontario Wait Time Strategy 2009). An advanced practice physiotherapist would be paid $100,000 per year, including benefits, and receive a one-time, four-month training program costing $25,000, shadowing a spine surgeon in the clinic, both in 2008 Canadian dollars. We assumed a working schedule of five days per week, seven hours per day, and 30 minutes per consultation, a conservative estimate to allow for a patient educational or counselling component. A typical year in Ontario consists of 104 weekend-days, nine statutory holidays, and three weeks of paid vacation, leaving 237 workdays. Therefore, one triage clinician would perform 3,318 consultations per year and alone suffice to conduct the 5,476 consultations required for the triage program for the study period. The one-time $25,000 training fee was added to the cost of the triage program. The consultation rate was calculated as $100,000/3,318 consultations = $30.14 per consultation. As per the hip and knee triage study, the triage clinician would be integrated into an existing surgical centre, eliminating the need for indirect cost assessments (Ontario Wait Time Strategy 2009). The costs were inflated to 2009 Canadian dollars using the annual average growth rate of per capita healthcare expenditure at 5.75%, computed with the 2004 ($4,123.50) and 2009 ($5,452.40) data from the Canadian Institute for Health Information (2009).

Post-consultation care was expensed from the fees for repeat consultations with PCPs (SoB code: A006) or orthopaedic surgeons (SoB code: A064), both of which included direct and indirect costs.

Different professions could assume the positions of the triage clinician and spine surgeon. To implement a PCP as the triage clinician or a neurosurgeon as the spine surgeon, the general fee-for-service rates for family practice consultation (SoB code: A005) and neurosurgery (SoB code: A045 for surgical consultation and A044 for post-consultation care) including both direct and indirect costs were used, respectively (Table 5).