Spring 3-26-2024

The Impact of Covid-19 on the Utilization of Early Magnetic Resonance Imaging (eMRI) in the Assessment of Acute Uncomplicated Low Back Pain (LBP) and the Subsequent Effect on Health Care Service Utilization and Patient Outcomes

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BY

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3/26/2024

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A doctoral project submitted to the faculty of the Medical University of South Carolina
in partial fulfillment of the requirements for the degree
Doctor of Health Administration
in the College of Health Professions

Acknowledgments

My husband: of 30 years, Doug, who has been the first, best and most supportive person through all my school and work journeys! Despite my best attempts at self-doubt and imposter syndrome, he never lets me forget I'm amazing and can do anything.

My daughter: Alyssa, midway through her own college journey (go Noles!) who has the most amazing spirit and drive, who also shares some of my doubts and anxieties, but perseveres in the face of some major obstacles placed in her way. She inspires me with her resilience and intelligence, but also finding time for fun! She inspires me to work hard and accomplish hard things so she can also be inspired.

My Committee: Dr. Walter Jones (Chair), Dr. Elinor Borgert, and Dr. Mary Dooley – Each provided great insight and feedback in different ways. Dr. Jones for your leadership and guidance as chair, Dr. Borgert for details and insight on my writing style and content, and Dr. Dooley for the analysis work itself and guidance on interpretation and findings.

Dr. Jillian Harvey: Her leadership and coordination of this program is outstanding. This has been by far the most challenging and rewarding academic experience I've had! The caliber of professors, speakers, and course content is superb! Dr. Harvey is present and approachable and works tirelessly to make sure all students are given the support they need for success.

Class of 2024: My fellow classmates and now friends. I've been blessed to get to know so many intelligent healthcare professionals and leaders. I've learned so much from their personal and professional experiences. I have been inspired by their projects and am wiser for all of it.

Abstract of Doctoral Project Presented to the
Medical University of South Carolina
In Partial Fulfillment of the Requirements for the
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OBJECTIVES: To examine changes in MRI rates between Pre-COVID-19 period (Feb-April 2019) and COVID-19 period (Feb-April 2020) among commercially insured patients aged 18-60 with a diagnosis of acute LBP, and to analyze differences in patient characteristics and outcomes between the time periods. Additionally, to examine the impact of eMRI on patient outcomes and health care costs for patients in the COVID-19 period.

DESIGN/METHODS: Using IBM® MarketScan® Commercial Database (MarketScan) we performed a quantitative pre-post comparative retrospective observational study of 117,150 total patients to examine adjusted differences in patient characteristics and rates of MRIs between time periods. We analyzed 49,020 patients in COVID-19 period to examine the impact of eMRIs on odds of having lumbar surgery (OR and 95% CI), and on adjusted total cost for health care services in a one-year follow up time.

RESULTS: The most significant between time periods was that eMRI rates decreased 1.41 percentage points from Pre-COVID-19 to COVID-19 period (P,0.0001). In COVID-19 analysis, patients with noMRI had 97.6% lower odds of having lumbar surgery vs eMRI (P<0.0001). The adjusted total health care cost difference between eMRI and noMRI was $7,881 (P<0.0001).

CONCLUSION: COVID-19 time period correlated with a statistically and clinically significant reduction in eMRIs for acute LBP, considering that prior to COVID-19, rates of MRIs were increasing exponentially each year. Results proved the hypothesis and confirmed literature review findings, that eMRIs result in worst patient outcomes, as measured by odds of surgery, and also result in significantly higher health care costs. Even the modest reduction in eMRI rates shown in this study could have a significant impact on costs, estimated at eight billion dollars of annualized savings, based on how many Americans suffer from LBP.

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1 INTRODUCTION

1.1 Background and Need

The United States spends more on health care than any other country; in 2021 the Organization for Economic Co-Operations and Development (OECD) published that the U.S. spent over $12,000 per capita on health care which was 17.8% of gross domestic product (GDP), twice as much as the average OECD country ("U.S. Health Care From A Global Perspective, 2022; Accelerating Spending, Worsening Outcomes," 2023). Despite this level of spending, the U.S. ranks lower in measures of health care access and quality than comparable countries such as Australia, Canada, and the UK. Kurani and Wager (2022) reported the U.S. had a 2016 Health Care Access and Quality (HAQ) Index score of 88.7 compared to a comparable country average of 93.7. The HAQ Index is measured on a scale of 0 (worst) to 100 (best) based on risk-standardized mortality rates from thirty-two causes that should not normally result in death in the presence of quality health care – also called amenable mortality.

A significant contributor to high U.S. health care costs is waste which accounts for 25-30% of total health care spending at an estimated annual $750 billion (Lyu et al., 2017; Shrank et al., 2019). A report by Optum categorized healthcare waste into six categories: clinical inefficiencies, missed preventative opportunities, overuse, administrative waste, excessive prices, and fraud and abuse (Speer et al., 2020). Of the $750 billion, $100-$200 billion is specifically attributed to overuse or the delivery of unnecessary services which have little or no proven clinical benefit or impact on clinician decisions, and is the single largest contributor (Carrol, A.E., 2017). Unnecessary care not only contributes to excessive costs, it also has been shown to cause patient harm (Chalmers, et al., 2021; Lyu et al., 2017). Advanced imaging is of particular

concern, with studies showing that over 25% of studies are either unnecessary or inappropriate (Emery et al., 2013; Lyu et al., 2017).

One area of care where advanced imaging, such as magnetic resonance imaging (MRI), is frequently misused is in the assessment of acute non-complicated low back pain (LBP), despite both evidence and guidelines advising against MRIs for this condition in the first three to six months (Chou et al., 2009; Lyu et al., 2017; Shraim et al., 2021). An MRI within the first 6 weeks of symptoms is defined as an early MRI (eMRI) and is not recommended for LBP without complications. These recommendations are based on clinical evidence demonstrating that most patients improve within the first month with conservative treatment, even with symptoms of radiculopathy or disc herniation (Webster et al., 2010). There is evidence that less than ten percent of LBP is due to spinal pathology (Hall, 2021) and that degenerative disc disease is a normal aging process that is seen in up to ninety-seven percent of asymptomatic patients (Brinjikji, et al., 2015). Moreover, multiple studies have shown that not only does the use of MRIs in assessing acute LBP not improve clinical decision making, but it can also result in a cascade of additional unnecessary medical services, including spinal surgery, with worse patient outcomes including increased length of disability and work absence (Chou et al., 2009; Ganguli et al., 2023; Shraim et al., 2021; Wang et al., 2019). For work-related acute LBP, a study by Webster et al. (2010) concluded that eMRIs resulted in a fivefold increase in total medical costs, an eightfold increase in risk for surgery, and worse disability. Chou et al., (2012) reported that surgery rates in the U.S. are two to five times higher than those in other developed countries with no evidence showing improved outcomes, which further confirms the underlying problem of unnecessary care leading to both higher health care spending and worse health outcomes.

1.2 Problem Statement

LBP is being focused on as it is a significant contributor to disability globally, having been ranked first among all diseases for years lived with disability (Shraim et al., 2021). Uncomplicated acute LBP is generalized low back pain lasting less than 6 weeks with or without radiating pain in the lower extremities. The Agency for Health Care Policy and Research (AHCPR), which is now the Agency for Health Care Research and Quality (AHRQ) and is the leading agency in supporting efforts to improve the quality of health care, published guidelines in 1994 advising against the use of any lumbar imaging, including MRIs, in the first 6 weeks of symptoms unless there was a presence of any of the following red flags: recent significant trauma, unexplained weight loss, unexplained fever, immunosuppression, history of cancer, intravenous drug use, prolonged use of corticosteroids, osteoporosis, age older than 70 years, or focal neurologic deficits with progressive or disabling symptoms (Bigos, 1994). Current guidelines by the American Academy of Family Physicians, the Board of Internal Medicine, and the American Association of Neurological Surgeons also all recommend against the use of MRIs within the first six weeks of symptoms, promoting the adherence to these guidelines in the Choosing Wisely Campaign (Gidwani et al., 2016; Hall et al., 2021; *Imaging for Low Back Pain*, n.d.). Finally, the American College of Radiology (ACR) publishes annually reviewed evidence-based guidelines establishing appropriateness use criteria (AUC) for the use of imaging; they indicate no imaging is indicated for acute LBP until after at least "…six weeks of medical management and physical therapy that resulted in little or no improvement…" (Expert Panel on Neurological Imaging, 2021).

Research clearly suggests that eliminating unnecessary eMRIs in the assessment of acute LBP would help reduce the cascade of unnecessary care, reducing health care costs associated

with LBP while maintaining quality of care and even improving patient outcomes. Despite these findings and clear guidelines against eMRIs, the use of advanced imaging continues to increase. Chou et al. (2012) reported a fourfold increase of lumbar MRIs between 1994 and 2005 for Medicare B beneficiaries, and a threefold increase between 1997 and 2006 for large health care organizations; this was associated with similar rates of increased risk for surgery and other interventional procedures such as epidural injections. Downie et al., (2020) found a fifty-three percent relative increase in complex imaging from 1995 to 2015 based on a systematic review and meta-analysis of twenty-seven included studies.

With the continued and increasing overuse of MRIs in the U.S., there has been limited data for a substantive comparative analysis on the benefits of avoiding eMRIs, particularly at a population level. Data has shown that other high-income countries perform significantly fewer MRIs than the U.S. at 82 MRIs per 1,000 people versus the U.S. which performs 118 MRIs per 1,000 people ("Healthcare Spending in US, Other High-Income Countries," 2018). However, significant differences in both health care coverage and unit costs make it difficult to directly compare how this difference in MRI utilization influences costs and outcomes. This study provides an opportunity to add to the body of evidence examining the impact of avoiding eMRIs for acute LBP on patient outcomes and health care costs in the U.S. Data gathered from this study can be used to help inform clinical decision-making for providers, patient education, and reimbursement decisions to support the population health initiative to deliver value-based care and improve U.S. health care quality and costs (Zangerle et al., 2016).

1.3 Research Questions and Research Hypotheses:

Was there an impact on eMRI rates in the assessment of acute LBP because of the pause on non-essential services during COVID-19 compared to pre-COVID-19, and did this impact

the utilization of other health care services and patient outcomes?

COVID-19 provided a natural experimental condition where elective procedures such as MRIs were reported to have significantly decreased; it is estimated that nonemergent medical care decreased by up to 60% in spring of 2020 (Roth and Lazris, 2021). This change in overall medical utilization reported during COVID-19 provides an opportunity to perform a retrospective pre-post quantitative observational study comparing the utilization of eMRIs in the assessment of acute non-complicated LBP and the subsequent impact on health care services and patient outcomes before and during COVID-19. The hypothesis of this study is that COVID-19 had a nationwide impact on elective procedures such as eMRIs. Based on research findings, a reduction in eMRIs against evidence-based guidelines should have resulted in reduced unnecessary health care services, particularly surgery, as well as improved patient outcomes of hospital stays and surgery.

The comparative time periods for the study will be February to April 2019 for Pre-COVID-19 and February to April 2020 for COVID-19. It was in March 2020 when the Centers for Medicare and Medicaid services (CMS) made recommendations to stop elective and non-essential surgeries and procedures (CMS Releases Recommendations on Adult Elective Surgeries, Non-Essential Medical, Surgical, and Dental Procedures During COVID-19 Response | CMS, 2020). The study thus used February for the date of an initial encounter to allow time for MRI referral and scheduling, with a maximum coverage of the March and April time periods for which most MRIs would normally be expected to occur. The shorter time period was decided upon based on the literature review, which revealed the most significant impact to volume was during the initial COVID-19 surge period from March to June, with most studies reporting a normalization of health care utilization from July 2020 onward (Doshi et al., 2021; Elton and

Zhang, 2023; Naidich et al., 2020). We are also using the same months of the year for pre-COVID-19 and COVID-19 time periods to control for seasonal effects to health care utilization (i.e., increased use of elective surgeries and procedures at the end of a calendar year when deductibles have been met).

The IBM® MarketScan® Commercial Database (MarketScan) will be the primary dataset used to perform a comparative study of health care utilization and patient outcomes, as it provides one of the largest collections of de-identified medical and drug data on working adults under age 65 (IBM Watson Health, 2021). This study will first examine the rate of MRIs between the two time periods to examine the hypothesis that COVID-19 reduced the incidence of eMRIs for acute LBP. This study will then examine differences in health care service utilization and patient clinical outcomes over the following year after diagnosis of patients in the COVID-19 period. Based on research findings, health care services expected to be impacted by a reduction in eMRI rates include physical therapy, prescribed medicine, surgery, and steroid epidural injection rates. Total health care costs will be used to measure the downstream impact on overall health care utilization 1-year after the initial encounter for LBP. Patient outcomes will be assessed based on the occurrence of lumbar surgical procedures in the 1-year follow up period.

1.4 Population

The population for this study is U.S. adult patients with a diagnosis of uncomplicated acute LBP. The study will include U.S. patients aged 18-60, with the upper age limit determined based on age groupings from previous research studies, and staying within the defined adult age population versus older adult (60-64) or elderly age grouping (>64) (Chou, 2009; Graves, 2012; Shraim, 2021). Older adults and seniors are excluded due to the advanced degenerative changes

that are more prevalent in seniors, and this also correlates with age >70 being a red flag that supports the use of an eMRI. Diagnosis codes will be limited to those specifically associated with uncomplicated LBP: ICD10 codes M54.50 for LBP unspecified, M54.51 for vertebrogenic LBP, and M54.59 for other LBP (M54.5 - Low Back Pain - ICD List 2023, n.d.). Patients with multi trauma or suspicion of fracture are excluded, and patients with comorbidities of cancer or previous lumbar surgery are also excluded. The first medical visit associated with the diagnosis must be within 6 months of the initial onset of symptoms to be considered acute, which will be controlled for by excluding patients with any previous diagnoses of lumbar region. There will be three comparison groups: 1) patients with an eMRI (an MRI performed within 6 weeks of the initial medical visit), 2) patients with no MRI and 3) patients with an MRI after at least 3 months from initial medical visit which is then within the recommended treatment guidelines.

2 SCOPING LITERATURE REVIEW

This literature review examines and summarizes the historical and current body of evidence on the effect of eMRIs for the assessment of acute LBP on health care costs and patient outcomes. A coded review was completed to establish the appropriate research methods and the specific patient outcomes for this study. An additional literature review was completed to examine recent comparative studies related to health care service utilization during COVID-19, examining the hypothesis that the utilization of elective procedures, such as MRIs, was significantly reduced during the COVID-19 epidemic due to the pause on non-essential procedures. Finally, to establish future practice and policy recommendations related to reducing the delivery of low-value care, such as an MRI within the first 6-12 weeks of diagnosis for acute non-complicated LBP, a literature review was performed to identify and summarize research on

the effectiveness of programs or policies in improving adherence to evidence-based treatment guidelines.

A systematic literature review and meta-analysis by Endean et al., (2011) summarized that LBP is not clearly attributable to abnormalities on an MRI and thus "…limits the value of MRI abnormalities in refining epidemiological case definitions for LBP." Additionally, studies have proven that age-related degenerative findings are frequently present in people without LBP, but these findings often lead providers to "…overinterpret the findings and carry out additional and possibly unnecessary interventions, such as surgery, epidural steroid injections…, and hospital admissions (Shraim et al., 2021)." A coded literature review was performed to summarize the current research findings on the association between eMRI frequency and its impact on downstream utilization of services, cost, and clinical outcomes and to establish the research methods for this study. Seven studies (3 systematic reviews and four primary studies) were reviewed to provide a broad view of existing research related to this study, and all but one of the studies support the hypothesis that eMRIs for acute LBP result in higher subsequent health care utilization and worse patient outcomes.

2.1 eMRI Impact on Patient Outcomes

Regarding patient outcomes, two systematic review studies were identified, by Chou et al., (2009) and Shraim et al., (2021), which provide a strong compilation of early and current research on the impact of eMRI on patient outcomes. These systematic reviews supplied detailed tables of patient exclusion criteria including age, diagnosis codes, mechanism of injury, surgical history, and co-morbidities. Chou et al., (2009) completed a systematic review and meta-analysis of six randomized controlled trials (RCT), with a total of 1,804 patients treated in primary care settings for acute LBP (< 3 months duration) and examined whether there was a difference in

primary outcomes of pain or function between patients receiving immediate lumbar imaging or usual care both in the short term (0-3 months) and long term (6-12 months). The population age ranged from 18-55. They concluded that there was no significant difference between immediate lumbar imaging and non-imaging for pain or function, confirming the hypothesis that lumbar imaging for LBP without red flags does not improve clinical outcomes and should not be performed.

Shraim et al., (2021) is a more recent systematic review of epidemiologic studies, examining the association between eMRI and length of disability (LOD) in patients with acute LBP without red flags. They included seven studies, netting 64,232 LBP cases across all studies, all using workers' compensation administrative databases. Their population included adults aged 18-65 and LBP duration of 30 days or less. Through a narrative synthesis, the authors summarized that all seven studies confirmed the hypothesis that, for acute LBP without red flags, eMRI is associated with a worse outcome of increased LOD compared to patients with no eMRI. Both studies discussed a key limitation being the small number of studies in their review, with Chou having an overall small total sample size of only 1,804 patients. The Shraim et al. (2021) study had a much larger sample size of 64,232 patients but was limited in using only workers' compensation patients which may limit generalizability to group health populations. Both studies confirm the hypothesis that eMRIs for acute, uncomplicated LBP result in worse patient outcomes compared to patients without eMRI.

Two primary studies, by Graves et al., (2012) and Webster et al., (2010), specifically examined the impact of eMRI on the outcomes of injured workers with acute LBP. Injured workers are an important population of interest as LBP forces more people out of work than any other chronic condition (T*he Lancet: New Study Shows Low Back Pain Is the Leading Cause of*

Disability Around the World, 2023). Graves et al., (2012) performed a population based, prospective cohort study with 1,226 participants assessing and comparing the impact of eMRI on the patient's report of pain and disability, one year post injury, between patients who received an eMRI versus patients who did not. Pain was measured using the visual analog scale (VAS) and disability was measured using the Roland-Morris Disability Questionnaire (RDQ), a widely accepted standard for measuring self-reported disability in patients (Roland, 2000). Graves' study concluded that eMRI was not associated with a statistically significant difference in pain scores between groups but was associated with follow-up RDQ scores that were 1.12 higher for patients with an eMRI (95% CI: 0.04–2.21, P =0.043) than those without, which indicates higher reported disability for patients who received an eMRI. However, the difference in scores was only 1.12 points and though statistically significant, it is not clinically meaningful. Webster et al., (2010) performed an observational study on 3,264 LBP workers' compensation claims, examining the impact of eMRI on disability duration, total medical costs post MRI, and surgery post MRI with a two-year follow up period. This study specifically created and analyzed a measure of 'propensity for eMRI,' grouping patients into low and high propensity for an MRI to account for differences in severity. Comparing matched low-propensity patients between those that received an eMRI and those with no-MRI, the study confirmed that the eMRI group had statistically significant longer disability, a fivefold increase in medical costs, and an eightfold higher risk for surgery.

An interesting literature finding was a RCT multi-phase study by Rajasekaran et al., (2021) which examined the effects of a routine MRI report on the patient's perception of his disease, pain, and function. While all other studies looked at the direct impact of having an eMRI, this study examined the differences in patient perceptions based on how the findings were reported to

the patient, with one group provided with the factual terms and results of the report as found on the radiologist written report and the other group told that their report was normal. The study measured perceived functional disability related to pain using the Pain Self-Efficacy Questionnaire (PSEQ). The factual reporting group had decreased PSEQ scores after the detailed factual explanation of their MRI findings (from 8.19 to 7) indicating negative perceptions about their pain and function, while the group receiving a 'Normal' finding had improved PSEQ scores (8.13 to 8.9) indicating improved perceptions of their back pain. The difference in the change of PSEQ scores between the two groups was statistically significant ($p = 0.002$). The factual reporting group continued to demonstrate worsening pain and function scores at 6 weeks follow-up from initial score. Pain, measured by visual analog scale (VAS), increased to 6.19 from 5.33 ($p=0.006$) and PSEQ scores decreased to 6.19 from 8.19 ($p<0.001$). The normal report group had clinically and statistically significant improvements in both VAS pain scores (from 5.96 to 2.43) and PSEQ scores (from 8.13 to 10.87). This underscores the proposed reason eMRIs results in worse patient outcomes, because it creates a higher patient perception of disability and disease severity that is also shown to worsen over time.

2.2 eMRI Impact on Health Care Utilization and Costs

The other important association that this study looks to examine is the cost burden associated with the MRI itself and the unnecessary resultant cascade of care. A systematic review by Lemmers et al., (2019) specifically examined the impact of eMRI on costs and health care utilization, reviewing fourteen studies (6 RCT and 8 observational). Narrative and table summaries of findings were provided as variability in study design, outcomes, and population was too great to perform a meta-analysis or data pooling. All studies reported higher mean costs for patients receiving early imaging in comparison to non-imaging patients. All but one RCT

study reported higher health care utilization in at least one service criteria: physical therapy, emergency department length of stay, medication prescription, surgery, injections, or additional outpatient visits.

Ganguli et al., (2022) completed a comparative retrospective observational study comparing service utilization and spending between patients with a diagnosis of uncomplicated LBP who had an x-ray or MRI within 28 days of diagnosis against clinical guidelines (i.e., low-value imaging) versus patients who did not. They used medical claims for a total study population of 30,892 patients diagnosed in 2018 from Blue Cross Blue Shield of Massachusetts with a look back period of 365 days, and a follow-up period of three, six, and twelve months for purposes of determining ongoing service utilization. Services measured and defined as a cascade of care services included: physical therapy, office visits, additional radiology studies, laboratory studies and surgery. Controlling for member age, sex, socioeconomic status, plan type, Charlson Comorbidity Index, and total medical expenditure from prior year (2017) they utilized a multivariable ordinary least squares regression model and compared spending on services at 3-, 6-, and 12-month cascade periods between members with and without low-value imaging. They found that those with low-value imaging had up to a fourteen-percentage point higher likelihood of receiving downstream services. The Ganguli study most closely resembles the methods for this study with a pre-COVID-19 study period and provides much of the covariables and service utilization measures that are available from commercial claims databases such as MarketScan and which will be included in this study.

2.3 Impact of COVID-19 Environment on the Utilization of Elective Procedures

COVID-19 is believed to have significantly reduced the frequency of imaging as an elective procedure, as "…it is estimated that nonemergent medical care in the U.S. decreased by

up to 60% during the spring of 2020 (Roth and Lazris, 2021)". A literature review was performed to specifically examine research findings associated with the utilization of non-emergent imaging during COVID-19 compared to pre-COVID-19.

Doshi et al., (2021) compared outpatient diagnostic imaging volumes and no-show rates from January to July 2020, using a 4-week period from February 3 to March 2, 2020, as the baseline pre-COVID-19 rate. Their study population was six outpatient practices of large, metropolitan hospital systems across 3 NYC boroughs. They confirmed the largest decline across all imaging occurred in the first 5 days between March 10 and 15, shortly after the governor declared a state of emergency in New York on March 7, 2020, with a total decline of 85% for all imaging and a 73% decline in MRIs. By July 2020, the daily volume of imaging remained 22% below baseline volume. Unfortunately, this study did not specifically examine MRIs by injury type and is less generalizable nationally as NYC was considered an epicenter of COVID-19.

Naidich et al., (2020) examined the impact of the COVID-19 environment on imaging utilization with data from a large inpatient health care system. They performed a retrospective analysis of weekly imaging volume from January 1, 2019, through April 18, 2020. For the 16 weeks in 2020, they categorized the weeks into subsets and defined weeks 1-9 as pre-COVID-19 and weeks 10-16 as post-COVID-19, with further subsets of early post-COVID-19 for weeks 10-13 and late post-COVID-19 for weeks 14-6. Compared with the same time periods in 2019, they reported a 13.6% decline in all inpatient imaging in post-COVID-19 (weeks 10-16) compared to 2019, but with a more significant drop early post-COVID-19 (weeks 10-13) of 16.6% versus a late post-COVID-19 (weeks 14-16) of 9.6%, and by week 16 of 2020, they found that inpatient imaging volume was down only 4.2% compared to 2019 volume. Specific to MRIs, comparing the volume of MRIs in the 16-week period from Jan-April, the mean weekly volume dropped

from 752.9 in 2019 to 577.9 in 2020, a 23% reduction. However, as with the study by Doshi et al., (2021) there was no specificity to injury types.

Finally, a study by Elton and Zhang (2023), that was still in preprint at the time of this review, examined the impact of the COVID-19 environment on the management of LBP. They analyzed almost 700,000 LBP episodes from a single national insurer with both commercial insurance (CI) and Medicare Advantage (MA) claims, comparing the utilization of a broad range of low-value services, including advanced spinal imaging studies. The most relevant finding was a decrease in all services, except for opioids, during the early COVID-19 surge from April to June of 2020; but when comparing the longer defined period of early COVID-19 (3/1/2020 to 2/28/21) to pre-COVID-19 (3/1/19 to 2/29/2020) most health care services were unchanged or only slightly reduced. When breaking out MRI utilization, the results showed no significant change pre-COVID-19 compared to Early COVID-19, and a slight increased utilization of two percentage points late COVID-19.

An Israeli study by Luxenburg et al. (2021) found similar trends to the U.S. studies when examining the impact of the COVID-19 environment on the utilization of imaging. Using Israel's national MRI registry which tracks MRI use across both inpatient and outpatient settings, they reported a 47.5% drop in MRI utilization during the peak surge of COVID-19 in April 2020, but that the overall rate of MRI utilization (March to December) in 2020 was only 2.5% lower than 2019 for the same time-period. However, while the 2.5% decrease was small, the authors noted that the prior 5 years had seen steady increases in the rate of MRI utilization.

This literature review provides support for the hypothesis that there was an impact on MRI utilization due to the environment created by COVID-19, where non-essential or elective procedures were paused. However, the research is early and seems to show a short time-period of

impact, mostly during the peak initial surge of COVID-19 from March 2020 to June 2020. The literature is also limited in applicability to imaging for LBP, with much of the research examining trends in overall imaging, not specific to LBP. The one study that is specific to health care service utilization for LBP by Elton and Zhang (2023) is not peer-reviewed and is in pre-print status, and it does not show significant changes in MRI rates for the management of LBP. This study will thus provide additional insight into the specific impact of the COVID-19 environment on MRI utilization for the assessment of LBP, as well as changes in subsequent health care service utilization and patient outcomes, for which there has been limited research.

2.4 Measures to Reduce eMRI and Improve Evidence-Based Practice

Another important aspect of this study is understanding what factors influence the trends in imaging referrals and what has been done in the past to reduce unnecessary or low-value imaging. As this study seeks to confirm the hypothesis that a reduction in eMRIs will result in reduced unnecessary health care spending and improved patient outcomes for patients with acute LBP, it will be important to understand what measures could be employed to sustain improved adherence to evidence-based guidelines and reduced eMRIs, which has heretofore not been accomplished. Thus, a literature review was also conducted to examine recent research related to specific measures to reduce eMRI and its impact on outcomes.

Fine et al., (2017) conducted a population-based interrupted time series analysis to examine the impact of restricting reimbursement on diagnostic imaging ordering. On April 12, 2012, Ontario removed reimbursement for diagnostic imaging for uncomplicated LBP. The authors analyzed overall annual test ordering for the three years before and three years after the policy change by primary care family physicians and specialists. There was a significant and sustained reduction in lumbar spine radiography by family physicians but no notable change by

specialists. There was only a slight decrease of 0.18/month by family physicians and 0.10/month by specialists of single-segment MRIs, though it is noteworthy that there had previously been an annual upward trend of ordering rates. However, by the end of the follow-up period, ordering rates had rebounded to even slightly above pre-policy levels, but with a rate of increase that was half the annual rate increase pre-policy. Overall, the authors concluded that there was a positive impact on reducing ordering rates for diagnostic imaging by reducing or eliminating reimbursement, though it was more impactful to radiography versus MRIs. However, this study was conducted in Canada, which limits generalizability to the U.S. as the health care reimbursement model differs significantly.

A systematic review with meta-analysis of international studies by Belavy et al., (2022) examined the impact on MRI frequency of various interventions to reduce imaging referrals. The study included eight total trials; six were included in a meta-analysis. All studies utilized clinician education about evidence-based guidelines; five trials additionally included audit or feedback components. Only one trial included education material for patients. The analysis of these studies concluded that these education-oriented interventions were ineffective. Based on this initial analysis, the authors collated findings from additional nonrandomized studies that incorporated either organizational changes in clinical practice workflows or changes in government funding. They reported a median reduction in imaging of 6.6%, which corroborates the findings from Fine et al., (2017) that reimbursement changes can have a positive impact on ordering patterns for imaging. The overall conclusion was that clinician education alone is ineffective, but that a muti-faceted approach which incorporates organizational changes that audit and enforce guideline adherence through clinical practice models and/or clinician feedback, has a much higher likelihood of producing sustained reductions in low-value imaging. Again,

this was a study not limited to the U.S., but offers applicable findings that clinician education alone does not effectively impact clinician behavior.

A study by Nevedal et al., (2019) offers more specific insight into factors influencing the utilization of low-value MRIs for the lumbar spine in the U.S. The authors performed a mixed-method qualitative study through a semi-structured telephone interview of fifty-five Veteran Affairs (VA) primary care physicians (PCPs). The study used purposeful sampling to get an equal distribution of high-guideline concordance (n=22) and low-guideline concordance physicians (n=33). The PCPs were blinded to their concordance status and were asked about environmental factors (e.g., stringency of radiology utilization review, time constraints), patient factors (e.g., beliefs on value of imaging, pressure on providers), and provider-level factors (e.g., guideline familiarity and agreement, beliefs on value of imaging, level of acquiescence to patients). Regarding environmental factors, the leniency or stringency of utilization review (UR) was very influential, with low-concordance PCPs noting lenient UR contributed to their higher use, while high-concordance PCPs noted the opposite, that stringent UR rules contributed to their lower use. Time constraints were indicated by low-concordance providers as factoring into increased use of ordering MRIs taking them less time than conducting a thorough medical history and examination. The key patient factor impacting MRI rates was the perceived patient's belief in the value of imaging and the pressure they applied to have an MRI. This pressure then had a downstream effect on provider factors, with high-concordance providers having a higher resistance to patient pressure. Finally, provider knowledge of guidelines and MRI value was a factor in MRI utilization, with low-concordance providers believing that MRIs would provide value for treating acute, uncomplicated LBP, despite evidence to the contrary. Overall, the Nevedal et al., (2019) study is consistent with the systematic review by Belevay et al., (2022),

concluding that single interventions, like provider education, are likely to be ineffective at reducing eMRIs for acute LBP. A multi-faceted approach that includes utilization review, clinical decision support tools and processes, combined with both physician and provider education is needed to have a more sustainable effect on MRI utilization.

There are very few studies that examine the impact of patient education on MRI rates, despite the finding that patient pressure to have an MRI is a contributing factor to physicians ordering one. Sharma et al., (2021) conducted a controlled experimental study examining the impact of providing education about the potential harmful effects of unnecessary imaging on adult patients presenting to the emergency department (ED) with complaint of LBP in an Australian ED waiting room. All messaging was delivered on 55' screens in the ED waiting room. The control group received standard messaging, while the intervention group received specific messaging on the screens about the potential harms of unnecessary imaging for LBP, in additional to standard messaging. The patients also received patient leaflets. Analysis concluded that the intervention group had a slightly lower imaging utilization rate (25%) as compared to the control group (29%), which provided low certainty evidence that patient education reduced the incidence of unnecessary MRIs in the treatment of LBP. However, the authors referenced the low-cost to implement a patient education campaign, so despite this study having uncertain evidence on the effectiveness of this intervention, it bears further studying. Patient education should be one of the factors considered in a multi-faceted approach to reducing eMRI use for acute LBP.

2.5 Literature Review Conclusion

In summary, the literature review strongly supports the hypothesis of this study that patients who receive an eMRI for acute LBP have worse outcomes. The patient outcomes that

were either not improved or worse for patients with eMRI included: pain, function, length of disability, patient perceived disability, and surgical rates (Chou et al., 2009; Graves et al., 2012, Shraim et al., 2021; Webster et al., 2010). In addition to worse outcomes, the downstream higher utilization of healthcare services and increased costs associated with eMRI was confirmed, with studies showing statistically significant higher mean costs and as high as 14 percentage point increased likelihood of downstream services such as physical therapy, emergency department length of stay, medication prescription, surgery, injections, or additional outpatient visits (Ganguli et al., 2022).

The findings associated with MRI utilization during COVID-19 were illuminating, as it unexpectedly showed a shorter time period of correlated reduction in MRI use and was more inconclusive on the impact specifically to MRI utilization for LBP. While the literature supported the hypothesis that there was a reduction in MRIs in early 2020 from 23% to as high as 73%, there was limited data concerning MRIs specific to LBP (Doshi et al., 2021, Elton and Zhang, 2023, Nadish et al., 2020). The one study that examined MRIs for LBP did not show a significant change in MRI rates. All research showed a relative return to pre-COVID utilization trends by June/July of 2020. The small amount of data and studies related to MRI utilization trends during COVID-19 confirms the value this study provides in further exploring the impact on Lumbar MRI rates during COVID-19 and if/how changes in utilization impact patient outcomes and costs.

Finally, the literature review regarding what measures have been studied to reduce eMRI helps inform future research needs as well as policy and practice implications. As we believe this study will provide further evidence regarding the benefits of avoiding low value eMRIs in the treatment of LBP, it is imperative to understand what measures might be most effective to

achieve that end. The literature supports a multi-faceted approach with funding, prior authorization, organizational changes, and provider education key components. The importance of patient's perception on the value of MRIs is also a key factor, as patient pressure on Physicians was a proven factor in MRI ordering. Patient education on the value of MRIs and/or how to interpret findings could impact both the utilization of MRIs and the impact of the findings on patients' perceived pain and disability (Rajasekaran et al., 2021).

3 METHODOLOGY

3.1 Research Design

This study is a quantitative pre-post comparative retrospective observational study with a natural experimental design created by COVID-19. Using the MarketScan Commercial database, this study compares MRI rates, surgical rates, and total cost for covered medical claims of commercially insured members aged 18-60 between two time periods: pre-COVID-19 (February - April 2019) and COVID-19 (February - April 2020). Total cost is based on total gross payments to all providers who submitted claims for covered medical services during the study defined periods. The period of February to April was chosen based on the literature review, which showed March being the start of the timeframe where imaging rates were most impacted during COVID-19 (Doshi et al., 2021; Naidich et al., 2020). As we were using the date of first encounter, we used February as a starting point to account for delays in referral and scheduling of MRIs and fully cover March timeframe where most eMRIs would have occurred. A quantitative retrospective analysis of claims allows us to evaluate the hypothesis that eMRIs result in statistically significantly higher costs and worse outcomes for patients. Prior to this study, based on the literature review, there have been only limited RCT and retrospective

observational studies to support avoiding eMRIs in the treatment of low back pain with no large-scale population study due to the prevalence of eMRI being performed as a matter of standard practice. This study also addresses the limitations of the earlier studies which were primarily associated with low sample size and narrow geographic or payer-type characteristics (e.g., Washington workers compensation, Massachusetts BCBS). A consistent finding across studies was the historical frequency of MRIs in patients with LBP which ranges from 19% to 30% (Ganguli et al., 2022; Graves et al., 2012; Shraim et al., 2021). This provides a comparative baseline value to compare MRI frequency results in this study against, both to determine if there were similar rates Pre-COVID-19 and if there was a significant reduction during COVID-19.

3.2 Sample Selection

A coded literature review was performed to identify research methods as well as inclusion and exclusion criteria for defining the patient population, specific diagnosis, treatment, and outcomes. The systematic reviews (Chou et al., 2009; Shraim et al., 2021) supplied detailed tables of patient exclusion criteria including age, diagnosis codes, mechanism of injury, surgical history, and co-morbidities which helped form the sample characteristics for this study. The Graves (2012) study provided limited inclusion/exclusion criteria for participants, but it provided a detailed comparative demographics / characteristics table that provided a framework for a demographics table for this study. Ganguli et al., (2022) utilized commercial medical claim's data from Blue Cross Blue Shield of Massachusetts, similar to MarketScan data for this study, and provided the framework for the look-back and look-forward time periods. The Ganguli study further confirmed patient inclusion criteria, limiting the sample to 18–50-year-olds with a diagnosis of uncomplicated acute low back pain.

MarketScan claims data included in the study were for adult private health insurance members aged 18-60 with an initial MD visit for acute, uncomplicated LBP identified by specific ICD-10 (M54.50, M54.51, and M54.59). Older adults (age 60-64) and elderly adults (age >64) were excluded in accordance with the existing literature and clinical guidelines, with age over 60 a recognized clinical red flag for an eMRI to be appropriate, as well as the fact that the elderly experience a higher incidence of co-morbidities and complicated low back diagnoses. Continuous enrollment was required for eligible members for a look-back and look-forward period of one year each, a total minimum of 2 years enrollment. The look-back of one year was used to exclude any members with a previous treatment diagnosis associated with the lumbar region or any previous spinal surgery (see Table 1 for a list of excluded ICD-10 or procedure codes). The look-forward period of one year was used to measure the subsequent cascade of health care services and costs which are hypothesized to be associated with eMRI use. Table 2 provides CPT codes used to identify any lumbar surgical procedure in the look-forward period for analysis of surgical rates between MRI groups. See Table 3 for the detailed method categories for the study population.

3.2.1 Table 1: List of all lumbar region ICD10s for exclusion in 1-year lookback time

ICD10	Description
M41.XX	Scoliosis
M43.XX	Spondylolysis, Spondylolisthesis, Fusion, Dislocations
M45.XX	Ankylosing Spondylitis
M46.XX	Inflammatory spondylopathies
M47.XX	Spondylosis
M48.XX	Spondylopathies including fractures, stenosis, and collapsed spine
M51.XX	Lumbar Intervertebral disc disorders
M53.XX	Dorsopathies
M54.XX	Dorsalgia, Radiculopathy, Sciatica, Lumbago, LBP,

M80.XX	Osteoporosis with fracture
M81.XX	Other Osteoporosis
M99.XX	Biomechanical lesions, not elsewhere classified
S32.XX	Fracture of lumbar spine and Pelvis
S33.XX	Dislocation and sprain of joint and ligaments of lumbar spine and pelvis
S34.XX	Injury of Lumbar and sacral cord and nerves

3.2.2 Table 2: List of CPT codes used for analysis of lumbar surgery rate

CPT Code	Surgery / Procedure	Description
63005, 63017, 63047, 63011	Surgery	Posterior Laminectomy Lumbar or Sacral
63030, 63042	Surgery	Posterior Discectomy Lumbar
63087, 63090	Surgery	Corpectomy Lumbar
22612, 22630, 22633	Surgery	Posterior Lumbar Fusion
22558	Surgery	Anterior Lumbar Fusion
22867	Surgery	Interlaminar/Interspinous Device Insertion
62311, 62323, 64483, 64484, 64470, 64475	Procedure for Pain Relief	Epidural Steroid Injections
62287	Procedure for Pain Relief	Disc Aspiration w/ Fluroscope
62319	Procedure for Pain Relief	Continuous Infusion for Pain Management

3.2.3 Table 3: Detailed methods design and population characteristics

Methods Category	Detail
Patient Population Defined	Patients with initial diagnosis of uncomplicated LBP with no prior LBP diagnosis in previous one year lookback, continuous insurance coverage for 1 year lookback period and 1-year follow-up period. Date of initial encounter being Feb-April 2019 for Pre-COVID-19 and Feb-April 2020 for COVID-19
Included ICD -10 for uncomplicated, acute LBP	M54.5 (prior to 10/1/21), M54.50, M54.51, M54.59
Excluded ICD-10 for more complicated low back diagnosis (red-flags)	M54.3, M54.4, M54.16
Patient Age	18-60
Other exclusion criteria	Prior lumbar diagnosis (see Table 1), multiple trauma (ICD10 T07.xx), history of cancer (any ICD10 'C' code or Z85.9)
Covariates	age, gender, geographic region

Independent Variable: eMRI definition	MRI within 90 days of first encounter MD appt for LBP diagnosis
Follow up time for outcomes	From first MD appt for diagnosis of LBP, follow-up period of one year for health care service utilization
Outcome: Health Care Services measured (within the 1-year look-forward follow-up period)	1) Total health care costs 2) Any lumbar surgical procedure

3.3 Data Set Description

MarketScan was selected to provide the dataset for this study as it contains U.S. medical and drug data for millions of commercially insured individuals, including employees, their spouses, and dependents (IBM Watson Health, 2021). Based on the relevant population age of 18-60 and the significant impact on disability from LBP, this database provides a robust national dataset for the working U.S. population, allowing a large-scale analysis of the impact of COVID-19 on the utilization of eMRIs and the resultant impact on additional health care services and patient outcomes across the U.S. With almost 40 million covered individuals, the database provides a nationally representative sample with sufficient sample sizes for the group segmentations required in this study. Additionally, MarketScan captures full episode of care services including physician office visits, pharmacies, ancillary care (e.g., rehabilitation) and hospital stays. This is a critical component when assessing the total downstream utilization of services and costs stemming from the initial MD visit for LBP.

3.4 Independent and Dependent Variables

The primary objective of this study is to evaluate the hypothesis that unnecessary use of eMRIs (independent variable) in the treatment of acute, uncomplicated LPB results in a cascade of additional unnecessary health care services (dependent variables) which results in higher costs and worse patient outcomes.

3.4.1 Independent Variable

Utilization of an eMRI in the diagnosis of acute, uncomplicated LBP is the primary independent variable. An additional sub-group of patients receiving an MRI three months or later post initial MD visit was also examined to address if patients only delayed their MRI due to the COVID-19 environment, versus foregoing an MRI altogether. However, even a delay artificially caused by lack of access to an eMRI is hypothesized to have fewer negative impacts on total health care costs and patient outcomes. It is possible that many of these patients would have either improved during this time, negating the need for an MRI, or their continued unresolved symptoms would then be an evidence-based indication to have the MRI.

3.4.2 Dependent Variables: Health Care Costs and Patient Outcomes

The first hypothesis of this study is that eMRIs for acute LBP results in a cascade of unnecessary and excessive health care services which contributes to higher health care costs. To test this hypothesis, total health care costs from the initial MD visit and a 1 year follow up is a primary outcome measure in this study; this is measured as the total gross amount paid by insurance for all covered medical services (total cost).

Along with excessive costs, it has also been hypothesized that eMRIs create catastrophizing behavior in patients and worse outcomes. Thus, patient outcomes are the second dependent variable for this study. Most of the literature review studies were RCTs with direct patient survey responses used to measure specific patient clinical outcomes of pain and function, or they utilized workers' compensation databases which provided specific length of disability data. MarketScan does not provide these direct measures of clinical outcomes but does provide health care utilization claims' details allowing proxy measures for patient outcomes, including surgery rates, as proxy measure of both patient disability and pain. Surgery rate is measured as a

dichotomous variable of occurring in the follow-up period or not and calculated as a percentage of cases with surgery. The analysis of clinical outcomes will include adjustment for confounding variables of age, gender, and geographic region.

3.5 Data Analysis

Descriptive statistics are reported as mean (standard deviation) or median (interquartile range) for normal and non-normal data, respectively; frequency (percentages) is reported for categorical variables. Comparisons between groups were assessed using non-parametric tests for continuous variables due to non-normal data and chi-square tests for non-continuous variables.

Logistic multivariable models were used to assess the odds of having a lumbar surgery in the follow-up COVID-19 period between the MRI groups, while controlling for patient characteristics. Total cost was assessed between the MRI groups using multivariable generalized linear models with a gamma distribution and log link, while controlling for patient characteristics. Patient characteristics and demographics included in the statistical models included age, gender, and geographic region. MarketScan data did not include race. All analyses will be conducted using SAS 9.4 (Cary, NC). Statistical significance was assessed using an alpha level of 0.05.

3.6 Protection of Human Subjects

MarketScan is a HIPAA compliant proprietary database that provides de-identified patient-level health data that is available to MUSC for research analysis. MarketScan has been pre-approved for use by IRB for MUSC studies. This study was also a retrospective study and did not involve interaction with any participants. For these reasons, this study was exempt from needing individual approval of the institutional review process for MUSC.

4 RESULTS

4.1 Table 4: Covariate and unadjusted outcome statistics for patients with initial encounter for acute low back pain (LBP) by time period: Pre-COVID-19 (Feb-April 2019) and COVID-19 (Feb-April 2020) (n = 117,150)

Do patients with acute LBP differ in covariate characteristics or healthcare outcomes between time periods Pre-COVID-19 and COVID-19?

Variable Name	Pre-COVID-19 n = 68,110	COVID-19 n = 49,040	P-Value
Covariate			
Age: mean (SD) (years)	43.1 (11.9)	43.1 (11.7)	0.9641
Sex: n (%)			0.4043
Male	30519 (44.7)	21864 (44.4)	
Female	37779 (55.3)	27335 (55.6)	
Geographic Region: n (%)			<0.0001
Northeast	9982 (14.6)	5372 (10.9)	
North Central	15015 (22.0)	10233 (20.8)	
South	33614 (49.2)	25017 (50.9)	
West	9499 (13.9)	8418 (17.1)	
Unknown	188 (0.27)	159 (0.32)	
Outcome			
MRI Category: n (%)			<0.0001
No MRI	60564 (88.7)	44043 (89.5)	
eMRI (0-90 days)	5449 (8.0)	3233 (6.6)	
MRI (>90 days)	2285 (3.4)	1923 (3.9)	
Lumbar Surgery: n (%)			0.0235
No	65362 (95.7)	47216 (96.0)	
Yes	2936 (4.3)	1983 (4.0)	
Total Cost: mean (SD) ($)	$7,068 (21,576)	$7,339 (22,662)	0.0002

This study examined whether there were differences in age, sex, geographic region, MRI category, lumbar surgery, or total cost (measured as total health care costs 1-year post initial encounter) between patients in Pre-COVID-19 time period versus patients in COVID-19 time

period. There was a total of 117,150 patients studied with 58.1% from Pre-COVID-19 time period and 41.9% from COVID-19 time period.

For age, the Wilcoxon test determined there was no statistically significant difference between the two groups (P=0.964); the mean age in both time periods was 43.1 years. The Wilcoxon test was also used for total cost and determined there was a statistically significant difference between the two time periods (P=0.0002), with the average total cost (measured for 1 year post initial encounter) increasing $271 between patients in Pre-COVID-19 time period versus COVID-19 time period.

The Chi-Squared test was used for sex and geographic region (categorical). There was no statistically significant difference in sex between the two groups (P=0.4043), with female patients representing approximately 55% of the population. There was a statistically significant difference in geographic region (P<0.0001), with the biggest change being a 3.7 percentage point reduction in patients in the Northeast (NE) and a 3.2 percentage point increase in patients in the West. The Chi-Squared test was also used to analyze differences in MRI rates and surgery rates between the two time periods. Differences in MRI rates between the two time periods (Pre-COVID-19 versus COVID-19) was statistically significant (P<0.0001): the No MRI rate increased 0.84 percentage points during COVID, while the eMRI (<90 days) rate decreased 1.4 percentage points, and MRI >90 days rate increased 0.6 percentage points. Differences in unadjusted surgical rates between the two time periods was also statistically significant (P = 0.0235) with surgery rate decreasing 0.3 percentage points between the time periods.

4.2 Table 5: Odds ratios (OR) and 95% confidence intervals of adjusted surgery estimates using logistic regression for patients aged 18-60 with acute, uncomplicated low back pain (LBP) in COVID-19 time period (Feb-April 2020) (n= 49,020)

Variable Name	OR (95% CI)	P-value
MRI category		<0.0001
No MRI	0.02 (0.02-0.03)	
eMRI (0-90 Days)	1.0 (ref)	
MRI >90 Days	1.04 (0.92-1.18)	
Age	1.02 (1.02-1.03)	<0.0001
Sex (Male vs Female)	1.33 (1.20-1.47)	<0.0001
Geographic Region		0.0026
North East	0.95 (0.77-1.17)	
North Central	1.30 (1.10-1.54)	
South	1.15 (0.99-1.33)	
West	1.0 (ref)	

We examined the odds of having surgery among patients with acute, uncomplicated LBP based on MRI groups (no MRI, eMRI and MRI>90 Days), controlling for age, sex, and geographic region. There were 49,040 patients assessed in the analysis. Based on odd ratios and 95% confidence intervals, and controlling for age, sex, and geographical region, no MRI had the largest decrease in odds for surgery compared to eMRI (OR = 0.02, 95% CI: 0.02-0.03), which means patients without an MRI had 98% lower odds of having lumbar surgery than patients with an eMRI.

The odds of surgery increased by 2% with each year of age (OR = 1.02, 95% CI: 1.02-1.03), controlling for MRI status, sex, and geographic region. The odds of surgery were 33% higher if the patient was male (OR = 1.33, 95% CI 1.20-1.47), controlling for MRI status, age, and geographic region. In comparing geographic regions, controlling for MRI status, age, and sex, the odds of surgery were 30% higher for patients in the North Central region as compared to

patients in the West region. No other geographical region comparison was statistically significant as the CI included 1 in the range.

4.3 Table 6: Comparison of unadjusted and adjusted total health care costs for patients with acute low back pain (LBP) in COVID-19 time period (Feb-April 2020) (n=49,040)

What are the unadjusted & adjusted Total Health Care Costs in 1-year follow between patients with No MRI, eMRI and MRI >90 Days

	Total Healthcare Costs ($)	
MRI Category	**Unadjusted Mean (95% CI)**	**Adjusted* Mean (95% CI)**
No MRI	6,461 (6,385-6,539)	6,243 (6,159-6,328)
eMRI (0-90 Days)	15,039 (14,395-15,712)	14,124 (13,522-14,752)
MRI >90 Days	15,315 (14,471-16,209)	14,079 (13,310-14,891)

**Model adjusted for Age, Sex and Geographic region*

Adjusted total healthcare cost differences of $7,881 between patients with eMRI and no MRI was statistically significant (P-Value <0.0001). Adjusted total healthcare cost differences between patients with MRI>90 Days vs eMRI was not statistically significant (P-Value=0.9291). Goodness of fit (Deviance) was under 1.89 which is under the 2.0 deemed acceptable. There were 49,040 patients observed, with 143 invalid responses (due to missing data), for a total of 48,897 patients included in the analysis.

5 DISCUSSION

5.1 Discussion of Results

The first research question addressed whether there was an impact on MRI rates in the assessment of acute LBP, particularly eMRI, during COVID-19 compared to Pre-COVID-19. Chi-squared test results confirmed the hypothesis that eMRI rates were reduced during the

COVID-19 time period, with a statistically significant reduction of 1.41 percentage points (P<0.0001). Though this is a relatively small decrease and might not seem clinically significant, the literature review highlights that the rate of MRI utilization had been exponentially increasing over the last two decades with as high as a fourfold increase between 1994 and 2005 and at least a 53% relative increase from 1995 to 2015 (Chou et al., 2012; Dowie et al., 2020). Thus, even a small percentage decrease in MRI utilization could be considered clinically significant. The drop in eMRI rates also correlated with a slight reduction in surgical rates of 0.27 percentage points between Pre-COVID-19 and COVID-19 time periods; this is also consistent with literature review findings that increasing MRI rates over time was associated with increasing surgery rates during the same time periods (Downie et al., 2020). The population count difference between the two periods is also an interesting finding, with Post-Covid-19 population about 19,000 less than Pre-Covid-19 for the same time frame. This could reflect changes in care-seeking behavior and could have an impact on results with possible under-reporting.

In summary of Table 4 findings, the demographics of the two patient groups were widely similar. There were no statistically significant differences in age or gender. In comparing geographic regions, there were slightly fewer LBP patients in the NE and more patients in the W during COVID-19 compared to Pre-COVID-19 a year before, each with a change of about 3 percentage points. This finding confirmed the need to control for geographic region in the analysis, with the understanding that policies regarding COVID-19 (e.g., stay-at-home orders, restriction of elective procedures, etc.) varied significantly across the U.S. and could impact outcomes. The rate of eMRI had the biggest statistically significant difference, with a reduction of 1.41 percentage points, between pre-COVID-19 and COVID-19 time periods, validating the expected reduced utilization of eMRIs during COVID-19. Average Total cost increased

$270.90, despite a slight reduction in surgery rates of 0.56 percentage points between time periods.

Additionally, this study looked to confirm the negative downstream effect on healthcare costs and patient outcomes due to eMRI, which was summarized in the literature review. This study used odds of lumbar surgery, in a 1-year follow up time period, as a proxy measure for patient outcomes. Examining 49,040 patients from the COVID-19 period, odds ratio analysis indicates that patients with no MRI have 98% lower odds of having lumbar surgery than patients with an eMRI. Overall, about 30% of patients who have an MRI, regardless of whether it is an eMRI or an MRI > 90 days, end up having surgery (see Table 7). An additional interesting finding that bears further review was that patients in the North Central geographic region had 30% higher odds of having surgery than patients from the West. This result may be reflective of different geo-political responses to COVID-19 and/or variances in costs and access to care.

Table 7: Unadjusted Surgery rates by MRI status in COVID-19 time period

Surgery	MRI category			
Count of patients: n (Category %)	**No MRI**	**eMRI**	**MRI > 90 Days**	**Total**
No Surgery	43476 (99.03)	1331 (69.43)	2254 (69.93)	47061
Surgery	424 (0.97)	586 (30.57)	969 (30.07)	1979
Total	43900	1917	3223	49040

The total downstream cost of healthcare services delivered and paid by insurance associated with eMRI was examined by analyzing the adjusted total gross healthcare costs paid by commercial insurance (total cost) difference over a one-year follow up period between MRI groups in the COVID-19 patient group. With 48,897 patients assessed, the total adjusted cost

difference was almost $8,000 higher for the eMRI group than for the no MRI group, accounting for geographic region, sex, and age. Even when discounting the allowable provider billed cost of the MRI itself, which according to Pow (2023) is at the highest about $2,000 with contrast, the total one-year healthcare costs incurred by patients with an eMRI is double that of patients with no MRI at a total mean cost of about $12,000 (with the $2,000 MRI discount).

5.2 Implications for Policy and Practice

While the evidence clearly supports reducing the use of eMRI in the assessment and treatment of acute LBP, the challenge remains on how to put this into practice. Unfortunately, the research shows that despite a small reduction for a brief period of time during the early period of COVID-19, long-term trends indicate a persistent upward trajectory in the utilization of eMRIs. The literature shows that education alone, such as through initiatives like the Choosing Wisely Campaign, does not have a significant impact on utilization; the biggest impact is seen when reimbursement or authorization is affected.

Medicare attempted to address overutilization of eMRIs by putting section 218 of The Protecting Access to Medicare Act (PAMA) into effect on January 1, 2020. This introduced appropriate use criteria (AUC) for physicians when ordering advanced diagnostic imaging and required documentation of AUC consultation to receive Medicare payment. Physicians were required to consult AUC through the Center for Medicare and Medicaid Services (CMS) qualified decision support mechanism (qCDSM), or other clinical decision support (CDS) resources developed by qualified provider-led entities (PLE), which includes the American College of Radiology (ACR) appropriateness criteria (*How PAMA Affects Orders for Imaging*, 2019). Unfortunately, the AUC requirement was paused in January, 2024, as part of the finalized 2024 Medicare Physician Fee Schedule (MPFS) final rule, without having actually implemented

any payment penalties. The ACR continues to support the use of CDS programs to reduce the use of low-value advanced imaging and promote evidence-based care but wants to reduce the burden associated with the real-time claims processing obligation. The resumption of AUC requirements by Medicare would directly impact the Medicare population with savings estimates as high as $700,000,000 annually (*Clinical Decision Support | American College of Radiology*, n.d.).

While the population of concern addressed in this study has a mean age of 43 and is not directly impacted by Medicare policy, CMS policies often set the trend and impact policies and reimbursement among private insurers. UnitedHealthcare (UHC) currently has prior authorization policies for elective, out-patient diagnostic imaging procedures (*Radiology Prior Authorization and Notification | UHCprovider.com*, n.d.). Workers' compensation is another payer that is significantly impacted by LBP injuries and overuse. Currently seventeen states require utilization review for MRI services, which involves either prior authorization or post-procedural review using evidence-based treatment guidelines (*State Treatment Guidelines for Comp Differ Significantly: WCRI - Business Insurance*, n.d.). Payment and prior-authorization policies are likely to remain the most effective tool in reducing the use of low-value advanced imaging, though technology offers the opportunity to improve the practice of evidence-based decision making through the use of artificial intelligence and clinical decision support tools.

5.3 Limitations

This study was a retrospective observational study which only confirms a correlation between COVID-19 time with a reduction in eMRI rates; one cannot surmise any causation. MRI utilization is certainly impacted by insurance coverage, income, and access to facilities. Furthermore, while we controlled for geographic region, there are wide disparities by state and

zip code that might not be fully accounted for in looking at characteristics among different MRI groups and time periods. We were also unable to control for race which is often found to be a confounding variable for disease progression and access to care.

In regard to patient outcomes, we were not able to fully account for comorbidities. We attempted to focus on acute, uncomplicated LBP by using specific ICD10s and excluding more complicated lumbar diagnosis, and we also excluded history of cancer (any ICD10 'C' code or Z85.9), but this does not fully account for confounding comorbidities such as diabetes which could impact a patient's total healthcare costs. Additionally, the unusual nature of a nationwide pandemic and the full extent it had on healthcare costs and patient health limits the general validity of the results. Despite the decrease in eMRI and slight decrease in surgery rates, the total healthcare cost in the one-year follow-up increased $271 or 3.8% from Pre-COVID-19 to COVID-19 time periods which may reflect inflation and/or increased healthcare utilization due to COVID-19 related symptoms.

5.4 Future Research

There has been extensive research regarding the impact of eMRIs on healthcare costs and patient outcomes. What remains is a significant gap of knowledge on how to permanently reduce the unnecessary utilization of eMRIs. The literature review confirms that there are many contributing factors to consider: patient education, provider education, reimbursement, prior-authorization requirements, organizational policies, etc. The Nevedal et al., (2019) study provided insight into the complex factors of provider and patient perceptions and concludes that the most effective approach must be multi-faceted and include utilization review, clinical decision support tools and processes, combined with both physician and provider education to achieve a more sustainable effect on MRI utilization. Additional quantitative analysis on the

impact of more specific measures of patient outcomes or health care services (e.g., disability, hospitalizations, emergency department visits, pharmaceutical utilization) might provide more clarity on what areas of practice to focus on.

Further qualitative research examining both patient and provider knowledge, perceptions, and behaviors regarding care seeking and ordering would be beneficial. Patients are increasingly influencing the demand for services, as patient pressure for MRIs has been shown to affect physician ordering behavior (Nevedal et al., 2019). Long-term follow-up on the impact on patient outcomes for those that have avoided eMRIs would provide additional resources for patient and provider education on the benefits of avoiding eMRIs. Considering much of the negative impact reported is related to population level costs and outcomes within a relatively short follow up period of one to two years, it may not be relatable to individual patients and providers making decisions on if and when to utilizing advanced imaging.

The regional variances in surgical odds, with a 30% higher likelihood of surgery for patients in the North Central region as compared to patients in the West region, would also warrant additional research on contributing factors and insight into best practices. As a possible factor, CA workers' compensation has stricter utilization review requirements and is one of the top states for workers' compensation spend.

Finally, a more longitudinal study across multiple years to further analyze changes in eMRI utilization would be beneficial, as well as further analysis of care-seeking behavior during COVID-19, related to the 19,000 lower population size of patients during COVID-19 discovered in this study.

5.5 Conclusion

This study provides further evidence confirming the increased healthcare costs and worse patient outcomes related to low value eMRIs against clinical guidelines. COVID-19 provided a natural experimental design that allowed us to analyze and quantify the potential impact of reducing eMRIs. In 2018, 75.8 million American adults were reported to have suffered with low back pain (Julia, 2024). Even the modest reduction in eMRI rates of 1.4 percentage points shown in this study that was experienced during COVID-19 time period could have a significant impact on costs; 1.4% of 75.8 million Americans would equate to one million patients avoiding surgery. Based on this studies' mean adjusted cost difference of $8,000 higher for the eMRI group than for the no MRI group, that would result in a potential eight billion dollars of annualized savings. Considering that our research finds that the U.S spends nearly $200 billion annually on unnecessary healthcare services, this would represent a significant positive contribution to reducing that number.

The challenge is that short a global epidemic like COVID-19, the utilization of MRIs for LBP has been steadily increasing, and the literature review showed that the decreased utilization of advanced imaging during COVID-19 was short-lived. The implications are clear that there is a need for future policy affecting reimbursement and authorization for advanced imaging as research shows that provider education alone is ineffective, and that restricted reimbursement has the biggest impact. Additionally, technological advances in the use of artificial intelligence (AI) and natural language processing (NLP) offer improved efficient means to provide evidence-based information to providers. AI tools such as ChatGPT offer practical clinical decision support tools that can be used by healthcare providers to not only access but interpret and assimilate vast evidence-based information to move forward in providing value-based care.

Finally, patient perceptions on the value of MRIs and their findings are also critical. Rajasekaran et al., (2021) confirmed that how the findings of the MRI are explained to the patient can have significant implications on patients' perceived disability and pain. By providing patients with assurance of "normal" findings, healthcare seeking behavior might be reduced, which would have similar intended effect on downstream healthcare costs, surgical rates, and patient outcomes.

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