Epidemiology and Health Care Utilization Associated with Chronic Pain in Newfoundland and Labrador, Canada: A Population-Based Study Using Health Administrative Data

by

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Abstract

Background: Chronic pain exerts a tremendous burden on individuals, families, and society, and has a high estimated prevalence (up to 54% globally and 44% in Canada) and direct health care cost ($7.2 billion in Canada in 2014). Most Canadian epidemiological and cost estimates do not include Newfoundland and Labrador; a knowledge gap potentially filled using health administrative data.

Aim: To extract information about chronic pain as a single chronic disease in Newfoundland and Labrador using health administrative data.

Methods: Health administrative data algorithms that identify cases of chronic pain as a single chronic disease were derived from the Newfoundland and Labrador Medical Care Plan Fee-for-Service Physician Claims File and Provincial Discharge Abstract Data of known chronic pain populations, and validated against an audit of the electronic medical records data of a primary care population sample. The most performant algorithm was used to identify chronic pain cases from fee-for-service physician claims data in Newfoundland and Labrador, which allowed estimation of both chronic pain incidence/prevalence, and chronic pain association with comorbidity presence and annual health care utilization.

Results: The most performant validated algorithm to ascertain chronic pain cases from Newfoundland and Labrador administrative data had 70.3% sensitivity, 66.8% specificity, and 40.3% positive predictive value. As defined by the algorithm, the 2009/10 age-standardized Newfoundland and Labrador chronic pain prevalence was estimated at 37,469 per 100,000 population and incidence rate was estimated at 4,585 per 100,000

person-years at risk. Estimates were higher in females, residents of urban areas, and with increasing age. Residents identified as chronic pain cases had two to four times the odds of having a chronic comorbidity and up to twice the rate of publicly funded health care utilization compared to residents not identified as chronic pain cases.

Conclusions: A health administrative data algorithm was derived and validated to identify chronic pain cases and estimate disease burden in residents attending fee-for-service physician encounters in Newfoundland and Labrador. The Chronic Pain Algorithm identified almost four out of ten Newfoundland and Labrador residents and they had a higher prevalence of comorbidities and utilization of publicly funded health services.

Key Words: chronic pain, validation, health administrative data, population-based, epidemiology, incidence, prevalence, comorbidity, health care utilization

General Summary

Chronic pain affects the physical, psychological, social, and financial health of individuals, families, and communities. It is reported that one in five Canadians has chronic pain costing the health care system approximately $7.2 billion annually. Our focus was to calculate statistics not previously reported about chronic pain in Newfoundland and Labrador by using data that is regularly collected each time a Newfoundland and Labrador resident attends an appointment with a doctor or is discharged from a hospital. This data is called health administrative data.

Data from people already diagnosed with chronic pain was used to build an algorithm that identifies them in Newfoundland and Labrador health administrative data. Algorithm accuracy was checked against an anonymous audit of medical charts from patients of local family doctors. We selected the best algorithm and identified people with chronic pain from the 1999-2010 health administrative data of all Newfoundland and Labrador residents. In 2009/10, 37.5% of Newfoundland and Labrador residents were identified, and 4.6% were newly identified, with chronic pain. We found that chronic pain was more common in females and people living in urban areas. Chronic pain also became more common as residents got older.

The presence of 16 different chronic diseases was determined, and the frequency of doctor visits, radiology tests, and hospital admissions for one year was counted. Residents in Newfoundland and Labrador identified with chronic pain were up to four times more likely to also have another chronic disease than residents not identified with chronic pain. They also used doctor and hospital services up to twice as often during one year.

Despite its limitations, health administrative data provided the resources to derive estimates on chronic pain not previously available. These findings can help stimulate change in public health and health care delivery to decrease the impact of chronic pain on residents, their communities, the economy, and the health care system in Newfoundland and Labrador.

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Lists of Abbreviations

aROC	area under the Receiver Operating Characteristic curve
ATC	Anatomical Therapeutic Chemical classification codes
CCDSS	Canadian Chronic Disease Surveillance System
CI	confidence interval
CPCSSN	Canadian Primary Care Sentinel Surveillance Network
CPDM	Centre for Pain and Disability Management
DDD	defined daily dose
DOR	diagnostic odds ratio
EMR	electronic medical record
FN	false negative
FP	false positive
HREB	Health Research Ethics Board
ICD	International Classification of Disease
ICD-9	*International Classification of Disease – 9th Revision*
ICD-10-CA	*International Classification of Disease – 10th Revision (Canadian)*
ICD-11	*International Classification of Disease – 11th Revision*
LR-	likelihood ratio negative
LR+	likelihood ratio positive
MCP Claims File	Medical Care Plan Fee-for-Service Physicians Claims File

MCP	Medical Care Plan
NL Discharge Abstract Data	Provincial Discharge Abstract Database
NL	Newfoundland and Labrador
NPV	negative predictive value
P	encounter with physician-recorded pain-related diagnostic code (Chapter 7, Section 7.3, Appendix 3) in Medical Care Plan Fee-for-Service Physicians Claims File
PC	encounter with anesthesiologist-recorded pain clinic Medical Care Plan provincial procedure billing code (Chapter 7, Section 7.4, Appendix 4) in Medical Care Plan Fee-for-Service Physicians Claims File
PDAD	Provincial Discharge Abstract Data
PPV	positive predictive value
S	encounter with medical specialist-recorded pain-related diagnostic code (Chapter 7, Section 7.3, Appendix 3) in Medical Care Plan Fee-for-Service Physicians Claims File or Newfoundland and Labrador Provincial Hospital Discharge Abstract Data
TENS	transcutaneous electrical nerve stimulation
TN	true negative
TP	true positive
WHO	World Health Organization
YR	year(s)

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Chapter 1 Introduction

1.1 Overview

Understanding the cause of and treatment for pain has remained elusive throughout human history.[1-4] Despite the advances of modern diagnostic and therapeutic medicine, no one can absolutely define the physical/physiological basis of pain; slowing the progress in pain treatment evolution.[5-10] Pain is said to become chronic after it persists beyond what is considered normal recovery time.[11] Past research defined the transition to chronicity as occurring three to six months post onset.[11-13] In the course of its development of a chronic pain classification system for the International Classification for Disease – 11th Revision (ICD-11), the International Association for the Study of Pain formalized the temporal definition of chronic pain as "pain that persists or recurs for longer than three months".[13,14] The phenomenon of pain was defined by the International Association for the Study of Pain in 2020 as "an unpleasant sensory and emotional experience associated with, or resembling that associated with, actual or potential tissue damage".[15] This definition attempted to capture the multidimensional aspects of pain by defining it as an "experience" and confirming the consensus that tissue damage is not required for pain to be felt.[11] The unpleasantness of the pain experience generates a negative impact on the quality of life of the individual experiencing it[10,16,17]; the longer it takes for pain relief to occur the greater the impact.[16,18] A plethora of literature describes both qualitatively and quantitatively the burden of pain on the physical, emotional, cognitive, behavioral, and social aspects of people's lives.[17-22] As the pain experience

becomes chronic, sufferers become more desperate for relief and seek access to specialized diagnostic, medical, paramedical, and complimentary medical services.[18,23]

There are substantial costs associated with lost productivity due to chronic pain conditions,[23-25] estimated at $297-336 billion in 2010 in the United States, A$48 billion in 2018 in Australia, and CAD$23.2 billion in 2019 in Canada.[26,27,28] With respect to direct health care costs, chronic pain is one of the most expensive conditions managed in the public health care system as 2019 annual estimates range from CAD$15.1-17.2 billion in Canada.[28] Primary treatment of pain over the ages was, and remains, medication as medical practitioners and scientists develop chemical "recipes" that attempt to stimulate, enhance, or replicate the body's natural pain relieving systems.[1,29] Medication strategies are supplemented by various forms of physical-based therapies, counseling, and naturopathic medicine, often provided concurrently as a multidisciplinary approach.[2,30] However, interdisciplinary treatment programs evaluating and addressing the complex multidimensional aspects of the chronic pain experience is shown as the most effective form of treatment.[3,30-33] There is limited availability of such treatment programs in Canada; Newfoundland and Labrador (NL) has only one such program.[18,34] This lack of widely available programming makes for insufficient access to appropriate services for people and their families impacted by chronic pain.[18,34,35]

Chronic pain advisory groups were struck in Canada in 2019 to survey how pain is being managed federally and provincially, and provide recommendations for service improvement.[35] An important first step in this effort is determining baseline epidemiological and health care utilization statistics.[36-38] Wide variation exists in national estimates of chronic pain prevalence, both globally (2-54%)[39-42] and in Canada (14-

29%).[43-49] The variation is even wider when considering regional chronic pain prevalence estimates, with reports ranging from 5.5-53.8% globally[39,50-52] and 6.5-44% in Canada[37,53-56] depending on region and data source/methodology. In Canada, smaller provincial/territorial populations, such as NL, are frequently excluded or pooled with other provinces to calculate one regional estimate.[45-47,49] Furthermore, most estimates excluded young children and adults over 75 years relying on age-specific studies for estimates and making the profile of chronic pain somewhat incomplete.[39,44-46,55,57-61] In terms of the incidence of new cases of chronic pain, four global studies reported annual incidence as 1.8-16% of the study population at risk,[52,60,62,63] and one study in Canada reported the national annual chronic pain incidence as 5.4-7.8% in those aged 25 and older.[57] There is a clear need to map prevalence and incidence in each province in Canada, including NL, and across all ages to inform any change in policy, resource allocation, or clinical practice for chronic pain care.

Epidemiological estimates on chronic pain were derived primarily from longitudinal and/or cross-sectional survey data.[39,40,45,49,57,64] Although longitudinal surveys are necessary for estimates of disease incidence and provide descriptive information, they are expensive and time/labor intensive.[65] Another easily-accessible and low-cost method to obtain longitudinal epidemiological estimates is to use case definitions applied to the health administrative data collected by the provinces/territories in Canada.[66] Health administrative data is defined as "information that is passively collected, often by government and health care providers, for the purpose of managing the health care of patients".[66] Although it is population-based and less resource intensive in terms of time and cost, health administrative data is not collected for research purposes and its accuracy

is dependent on entry at source.[66,67] There is a paucity of studies examining whether cases of chronic pain, a complex and multi-faceted condition, could be extracted from administrative data, with specific chronic pain conditions often being the focus.[68-72] However, most queries from a policy perspective center on chronic pain as a single chronic disease.[35] If accurate and valid, this technique would enable a rapid and efficient method to obtain important epidemiological and health care utilization data for chronic pain as a discrete chronic disease.

1.2 The Evolution of Pain Theories

The Oxford Dictionary of English defines "pain" as "highly unpleasant physical sensation caused by illness or injury" or "mental suffering or distress".[73] The word "pain" has its origin in Middle English meaning "suffering inflicted as punishment for an offense" derived from the Old French word "peine", which is rooted in the Latin word *poena* meaning "penalty".[4] Pain's word origin is a reflection of its sociocultural history that pain is a punishment for past or present transgressions, a millennia-held belief that continues today.[4] Pain also has political roots as a method to wield power over society's vulnerable and marginalized; used to rationalize horrific treatment, such as torture, abuse, or pain under treatment, inflicted on people of certain age or religious/ethnic origins.[4] The history of pain in the medical context lies in the evolution of theories that explain its physical causes and manifestations and inform treatment development.

The history of pain and its treatment goes back as far as the origin of man. Prehistoric human remains reveal evidence of painful conditions and injuries, as well as the attempts to ward off the advances of "pain demons".[1] Records describing the human

pain experience, the theories of its origins, and its treatment date back to early civilizations.[1,2] For example, ancient Egyptians thought pain was caused by either the entrance of demons or foreign objects, Buddha in ancient India thought pain was attributed the frustration of desires,[1] ancient Chinese medicine wrote the source of pain was the imbalance of vital energy, or chi,[2] and Plato and Aristotle in ancient Greece wrote that pain arose from the senses in the periphery and was felt in the heart (believed to be the central organ for sensation) as the "epitome of unpleasantness".[1] Galen in ancient Rome did significant work with nerves and the nervous system. He classified the sensory, motor, and pain nerves, and hypothesized that the brain was the center that received the sensations.[1] Avicenna, an Iranian philosopher and physician, also proposed pain as a sensation independent from touch and temperature.[2] However, Aristotle's belief that pain was one of the five senses processed by the heart remained the main theory of pain until the Renaissance.[1,2,4]

In 1665, René Descartes defined the mind/body dichotomy and proposed that pain was the result of a physical direct connection between tissue damage and the brain and that the mind (or soul) did not contribute to pain sensation.[1,2,4] His theory was the first to propose that pain had an internal pathway to cerebral interpretation and was not externally based in the "soul".[2,4] According to Descartes, the physician took care of the pain while religious leaders took care of the suffering.[4] The Cartesian theory of pain was the birth of modern pain physiology and gave rise to multiple theories, the most popular being the specificity theory (pain had a specific pathway in the nervous system) and the pattern theory (pain results from a central nervous system coding of summation and

pattern of peripheral neural activity).[1,2,4] This reductionist, cause-effect, dichotomous body-mind view prevailed in pain medicine for 300 years.[1]

In 1965, Ronald Melzack and Pat Wall revolutionized medicine's understanding and treatment of pain by proposing the Gate Control Theory.[1,2,4,74] The Gate Control Theory combined the principals of the specificity theory by acknowledging the existence and function of pain-perceiving nerve endings (nociceptors) and the small nerve fibers carrying their signals, and the pattern theory by describing the interaction at the spinal cord between the nociceptive neural impulses and other ascending peripheral sensory impulses and descending modulating brain impulses.[1,2,4,74] The Gate Control Theory postulated that both the relative ascending nociceptive and sensory activity from the periphery and the descending modulating activity from the central nervous system will either open or close the "pain gate".[1,2,4,74] Melzack and Wall described for the first time that the brain could exert descending control over the pain experience finally blurring the lines between the mind and the body.[4] Melzack and Casey expanded the model three years later to include the action of specialized systems in producing the sensory-discriminative, motivational-affective, and evaluative components of pain perception.[1,75] Although deemed a simplistic explanation given the expanding knowledge of pain physiology today, it revolutionized the stagnant direction of pain science and treatment.[2,10]

In the years following, the Gate Control Theory was expanded to account for the complex observations associated with pain. For example, John Loeser in 1982 proposed a pain model comprised of four successive but interlocking circles (nociception defined as the pain nerve stimulation, pain defined as the brain's processing and recognition of the

pain nerve stimulation, suffering defined as the individual's reaction to the pain, and pain behaviors defined as the unintentional communication of the pain and associated distress), which was eventually modified into a Venn diagram showing equal contribution of each component.[76,77] However, Ronald Melzack proposed in 1989 a new "conceptual nervous system" called the "neuromatrix" to explain the phenomenon of phantom limb, which he expanded to the areas of pain and chronic pain.[75,78] He proposed that the body-self, both internally and within the three-dimensional environment, is a widespread, complex network of connections, or neuromatrix, between many areas of the brain, including the cortex, thalamus, and limbic system, that is "determined genetically and later sculpted by sensory inputs".[75,78] The neuromatrix simultaneously processes past, present, and future stimuli, memories, and knowledge within a genetically pre-determined framework through "cyclical processing and synthesis", and produces a neurosignature sent to the "sentient neural hub" (of which the thalamus is considered a major component) that creates awareness of the internal and external self and motivates action.[75,78] The neuromatrix theory provided a new framework to explain the unexplainable, e.g. sensations that occur without sensory stimuli such as phantom limb sensations/pain or ongoing pain without organic evidence of tissue damage,[75,78] thrusting future pain research to focus its efforts more on the complex interaction of all levels of the nervous system.

The advancement of research and diagnostic technology continues to expand on the neuromatrix theory and pain science. Neuroimaging studies, using techniques such as functional magnetic resonance imaging and positron emission tomography, continues to identify multiple areas of the brain, brainstem, and spinal cord involved with the sensory-

discriminative, motivational-affective, and evaluative aspects of nociception and pain processing/expression.[79] Neuroimaging and animal studies provide the structural and physiological evidence of the links between the nervous system, the immune system, and the genetic profile.[79,80] The strong relationship between the stress response systems, in which the endocrine system plays an important role, continues to be established in basic science research.[5,10,79,80] Confirming the multisystem involvement in pain generation, interpretation, and modulation provides validation for the observable behavioral expression of the pain experience.[10,79]

Reviewing the physical, psychological, behavioral, social, and cultural aspects of pain begs the question of how to define pain. Clearly, the Oxford English Dictionary version is deficient. The International Association for the Study of Pain struck a task force for pain taxonomy, which defined pain in 1979 as "an unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage".[11] While attempting to capture the multidimensional aspects of pain, the definition was, and continues to be, the subject of heated debate among pain experts.[14,81,82] In light of this debate and the research and clinical findings over the past four decades, the International Association for the Study of Pain struck another Definition of Pain Task Force who proposed the recently accepted (2020) revised definition of pain: "an unpleasant sensory and emotional experience associated with, or resembling that associated with, actual or potential tissue damage".[15] The complexity of pain will ensure the debate over "what is pain" will continue for many years to come.

1.3 Chronic Pain as a Chronic Disease

The neuromatrix theory and the advancement of pain science sought not just to explain the phenomenon of pain, but how it advances to the chronic pain states that prove intractable to treatment. Pain was defined as chronic once it continued beyond normal recovery time.[11] Past research determined the transition to chronicity as occurring three to six months post onset, but the definition of chronic pain was formalized by the International Association for the Study of Pain in 2019 as "pain that persists or recurs for longer than three months".[11-14] While this definition is a grossly inadequate representation of the multidimensional clinical presentation of chronic pain, it does indicate that ongoing biological, psychological, and social processes associated with ongoing pain must occur for a time period before permanent changes are made and pain becomes chronic.[76,77,83] The time period required to move a pain state to one of chronicity is individualized depending on a multitude of factors, but the temporal divide of three months was chosen because it classically coincided with progression from the subacute to the remodeling phase in the healing process, and of six months because it coincided with generations of clinical observations of many pain conditions.[11] The processes behind chronic pain development and maintenance are still being uncovered and are as complex as its clinical presentation.

The ongoing nature of pain, in the absence of apparent stimulus that is unalleviated by treatment, is one of the most challenging features of chronic pain conditions. Structural, physiological, and functional changes occur at all levels of the nervous system, and include changes in cortical thickness of grey matter and structural connectivity of

white matter in the brain,[79,83] altered correlated activity of brain regions both at rest and with noxious and non-noxious stimulation,[79,83] increased concentration and activity of nerve growth factor (involved in inflammation and sensitization), nociceptive facilitating neurotransmitters, and microglia (involved in neuroplastic and nociplastic changes)[80] at all nervous system levels. Neuroimaging studies described "characteristic fluctuations … that are distinct for different types of chronic pain and cannot be mimicked by healthy subjects pretending to have pain".[80] Although many nervous system changes demonstrate some reversal with effective pain treatment of the chronic pain states, they are rarely extinguished because of the potent induction and maintenance of pain memories influencing the learned association between pain and physical, psychological, and social activity.[79,83]

Chronic pain states also influence and are influenced by other body systems besides the nervous system.[5,10,77] Melzack in 1999 considered the significant role of stress and its impact on the immune and endocrine systems in the development and maintenance of chronic pain, and advocated for these systems to be included as part of the neuromatrix theory.[10] Pain, he postulated, disrupted the body's homeostasis activating the stress response through the hypothalamic-pituitary-adrenal axis and the sympathetic nervous system.[10] The stress response mobilizes the immune system and release of several hormones, particularly cortisol, in an attempt to return the body to homeostasis. Prolonged pain states, as well as prolonged stress states, can lead to excessive, prolonged or abnormal patterning of cortisol output, which in turn may atrophy bone, muscle, and nerves.[5,10] The effect of abnormal cortisol output on the immune system may be implicated in the development of autoimmune disorders, such as rheumatoid arthritis and

multiple sclerosis, many of which have a chronic pain component to their clinical presentation.[5,10] The prolonged reciprocal relationship between chronic pain states and dysregulation of the delicate balance between the nervous system, immune system, and endocrine system contributes to poor treatment outcomes,[5,6,10] and it supports the notion that an external noxious stimulus is not necessary for chronic pain to develop or endure.

Growing evidence from neuroimaging and animal research in recent decades supported calls from pain experts to have chronic pain classified as a chronic disease "in its own right".[84-86] In 2011, the Government of Newfoundland and Labrador formally recognized chronic pain as a chronic disease when it formulated the Improving Health Together: A Policy Framework for Chronic Disease Prevention and Management in Newfoundland and Labrador.[87] The International Association for the Study of Pain successfully advocated for specific classification of chronic pain in the upcoming ICD-11.[13,14] The classification was based on chronic pain being defined as "persistent or recurrent pain lasting longer than three months".[13,86] Chronic pain is considered the "parent code" to seven top level diagnostic groups in the ICD-11. One top level diagnostic group is chronic primary pain syndromes defined as pain that "cannot be accounted for by another chronic pain condition," and includes chronic widespread pain, chronic regional pain syndrome, chronic primary headache, orofacial pain, visceral pain, and musculoskeletal pain. The other six top level diagnostic groups are considered chronic secondary pain syndromes defined as pain "linked to other diseases as the underlying cause", and includes chronic cancer-related pain (pain related to cancer or its treatment), chronic post-surgical or posttraumatic pain, chronic neuropathic pain (which may be a codiagnosis with chronic post-surgical/posttraumatic pain), chronic secondary

headache or orofacial pain (such as pain related to cervical injuries or dental issues), chronic secondary visceral pain (visceral pain where the primary cause can be defined), and chronic secondary musculoskeletal pain (where a disease process of the musculoskeletal system can be defined).[86] While we have different versions of chronic pain conditions, chronic pain itself is the overarching chronic disease warranting epidemiological and economical assessments within the context of public health and health care.

1.4 Quality of Life with Chronic Pain

Pain is an unpleasant human experience often equated with suffering, even when lasting a short time period measured in hours or days. The goal of acute pain treatment is to quickly relieve pain, reduce suffering, and allow the body's systems to reset to their normal homeostatic state.[5,6,10] This goal is achieved for most situations resulting in a timely reduction of pain sensation output and rapid return to activity levels enjoyed pre-pain onset.[6] For some individuals, the cure for pain does not occur when expected. This can result following injury (e.g. 50% of people post-whiplash injuries[88] and 33% of people post-acute low back pain episodes[89] experience continued pain one year later), surgery (e.g. 29% of people post-thoracotomy surgery[90] and 22.1% of people post-cardiac surgery[91] experience continued pain six months later), infection (e.g. 12.5% of people post herpes zoster infection[92] and 54% of people with HIV/AIDS[93] experience continued pain), psychological trauma (up to 83% of refugees who endured torture experience continued pain)[94], or no known etiology. Persisting pain can result in reduced physical function and elevated fear levels as the body's nervous system, immune system,

endocrine system, and musculoskeletal system mobilize to protect against further harm.[6,95] As pain advances towards chronicity, the person descends the downward spiral towards chronic pain negatively impacting quality of life.[95]

Experiencing chronic pain reportedly interferes with daily physical, emotional, cognitive, and social functioning.[16,17,95,96] Physical sequelae of ongoing pain include increased fatigue, decreased endurance, strength, and vitality, and disturbed sleep and circadian rhythm.[16,18,97,98] Emotional sequelae include anger, frustration, fear, irritability, mood swings, reduced self-esteem, and guilt around being a burden.[18,98] Depression and anxiety are strongly associated with chronic pain, with more than half endorsing moderate to severe ranges.[18,99-101] Up to 35% of people with chronic pain endorse some degree of suicidal ideation, reported to be up to four times that reported in the general population.[18,102,103] Cognitive sequelae of chronic pain include catastrophic thinking, reduced concentration, dysfunctional coping skills, and difficulty making decisions.[175,99,104] Socially, both sufferers and their families report reductions in social and leisure activities, loss of circle of friends, financial stressors from reduced/lost work and out-of-pocket medical and household care expenses, social isolation, loss of sense of identity, altered relationships and family dynamics, failed marriages/relationships, and changed/lost roles within society and family circles.[23,24,98,105-107] Described experiences by people with chronic pain are supported by scores endorsed on quantitative quality of life measures, which are significantly lower on average in both physical and mental health indices when compared to both people without pain and people with function-limiting disease.[18,98]

It is not uncommon for chronic pain to occur co-morbidly with other chronic diseases (i.e. chronic pain prevalence is reported in 13-95%[44,48,108-112] of people with specific comorbid conditions). Chronic pain is cited as a factor negatively impacting disease recovery/management and health related quality of life. Those who experience chronic pain following ischemic stroke are known to achieve less functional independence and increased concurrent cognitive decline.[113] Pain is one of the predictors for reduced quality of life in people with types of neurological conditions other than ischemic stroke that are either traumatic (e.g. traumatic brain injuries[114] or spinal cord injuries[115]) or neurodegenerative (e.g. multiple sclerosis[116] or Parkinsonism[112]). Those who experience pain as a concurrent condition with heart failure report significant reductions in quality of life and increased psychological impact compared to those with heart failure who do not experience ongoing pain.[117] Chronic Pelvic Pain Syndrome is commonly reported by those diagnosed with chronic prostatitis, and pain intensity significantly predicts perceived quality of life.[118] A large prospective cohort study in the UK found that the onset of widespread pain significantly impacted quality of life and reduced healthy aging indices in older people with osteoarthritis.[16] With increasing survival rates of people with cancer or HIV infection, there is increasing incidence of those living with neuropathic pain resulting from the disease and/or treatment.[119,120] Pain is the factor that negatively affects their quality of life the most.[105,121-123]

The impact of pain in the global community is significant. In the 2017 Global Burden of Disease Study by the World Health Organization, four of the top eleven causes of years lost to disability were pain-related conditions (low back pain, headaches, neck pain, and other musculoskeletal disorders).[124] Musculoskeletal conditions alone affected

13,121 per 100,000 of the world's population with 135 million years lost to disability worldwide.[124] Low back pain alone was the number one disease for years lost to disability globally in 2017 with an estimated 65 million years lost to disability.[124] Chronic pain places a marked multidimensional burden on all levels of society from the individual to the global community.

1.5 Chronic Pain Treatment

Pain treatment evolved over human history, often guided by the accepted pain theory at the time. Surprisingly, many treatments used in ancient civilizations are still employed today, albeit modified in the context of modern technology. The holy man or medicine man in ancient times carried out pain treatments using prayers, sacrifice, and natural remedies; pain sufferers today are reported to use prayer, faith practice, and naturopathic healing therapies.[1,4,89] Use of concoctions involving the opiate properties of the poppy date as far back as the earliest records in Babylon, Egypt and Greece.[1,2] Refinement of opiates from poppy and mandragora continued through the ages; opioid medications are used still.[1] Traditional Chinese medicine methods, including acupuncture, that were theorized to re-establish balance of the body's energy to relieve pain have been used for over 3,000 years.[2] Electrotherapy, now used through various forms of Transcutaneous Electrical Nerve Stimulation (TENS), was applied via electric fish and torpedo fish by ancient civilizations in Egypt, Greece, and Rome.[1]

Technological advances in medicine combined with the continued adoption of the specificity theory in the early 1900's saw development of regional anesthesia and neurosurgical procedures to treat chronic pain conditions.[1] Psychological treatment

approaches came to the forefront by the 1960's due to John Bonica's observations of Second World War veterans' pain experiences, Melzack and Wall's Gate Control Theory, and William Fordyce's operant conditioning therapy.[3,4] The biopsychosocial model, which describes "pain and disability as a complex and dynamic interaction among physiologic, psychologic, and social factors that perpetuates - and may even worsen - the clinical presentation",[33] was developed around the same time and became the accepted model of care for chronic pain conditions.[3,125] The neuromatrix theory and modern discoveries in pain physiology promote our understanding of pain, and advances in pharmaceutical, procedural, and non-interventional therapies provide a significant repository of treatments for pain. Despite evolving research and treatments,[6,7,80] most chronic pain conditions remain poorly understood and/or managed.[3,30]

Modern chronic pain treatment delivery is medical (e.g. medication, intervention, or surgery) and/or nonmedical (e.g. physical modalities, complementary and alternative medicine, physical therapy, psychological therapy, education programs, and rehabilitation/functional restoration).[30,125] Medication is the first and most common medical treatment utilized, and includes analgesics (non-opioid, weak opioid, and strong opioid), non-steroidal anti-inflammatories, anti-depressants, anticonvulsants, muscle relaxants, and topical agents.[3,29,30,125] Interventional treatments (or injection therapy) are commonly utilized when conservative treatments prove ineffective in achieving desired pain relief, and include nerve blocks, epidural injections, articular injections, intravenous infusions, and intramuscular injections with various pharmaceuticals such as steroids, lidocaine, and Botulinum toxin.[30,125-127] Surgery is considered when pain is severe and

intractable to all other medical management, and includes spinal fusion, implanted spinal cord stimulation, and implanted deep brain stimulation.[3,7,30,125,128,129]

Nonmedical treatment for chronic pain comes in many forms. Passive physical modalities include electrotherapeutic (such as transcutaneous electrical nerve stimulation known as TENS), ultrasound, thermal application (heat or ice), massage therapy, and articular manipulations (such as chiropractic treatment).[130-134] Complementary and alternative medicine includes acupuncture, herbal supplements, aromatherapy, and touch therapies (e.g. Reiki therapy or Healing Touch that manipulate life force energies to facilitate healing).[135-138] Physical therapy includes general and specific exercise, postural correction, and neurodynamic therapies (specific active or passive movements that facilitate nervous system tissue movement).[139-143] Psychological therapy includes operant conditioning, cognitive behavioral therapy, hypnosis, graded exposure, mindfulness-based stress reduction, and acceptance and commitment therapy.[144-147] Education programs include peer- or provider-led self-management programs and pain neurophysiology education (provision of specific information about the role of the nervous system in the perception of pain).[12,148]

Medical and nonmedical treatments are used as unimodal (a single treatment technique employed by a single health discipline), multimodal (multiple treatment techniques employed by a single health discipline), or multidisciplinary (uni- or multi-modal treatment techniques employed by multiple health disciplines working separately with the same person in pain and not necessarily with the same aims).[149] Research into the efficacy, effectiveness, indication, and contraindication for medical and nonmedical forms of treatment is ongoing. To date mediocre quality of evidence for each pain

treatment modality or combination of modalities demonstrates overall minimal to moderate impact on pain levels, return to function, and reduction in health care utilization.[30,125,150]

Rehabilitation programs are typically reserved for people whose pain did not respond to other treatments.[125] Most are comprehensive interdisciplinary pain rehabilitation programs that utilize psychological therapy (e.g. cognitive behavioral therapy) in conjunction with functional restoration to produce positive changes in quality of life, health care utilization, pain reduction, return to work, and medication reduction.[3,30,125] Interdisciplinary treatment comprises unimodal or multimodal treatments employed simultaneously by multiple health disciplines working with the person in pain, using the biopsychosocial approach to care, and regularly collaborating during assessment and treatment towards shared client-centered goals.[149] Multiple studies, systematic reviews, and meta-analyses demonstrate interdisciplinary care for chronic pain conditions based on the biopsychosocial model are more effective compared to unimodal or multimodal care for clinical, quality of life, and economic outcomes.[33,151-153] Despite the evidence in favor of early interdisciplinary intervention, there has been a reduction of true interdisciplinary pain clinics in the United States,[3] and clinics in Canada are located in urban areas with large waitlists.[18,154,34] NL only has one such clinic and it is located in St. John's.[18]

Any discussion on chronic pain treatment is deficient without considering the public health issues arising from opioid use. The escalation of strong opioid prescriptions since 1997 has engendered the unintended public health, social, and economic fallout from opioid diversion and problematic opioid use, such as opioid use disorder and

overdose.[155,156] Problematic opioid use contributed to an incurred estimated cost in 2014 of $313.1 million in health care and $1.83 billion in lost productivity,[157] and opioid overdose was responsible for over 3800 deaths in 2019 in Canada.[158] Despite the lack of evidence for the effectiveness of long-term opioid use for chronic pain management and mounting evidence regarding adverse events,[159-163] Canada had the third highest opioid defined daily dose per one million residents in 2018 in the world,[164] and NL had the highest opioid defined daily dose per 1,000 residents in 2019 in Canada.[165] The updated Canadian Guidelines for Opioids for Non-cancer Pain were released in 2017 to provide evidence-based guidance to both prescribers and policymakers involved in this issue.[29] While the public health, socioeconomic, and political context of the "opioid epidemic" globally and in Canada is beyond the scope of this project, it is important to recognize its intimate relationship with the issue of effective chronic pain management.

Multimodal interdisciplinary care for chronic pain is presently the gold standard, and there is growing support towards timely access to patient-oriented care that tailors treatment combinations to individual needs.[27,32,35] In 2019, Health Canada established the Canadian Pain Task Force that engaged a wide range of stakeholders across the country to survey how pain was being managed and make recommendations regarding service delivery improvements.[35] The Department of Health and Community Services, Government of NL established the Provincial Pain Management Advisory Council in 2019 with a similar mandate.[35] An important step is determining baseline epidemiologic and health care utilization statistics upon which to base decisions around policy and clinical practice.[36-38]

1.6 Cost and Health Care Utilization Associated with Chronic Pain

While discussing financial cost is reductionist considering the wide, multi-dimensional, negative impact of chronic pain on all societal levels, the high financial cost associated with chronic pain is an important factor to examine. Costs not related to health care (indirect costs) provide an estimate of chronic pain's societal impact. Indirect costs were estimated in 2008 at €18.8 billion for patients with a diagnosis related to chronic pain in Sweden, and €2.5 billion for people aged 20 and older self-identified as having chronic pain in Ireland.[41,166] Australia estimated productivity costs in 2018 of A$48.3 billion and loss of wellbeing costs at A$66.1 billion related to chronic pain diagnoses.[27] Lost productivity costs secondary to chronic pain were estimated at $299-334 billion for adults aged 18 and over in 2010 in the United States and CAD$23.2 billion in 2019 in Canada.[26,28] Productivity costs are measured by work absenteeism/presenteeism, sick leave rates, and short-term/long-term disability claims. Cost reports per person and their family further illustrate the economic impact of chronic pain due lost employment and payment for assistance with personal and home maintenance care. Annual cost for assistance with personal and house care per person with chronic pain in Denmark was estimated at kr15,060 as paid by town councils and kr12,408 as paid privately.[24] In a similar Canadian study conducted in 2004-2007, people on waitlists to attend multidisciplinary pain clinics reported an average monthly cost of CAD$3,112 per person for private care, lost work/leisure time, caregivers' lost work/leisure time, and assistance with housework and maintenance.[23] Parents of children attending intensive interdisciplinary pain programming reported a mean annual cost of $12,229 in missed

work and a mean annual time commitment of 343 hours to assist in the personal care, transportation, and education for their child.[106,167] Such high cost of pain on individuals and society make it prudent to ensure accessible, timely, and appropriate treatment of pain conditions.

With respect to direct health care costs, several studies globally and in Canada provided national estimates. Direct health care costs were estimated at €13.2 billion in 2008 for patients with a diagnosis related to chronic pain in Sweden,[41] and €2.8 billion in 2008 for people aged 20 and older who self-identified as having chronic pain in Ireland.[166] Direct health costs attributable to chronic low back pain alone were estimated at £2.8 billion in 2009 in the United Kingdom.[168] Annual health system costs associated with chronic pain-related conditions were estimated at A$12.2 billion in 2018 in Australia.[27] Incremental direct health care costs attributed to select chronic pain conditions were estimated between $261-300 billion in 2010 for adults aged 18 and over[26] and $11.8 billion in 2008 for children aged 6-17 in the United States.[106] In Canada, overall direct health care costs for chronic pain sufferers were estimated at CAD$15.1-17.2 billion in 2019,[28] and incremental direct health care costs attributable to chronic pain were estimated at CAD$7.2 billion in 2014 for residents aged 12 and older.[169] When compared to total annual direct health care costs attributed to other chronic diseases in Canada (CAD$11.7 billion for cardiovascular disease, CAD$11.4 billion for neuropsychiatric disorders, CAD$5.8 billion for musculoskeletal diseases, CAD$5.5 billion for digestive diseases, and CAD$2.2 billion for diabetes in 2008),[170] it is clear that managing chronic pain conditions exerts a significant cost on the health care system from a national perspective.

Examining the cost per person provides a more comprehensive picture of the disease burden of chronic pain. Direct health care costs in 2008 were estimated at €2,650 per patient with a diagnosis related to chronic pain in Sweden,[41] and €2,959 per person aged 20 and older who self-identified as having chronic pain in Ireland.[166] In 2010, a person reporting chronic pain incurred more than twice the direct health care costs (€550) of a person reporting no pain (€260) in Germany.[171] Direct health care cost per person with chronic low back pain in the United Kingdom in 2009 was also estimated as twice that for matched controls (£1,074 versus £517).[168] A study in Denmark showed an increase in direct health care costs of kr17,500 in the first year post pain onset and kr8,000 annually in years two to nine post pain onset.[24] It was estimated the direct health care cost per person associated with chronic pain in 2018 was A$3,771 in Australia.[27] Incremental direct health care cost related to a chronic pain condition was estimated at $4,516 to $7,726 for moderate and severe pain in 2010 per adult aged 18 and older[26] and $1,339 in 2008 per child aged 6-17 in the United States.[106] In Canada, overall direct health care cost was estimated at CAD$7,334 to CAD$11,128 per person in 2009/10 who reported pain severity ranging from mild to severe.[172] Incremental cost attributable to a moderate to severe chronic pain condition was estimated at CAD$1,643 to CAD$3,960 in 2014 for Canadian residents aged 12 and over,[169] which was comparable to annual incremental costs attributed to managing hypertension (CAD$2,341 in 2014)[173] and diabetes (approximately CAD$3,800 the first year post diagnosis and CAD$550-1,220 annually for year two to eight post diagnosis).[174] Reported direct health care costs per person were quite variable depending on country, defined pain severity, sample age range, and method of cost identification and calculation.

Health care utilization presents another metric to measure direct health care costs, since higher health care utilization of both high and low value translates into higher health care costs.[175,176] In the context of chronic pain, prolonged moderate to severe pain heightens a person's desperation for relief resulting in increased utilization of various and increasingly specialized health services.[18,23] Pain is one of the most common chief complaints of those accessing primary care globally, with up to 40% of people with chronic pain consulting with a primary care physician in the previous 3 months[177] and 96.7% consulting with a primary care physician ever for their pain condition.[18] Adults and children who self-identify as having chronic pain on surveys have 1.5 to 2.0 times the likelihood of having an encounter at the emergency department when compared to people who don't self-identify as having chronic pain.[169,178-181] It was reported that up to 25% of adults self-identified as having chronic pain[169] and 17% of children attending a chronic pain clinic[106] will have at least one inpatient admission, and up to 46% of adults on a multidisciplinary pain clinic waitlist[18] and 36% of children and adolescents self-identified as having chronic pain on a survey[180] will consult at least one specialist. Higher utilization of expensive diagnostic imaging was observed in people self-identified as having chronic pain on a survey compared to those who were not self-identified as having chronic pain (13% versus 9% had a computed tomography scan and 7% versus 4% had a magnetic resonance imaging scan).[169] A recent study reported that in 2013-2014 expensive magnetic resonance imaging scans accounted for just over half of all diagnostic imaging costs incurred by people seeking care for musculoskeletal conditions in Ontario.[176] The annual rate of visits per person with chronic pain to physicians (4.3 to 8.3 annual visits depending on the population sample) and allied health professionals (2.7 to

40.3 annual visits depending on the profession) was reported as high.[41,108,172,182] Costs and health care utilization estimates provide a method to inform and evaluate changes to health service delivery and clinical care, and are presently unavailable for NL.

1.7 Chronic Pain Epidemiology

Referred to as "the hidden epidemic",[183] combined estimates place chronic pain prevalence at 21.5% globally.[50] However, national prevalence estimates of individual countries are widely variable (2-54%) due to methodology (particularly data source, chronic pain case definition, and sampling procedures) and heterogeneity in population sociocultural-demographics.[40,41] Survey estimates reported chronic pain prevalence as 12%-30% of residents aged 18 and over in 15 European countries and Israel,[39] 15.4% in residents aged 15 and over in Australia,[27] 15% of residents aged 20 and over in Japan,[62] 38.4% in residents aged 18 and over (except 20 and over in Japan, 21 and older in Israel, and 16 and over in New Zealand) in ten developed and seven developing countries,[42] and 20.4% of residents aged 18 and over in the United States.[184] National prevalence estimates obtained from administrative data were reported as 54% of all residents in Sweden.[41] Regional estimates within countries globally were also widely variable, reported as 2.4% for residents 26 and over in a German regional survey,[40] 53.2% for residents aged 25 and over in the Grampian region of the United Kingdom,[52] 32% for residents aged 18 and over in northern Italy,[39] less than 22% for residents aged 18 and over in southern Italy,[39] and 35% for residents aged 30 and over in the Tromso region of Norway.[51] Analysis of Veterans Affairs administrative data in the United States reported 2008 chronic pain prevalence ranging from 42.3% of veterans aged 35 and over with no

comorbid psychiatric diagnosis to 65.6% of veterans with comorbid depression.[185] Analysis of electronic medical record data reported chronic pain prevalence as 19% of a health center's patients aged 18 and older in Connecticut.[186]

Similar wide variations in chronic pain prevalence estimates exist in Canada. National survey estimates reported chronic pain prevalence as 15.7-21.0%[49] of residents aged 12 and over from the 2000/01 to 2013/14 cycles of the cross-sectional Canadian Community Health Survey, 15.3-19.5%[57] of residents aged 25 and over from the 1994/95 to 2006/07 cycles of the longitudinal National Population Health Survey, and 18.9-29%[43,45,47] of residents 18 and older from independent national surveys. Regional, provincial, or municipal survey estimates are significantly more variable, reporting chronic pain prevalence as 11%[37] of adults aged 20 years and older in 1984 in Burlington, Ontario, as 44%[53] of adults aged 18 years and older in 1998 in Edmonton, Alberta, and as 37%[56] of adults aged 20 and older in 2004 in southeastern Ontario. Some studies reported regional or provincial estimates derived from national surveys, and chronic pain prevalence ranged from 15.7% in Quebec to 36% in Atlantic Canada.[43,45,47] Prevalence of chronic pain in NL was estimated as 14.1% of women and 9.1% of men aged 25 and older in the 2006/07 National Population Health Survey, which had a sample size of 1,392 NL households.[57,187] No other chronic pain prevalence estimates for NL have been published, with many studies instead choosing to report on the four Atlantic Provinces as one region.[45,47,49] However, aging demographics, higher chronic disease rates, and poorer population health indicators in NL compared to other Canadian jurisdictions (including the other three Atlantic provinces) may contribute to higher chronic pain rates.[188,189] This

highlights the importance of determining NL-specific chronic pain disease distribution for the purposes of public health initiatives and resource planning.

There are fewer studies reporting chronic pain incidence versus prevalence estimates, possibly due to the expense associated with using survey methodology in a longitudinal study design.[65] Similar to chronic pain prevalence, reported incidence estimates are widely variable due to methodology (particularly chronic pain case definition and sampling procedures) and heterogeneity in population sociocultural-demographics.[40] Globally, one-year cumulative incidence was estimated as 1.8%[63] of residents at risk aged 16 and over in Denmark, 8.3%[52] of residents at risk aged 25 and over in the United Kingdom, and 11.1%[62] of residents at risk aged 20 and over in Japan. Three-year cumulative incidence was estimated as 48% of residents at risk aged 50 years and over in the United Kingdom.[60] One-year cumulative incidence in Canada was calculated from the 1996/97 to 2006/07 cycles of the longitudinal National Population Health Survey, and was estimated as 5.4-7.8% of residents at risk aged 25 years and older.[57] Incidence is an important measure of possible contributing exposures and of prevention program effectiveness;[65] it is prudent to explore economical and consistent methods to measure and report chronic pain incidence that can inform effective policy and clinical decision-making.

Global and Canadian studies reported similar prevalence trends based on sex and age. Females are observed to have higher chronic pain prevalence (estimated at 16.9-69.2% globally and 13-66.7% in Canada) than males (estimated at 15.0-68.4% globally and 8-57.1% in Canada).[27,42,44-48,52,53,55-57,184,190,191] Females also observed to have higher chronic pain incidence (estimated at 2.1-16.3% globally and 6.0%-8.7% in Canada) than

males (estimated at 1.4-15.7% globally and 4.8%-7.1% in Canada).[57,60,62,63] This phenomenon was reported both in the overall population and at different ages across the lifespan. Females are described as suffering from chronic pain and pain-related interference more often than males and have associated higher health care utilization.[47,60,192-194] Sex- and gender-related differences with respect to pain experiences are described as complex, and include biological, psychological, and social processes.[192,193,195] There is also consistent evidence of increasing chronic pain incidence and prevalence with increasing age in both sexes. Although chronic pain prevalence estimates in children and adolescents is widely variable (up to 88%) depending on the age range, pain condition(s), and time frame examined, it was generally reported that approximately 5-6% of children have moderate to severe chronic pain-related interference.[58,191,196] Most chronic pain epidemiology studies examined adult populations, and reported that prevalence increased with age, from 6.3-48.1% in the 18-25 age group to 14-69.0% over 65 years.[27,44,53,60,63,184] Surveys were the most common data collection method to estimate chronic pain epidemiology, and most surveys either included a disproportionately small sample size from the youngest and oldest members of the population, or excluded them altogether, making the profile of chronic pain somewhat incomplete. There is a clear need to find an efficient method to map prevalence and incidence of chronic pain across all ages in each Canadian province, including NL, and link it to information on health care utilization in order to plan for future health care needs.

1.8 Health Administrative Data as an Epidemiological Data Source

With one exception,[54] chronic pain incidence and prevalence estimates in Canada were provided by studies using cross-sectional and/or longitudinal survey methodology.[37,45,47,49,53,56,57] Survey data is rich in descriptive information, but longitudinal data is required for estimates of disease incidence and can be expensive to obtain in terms of cost, time, and labor, making it prudent to consider a more feasible data source to fill the knowledge gap on chronic pain in Canada.[65] Health administrative data is a collection of information passively recorded in the course of rendering and/or remunerating health services.[66,197] Each province and territory in Canada administers a comprehensive health plan covering most hospital and physician services for nearly all residents generating large national and provincial/territorial databases.[198] These databases contain service dates with accompanying diagnostic, procedural, financial, and demographic information organized by each resident's unique provincial health insurance number.[66,67,199] Described as somewhat mirroring the medical record,[197] health administrative data is used to extract annual population-based estimates on distribution, trends, and direct health care costs of various medical conditions.[66,200]

The use of health administrative data as a data source to provide epidemiologic and economic information on chronic pain conditions was reported by several studies. Some studies used diagnostic code sets not previously validated to identify chronic pain cases in administrative data and extract epidemiologic and/or cost estimates.[41,185,201] One study in the United States validated a case definition to identify chronic pain cases in a health group electronic medical record database, and used it to determine prevalence.[186] Health

administrative data case definitions were found valid to identify cases of only a few specific chronic pain conditions (e.g. chronic/recurrent low back pain, fibromyalgia, osteoarthritis, rheumatoid arthritis, and painful neuropathy),[68-70,202-207] which were then used to extract epidemiologic and/or cost estimates. Cited limitations that contributed to the difficulty in creating valid health administrative data case definitions for chronic pain conditions included billing practices related to limits on permitted diagnostic/procedure codes per claim, coding practices related to possible lack of recognition and/or under-treatment of chronic pain, and unavailability of chronic pain coding taxonomy in commonly used diagnostic/procedural coding systems.[41,68,70,86,186,206,208] Other studies combined data sources by linking chronic pain comparator groups identified via survey/patient list data to health administrative data to report healthcare utilization and/or cost associated with chronic pain.[55,169,172] Even though chronic pain is considered a chronic disease in its own right,[84,86] no study to the best of knowledge obtained epidemiologic and/or health care utilization information related to chronic pain as a "single disease entity"[150] from health administrative data via the use of a validated case definition.[70]

There are several issues to address when determining the validity of NL health administrative data to provide information on chronic pain as a single disease entity. First, administrative data is not collected for research purposes making its record level data accuracy dependent on data entry at source.[66,67] Assessing the data's validity is complicated by the temporal criterion (three to six months) of chronic pain that must be met and the comorbid occurrence of chronic pain with other chronic diseases.[209-211] Second, chronic pain is a multidimensional condition involving complex neurological and

systemic interactions influenced by all aspects of the human experience.[5,10,32,76] It is often considered, and therefore recorded, as a symptom of another trauma or disease process with no objective diagnostic "gold standard" to use for validation, unlike other chronic diseases such as diabetes.[32,41,86,186,208,212,213] Finally, best practice recommends validating the health administrative data case definition against the medical record audit of a cohort that closely resembles the overall population under study in all respects, including disease prevalence rates.[66] Finding an efficient means to perform such an audit on a large enough cohort representative of NL age and rural/urban demographics was a challenge.

The NL Provincial Pain Management Advisory Council is currently working to bring about changes to health service delivery to mitigate the devastating impact chronic pain has on sufferers, their families, their communities, the economy, and the health care system.[35] However, there is a significant knowledge gap on the disease distribution and health care utilization associated with chronic pain in NL. The main aim of this thesis was to determine if the NL health administrative data was a valuable source of information on chronic pain, and provide a feasible method to fill this knowledge gap and assist in improving the quality and timeliness of health service delivery to this important subpopulation.

1.9 Thesis Objectives and Statement of Coherence

The aim of the overall study titled "Epidemiology and Health Care Utilization Associated with Chronic Pain in Newfoundland and Labrador, Canada: A Population-Based Study Using Health Administrative Data" was to compile detailed statistics on the chronic pain condition in the NL context, which can be used to inform policy around

health service provision for people with chronic pain. Most studies examining chronic pain epidemiology and health care utilization in Canada used the Canadian Community Health Survey and/or National Population Health Survey as data sources.[44,46,48,49,55,57] However, the sample drawn from NL in these two surveys was considered too small (target of 4010 individuals surveyed for the Canadian Community Health Survey and 1392 households surveyed for the National Population Health Survey)[187,214] to allow for sufficient stratification needed to give meaningful information on disease distribution. Designing and administering a survey specific to the NL context, particularly one longitudinal in design, was deemed unfeasible due to its cost in terms of funding, time, and human resources.[65] Routinely collected health administrative data in NL is a readily available data source that is regularly subjected to rigorous quality control procedures.[215-218] Since the health administrative datasets were already used to monitor annual incidence and prevalence trends of other chronic diseases in NL,[200] it was postulated that these were valid data sources from which to extract information on chronic pain.

The thesis is comprised of three distinct studies - each building on the results of the study preceding it - to achieve the overall study aim. The first study aimed to test the validity of the NL health administrative data to provide information on chronic pain through derivation and validation of a chronic pain health administrative data case definition. The second study aimed to apply the validated case definition to the health administrative data of all NL residents and determine incidence and prevalence of chronic pain in NL. The third study aimed to utilize the validated case definition to establish two population-based comparator groups (the Chronic Pain Group and the No Chronic Pain Group) to examine utilization of publicly funded health care services. The manuscript

style was the chosen format for the thesis; each manuscript was prepared for publication submission. As such, there was unavoidable overlap of the content contained in the Introduction, Methodology, and Limitations sections of each manuscript. Preliminary results of all three studies were briefly presented in a teleconference to the Provincial Pain Management Advisory Council on June 11, 2019, and as an oral presentation at the 2019 PriFor Conference in St. John's, NL, on June 28, 2019.

Chapter 2 is entitled "Identifying Cases of Chronic Pain using Health Administrative Data: A Validation Study". The study aim was to determine whether NL health administrative data would provide valid information on cases of chronic pain. The specific study objectives were: (1) to derive a case definition that could identify cases of chronic pain from NL health administrative data; and (2) determine validity and reliability of the case definition against an electronic medical record database audit. An earlier version of Chapter 2 was published as a Preprint online on the Research Square Preprint Platform on December 18, 2019.[219] The presented manuscript was published with the *Canadian Journal of Pain* on December 3, 2020.[220]

Chapter 3 is entitled "Incidence and Prevalence of Chronic Pain in Newfoundland and Labrador, Canada: A Retrospective Cohort Study using Health Administrative Data". The study aim was to describe incidence and prevalence of chronic pain in NL by using a provincial health administrative data algorithm validated to identify cases of chronic pain among residents who attended encounters with fee-for-service physicians for pain-related conditions. The specific study objectives were: (1) to determine annual prevalence of chronic pain in NL from 2006/07 to 2009/10 fiscal years; (2) to determine annual incidence rates of chronic pain in NL from 2006/07 to 2009/10 fiscal years; and (3) to

determine distribution of chronic pain in NL stratified by sex, age group, health authority region of residence, and rural/urban residential location. This manuscript was submitted for consideration to the *Journal of Pain*.

Chapter 4 is entitled "Association of Chronic Pain with Comorbidities and Health Care Utilization: A Retrospective Cohort Study using Health Administrative Data". The study aim was to determine the association of chronic pain with other comorbid conditions and publicly funded health care utilization in NL. The study hypotheses were: (1) having a likely chronic pain diagnosis would be strongly associated with having other comorbid conditions; and (2) having a likely chronic pain diagnosis would be strongly associated with having a higher utilization of publicly funded health care resources. The study objectives were: (1) to characterize and compare comorbidity prevalence in provincial cohort members identified as having a likely chronic pain diagnosis to provincial cohort members not identified as having a likely chronic pain diagnosis; and (2) to characterize and compare the 2009/10 fiscal year health care utilization of provincial cohort members identified as having a likely chronic pain diagnosis to provincial cohort members not identified as having a likely chronic pain diagnosis. This manuscript was submitted for consideration to the journal *Pain.*

Chapter 5 is entitled "Summary". The chapter will first summarize the aims, objectives, and methodology of the preceding three chapters. The key findings and concluding takeaways of each chapter is then summarized. The general discussion of the application of the thesis findings will include two main themes. First is a discussion of how the epidemiologic and health care utilization information reported in this thesis related to chronic pain in NL can inform health service changes currently being

considered at a policy and clinical level. Second is a discussion of the challenges around utilizing NL health administrative data to extract information about chronic pain. The thesis will close with general recommendations for future research and concluding remarks.

Chapters 2 and 3 contain pertinent, chapter-specific results tables that are too large to include in the chapter text. These tables are placed at the end of the associated chapter in Section 2.8.1, Appendix 2.1 (contains results pertaining to Chapter 2), Section 2.8.2, Appendix 2.2 (contains results pertaining to Chapter 2), and Section 3.8.1, Chapter 3 Appendix (contains results pertaining to Chapter 3). The references (Chapter 6) are formatted in the American Medical Association style and are consolidated at the end of this thesis after Chapter 5. Eight appendices (Chapter 7) follow the Reference List. Seven appendices contain important information in tabular form referenced in the methodology for Chapters 2, 3, and 4. The eighth appendix contains the most recent ethics approval.

1.10 Co-authorship Statement

Heather E. Foley drafted Chapter 1 and made substantial contributions to its content and revision. Dr. Rick Audas contributed to the draft writing and revision of Chapter 1. Dr. Michelle Ploughman contributed to the draft writing and revision of Chapter 1. Dr. John C. Knight contributed to revision of Chapter 1. Dr. Shabnam Asghari contributed to revision of Chapter 1.

Chapter 2 Identifying Cases of Chronic Pain using Health Administrative Data: A Validation Study

Foley HE, Knight JC, Ploughman M, Asghari S, Audas R. Identifying cases of chronic pain in health administrative data: A validation study. *Can J Pain*. 2020;4(1):252-267. doi: 10.1080/24740527.2020.1820857.

Foley HE, Knight JC, Ploughman M, Asghari S, Audas R. Identifying cases of Chronic Pain in Health Administrative Data: A Validation Study. PREPRINT (Version 1) available at Research Square. 2019. doi:10.21203/rs.2.19115/v1.

 Preliminary results from this chapter were presented in a teleconference to the Provincial Pain Management Advisory Council on June 11, 2019, and as an oral presentation at the 2019 PriFor Conference in St. John's, NL, on June 28, 2019. Preliminary results from this chapter were accepted for a poster presentation at the 41st Annual Scientific Meetings of the Canadian Pain Society that were scheduled for May 19-22, 2020 but cancelled due to the global pandemic.

Abstract:

Background: Most prevalence estimates of chronic pain are derived from surveys and vary widely, both globally (2-54%) and in Canada (6.5-44%). Health administrative data is increasingly used for chronic disease surveillance, but its validity as a source to ascertain chronic pain cases is understudied.

Aim: To derive and validate an algorithm to identify cases of chronic pain as a single chronic disease using provincial health administrative data.

Methods: A reference standard was developed and applied to the electronic medical records data of a Newfoundland and Labrador general population sample participating in the Canadian Primary Care Sentinel Surveillance Network. Chronic pain algorithms were created from the administrative data of chronic pain patient populations, and their classification performance was compared to that of the reference standard via statistical tests of selection accuracy.

Results: The most performant algorithm for chronic pain case ascertainment from the Medical Care Plan Fee-for-Service Physicians Claims File was: one anesthesiology encounter ever recording a chronic pain clinic procedure code OR five physician encounter dates recording any pain-related diagnostic code in five years with more than 183 days separating at least two encounters. The algorithm demonstrated 0.703 (95% confidence interval: 0.685-0.722) sensitivity, 0.668 (95% confidence interval: 0.657-0.678) specificity, and 0.408 (95% confidence interval: 0.393-0.423) positive predictive value. The Chronic Pain Algorithm selected 37.6% of a Newfoundland and Labrador provincial cohort.

Conclusions: A health administrative data algorithm was derived and validated to identify chronic pain cases and estimate disease burden in residents attending fee-for-service physician encounters in Newfoundland and Labrador.

Keywords: chronic pain, validation, health administrative data, algorithm, population-based, electronic medical records data, case ascertainment

2.1 Introduction

Chronic pain is a pervasive and challenging public health issue.[32,39,41,46,50] Globally, prevalence estimates range drastically from 2 to 54%,[39-41,62,64,186,221] with similar variability reported in Canada (6.5-44%).[37,43-48,53-56] Such variability in prevalence creates uncertainty when planning for present and future health care needs. Annual costs related to chronic pain in Canada are expected to exceed over $10 billion by 2025.[55,222] In Canada, most chronic pain prevalence estimates were derived from national or regional surveys.[37,43,45-47,53,55,56] Although surveys provide descriptive information, they are expensive and labor intensive.[65] Another easily-accessible and low-cost method to obtain prevalence estimates is to use algorithms applied to health administrative data that is collected by provinces in Canada.[66] There is a paucity of studies examining whether cases of chronic pain, a complex and multi-faceted condition, could be extracted from administrative data, with specific chronic pain conditions often being the focus.[68-72] However, most queries from a policy perspective center on chronic pain as a single chronic disease.[35] If accurate and valid, using health administrative data as an information source will enable a rapid and efficient method to obtain important epidemiological, health planning, and policy data on this significant chronic condition.

Each province and territory in Canada administers universal health plans that cover most hospital and physician services to nearly all of their residents.[198] Despite only capturing information obtained through physician and hospital encounters, the health administrative data generated is used to extract annual population-based estimates on distribution, trends, and direct health care costs of various medical conditions in Canada

through validated algorithms.[200] Previous studies on chronic pain that used administrative data ascertained cases through convenience samples,[24] surveys,[169] code sets not previously validated,[41,185] or validated algorithms for specific pain conditions,[69,71,72,206] such as low back pain.[68] One study successfully derived a chronic pain case definition for electronic medical record data,[186] but the clinical information utilized (in an American health care setting) is not universally collected and is not available in Canadian administrative data.[199,223]

The growing dependence on administrative data for chronic disease surveillance emphasizes the importance of using valid algorithms for case ascertainment.[66] The challenge of using health administrative datasets is that its record level data is not collected for research purposes and may have significant data entry errors.[66,67] This is exacerbated by chronic pain often being considered a symptom of another trauma or disease process with no objective diagnostic "gold standard" to use for validation,[32,41,86,186,208] unlike other chronic diseases with standard objective diagnostic tests such as diabetes,[212,213] multiple sclerosis,[67] and rheumatoid arthritis.[205] Applying standardized methodology to create, validate, and report administrative data algorithms that identify cases of chronic pain as "a single disease entity"[150] advances the utility of the information obtained and examined by researchers, clinicians, and health policy makers.[66]

An administrative data algorithm is a combination of diagnostic and procedural code patterns (known as spatial frequency) together with encounter frequency patterns (known as temporal frequency).[66,224] It operates similar to diagnostic testing in medical practice.[66,224] A chronic pain algorithm must include spatial and temporal frequency criteria that align with accepted practice in the diagnosis of chronic pain.[66] A standardized

set of diagnostic and/or procedural codes is required to identify chronic pain-related conditions and treatments in administrative data.[66] Pain extending beyond three months post onset, or six months for the purposes of research, as defined by The International Association for the Study of Pain is the required temporal benchmark for chronic pain case ascertainment.[11] A review of eleven studies in the field revealed eleven different chronic pain definitions and/or code sets used in research.[37,39,41-43,46,51,62,64,185,221] Currently, there is no consistency in chronic pain research regarding appropriate spatial and temporal frequency.

The aim of the present study was to determine whether Canadian health administrative data would provide valid information on cases of chronic pain in the context of a single disease. The study sought to achieve this by using administrative data collected in one Canadian province, Newfoundland and Labrador (NL), to develop an algorithm with the appropriate spatial and temporal criteria. Validity and reliability were examined against an electronic medical record database audit. This study marks the first step in addressing the long-term goal of compiling detailed statistics on the chronic pain condition in the Canadian context, which can be used to inform policy around health service provision for this high needs population.

2.2 Methodology

The Health Research Ethics Board (HREB) of the Health Research Ethics Authority of Newfoundland and Labrador provided full approval of the study protocol (HREB Reference #13.157). The Secondary Uses Committee of the NL Centre for Health Information and the Research Proposals Approval Committee of the Eastern Regional

Health Authority also reviewed and approved the study protocol following HREB approval.

2.2.1 Setting

The Canadian Primary Care Sentinel Surveillance Network (CPCSSN)-NL data was used for algorithm validation. The CPCSSN is a clinical data source comprised of information retrieved directly from the electronic medical records of patients attending participating primary care practices across Canada.[225] In February 2013, the CPCSSN-NL was annually receiving de-identified data on just over 35,000 patients of all ages (approximately 7% of the NL population)[188] from 45 physicians (approximately 9% of the NL registered primary care physicians)[226] practicing in 8 primary care clinics in mainly urban NL.[218]

The primary care physicians participating in the CPCSSN database provided written consent on behalf of their patients to have their patient electronic medical record data regularly transferred to the CPCSSN, which follows strict and secure privacy protocols when using the de-identified data from the patients' electronic medical records. Data sharing and confidentiality agreements were put in place. The participating primary care physicians provided written information (posters and pamphlets in their offices) to patients about the CPCSSN, how their data will be used, and that they had the option to opt out of data collection at any time. The ethics approval obtained for the CPCSSN project in NL included a waiver of explicit patient consent because of the infeasibility of obtaining individual consent for the large geographical population involved in the project, and because only secondary data analysis of pre-existing de-identified data was

performed. Patients' consent to participate in the CPCSSN database and for their de-identified information in the electronic medical record to be used for research purposes, including data linkages, was thus implied.[227,228]

The CPCSSN data tables containing medical record information utilized for the purposes of this study included the Encounter, Encounter Diagnosis, Health Conditions, Medication, Patient Demographics, and Provider tables. These tables contained clinical information extracted directly from each entry in the medical record and included raw text, diagnostic codes, Anatomical Therapeutic Classification codes (medication codes), procedures performed, and relevant dates (e.g. dates of encounters and medication start/stop dates) as entered by the attending primary care physician.[227] The World Health Organization maintains and updates a standardized system of numeric or alphanumeric codes to classify medical diagnoses called the International Classification of Disease (ICD), and the CPCSSN utilizes three- to five-digit codes from the 9th revision of the ICD (ICD-9).[227,229] Clinical data is organized via the patient's unique health insurance number and is de-identified prior to data transfer to CPCSSN.[225] The CPCSSN data undergoes rigorous quality control procedures and was previously determined to be a valid data source to study eight chronic diseases,[230] and a valid proxy (77.5-97.2% sensitivity and 93.1-99.4% specificity) to manual review of electronic chart raw data for validation studies.[231]

2.2.2 Reference Standard Cohort and Reference Standard

The Reference Standard Cohort was comprised of primary care patients of all ages who met the inclusion criteria of implied consent to participate in the CPCSSN-NL since

December 31, 2009 or earlier, and a minimum of two years of electronic medical record data for analysis. Since the CPCSSN-NL data has only been collected since 2005,[225] the data range from January 1, 2006 to December 31, 2011 was extracted for this cohort.

The presence of chronic pain in the Reference Standard Cohort was determined using both spatial and temporal benchmarks that align with a chronic pain definition. The temporal benchmark was defined as persistent or recurrent pain lasting longer than six months.[11,86] A comprehensive search of all sources of clinical information for evidence of assessment/treatment of pain-/chronic pain-related conditions was performed by one of the authors with clinical expertise in chronic pain (HF). A combination of ICD-9 diagnostic codes, Anatomical Therapeutic Chemical Classification Codes, medication start/stop dates, raw and cleaned textual data, and encounter frequency from the CPCSSN data served as the CPCSSN-NL reference standard for chronic pain. The spatial benchmark for the reference standard was informed by published literature,[41,68,71,72,185,186,206,208,232-238] consultations with chronic pain experts (HF, ET, and JF) and a pharmacy expert (CD), and codes/text utilized in the CPCSSN-NL data. Patients in the Reference Standard Cohort were classified as having chronic pain if any one of the following CPCSSN-NL data criteria was met in the cumulative patient electronic medical record data up to December 31, 2011: (1) a single encounter date recording (the ICD-9 diagnostic codes 338.0[1], 338.21[1], or 338.4) OR (text with "chronic" and "pain" in the same text entry not necessarily following each other); OR (2) receipt of

[1] International Classification of Disease-9th Revision diagnostic codes of 338.0 and 338.2 are not utilized in Canadian Primary Care Sentinel Surveillance Network-Newfoundland and Labrador data but are included in this manuscript for completeness.

at least 90 days of opioid medication used almost exclusively for pain (Chapter 7, Section 7.1, Appendix 1) in the CPCSSN-NL study period; OR (3) four or more encounter dates recording (any ICD-9 pain-related diagnostic code (Chapter 7, Section 7.2 Appendix 2)) OR (text with "pain") within a 2-year period with more than 183 days separating at least two pain-related encounter dates.

2.2.3 Administrative Data Sources

Two administrative data sources were used for the chronic pain algorithms: (1) the Provincial Discharge Abstract Database (NL Discharge Abstract Data), which is the NL component of the Canadian Institute of Health Information national Discharge Abstracts Database, containing information on all separations from acute health care facilities in NL, including admission date and up to 16 diagnostic codes, and (2) Medical Care Plan (MCP) Fee-for-Service Physicians Claims File (MCP Claims File) containing information, including one diagnostic code and one provincial billing code, on all claims for health services provided by fee-for-service physicians in NL. All data is organized by each NL resident's unique health insurance number.[199,239]

All NL Discharge Abstract and MCP Claims File data is used for research and surveillance of multiple injuries and disease states.[200] Rigorous quality control procedures are applied to the NL Discharge Abstract data on an annual basis, and MCP Claims File data is considered complete due to its collection for service remuneration.[215,216,218] The MCP Beneficiary File was used to obtain demographic and benefits eligibility information, including age, sex, rural/urban location of residence, and health authority

region of residence. All required record-level data from January 1, 1999 to March 31, 2010 were obtained from these datasets.

The NL Discharge Abstract Data used five-digit ICD-9 codes up to March 31, 2001, and six-digit *International Classification of Disease – 10th Revision (Canadian)* (ICD-10-CA) codes from April 1, 2001 onwards. The MCP Claims File data used three-digit ICD-9 codes throughout the data study period. Although the eleventh revision of the ICD contains specific classifications of chronic pain conditions,[86] the ICD-9 and ICD-10-CA do not.[229] To determine the spatial benchmark and account for the many proxies used by clinicians and researchers for pain-related diagnoses,[41,185,186,208] previous studies and consultations with pain experts (HF, ET, and JF) were used to select the pain-related ICD-9 and ICD-10-CA diagnostic codes (Chapter 7, Section 7.3, Appendix 3) searched in the NL administrative data.[41,68,71,72,185,186,206,208,232-237] Chronic pain-related provincial procedure billing codes (Chapter 7, Section 7.4 Appendix 4) searched in the MCP Claims File were reserved for medical assessment and treatment of people with chronic pain carried out by anesthesiologists in organized hospital pain clinics.[240]

2.2.4 Administrative Data Algorithms

Convenience samples of known chronic pain cases were obtained to develop and sensitivity-test preliminary chronic pain algorithms. Inclusion criteria for the pain patient populations were: (1) attending an interdisciplinary chronic pain rehabilitation program from 2006-2011, (2) attending an interdisciplinary chronic pain rehabilitation program from 1999-2005, (3) being on the waitlist to attend an interdisciplinary chronic pain rehabilitation program on September 1, 2012, or (4) being prescribed and dispensed any

opioid medication used almost exclusively for pain (Chapter 7, Section 7.1, Appendix 1) during the period from 1999-2011 as a subsidized patient of the NL Prescription Drug Program. The interdisciplinary chronic pain rehabilitation program is located in St. John's, NL, and is known as the Centre for Pain and Disability Management.[241] The NL Prescription Drug Program provides financial assistance for eligible prescription medications to qualified seniors and low-income individuals/families.[242]

Since the health administrative data analyzed was part of routine data collection and normal operations of the NL Centre for Health Information, NL Prescription Drug Plan, and the Eastern Regional Health Authority, and the data was then de-identified, individual patient and/or NL resident consent was not required.

For the algorithm development step, MCP Claims File and NL Discharge Abstract Data for the pain patient population attending the interdisciplinary chronic pain rehabilitation program from 2006-2011 was searched for the presence of pain-related diagnostic and procedure codes (spatial benchmarks). Encounter and hospitalization dates associated with pain-related diagnostic codes were searched for the presence of the six-month temporal benchmark. Preliminary algorithms were created by combining the presence of: (1) up to five dates of encounters and/or hospitalizations with any physician recording any pain-related diagnostic code (Chapter 7, Section 7.3, Appendix 3) in either the MCP Claims File or NL Discharge Abstract Data, (2) one or more encounters with a medical specialist recording any pain-related diagnostic code (Chapter 7, Section 7.3, Appendix 3) in either the MCP Claims File or NL Discharge Abstract Data, (3) more than 183 days separating at least two encounter dates with a physician recording any pain-related diagnostic code in the MCP Claims File or the NL Discharge Abstract Data, and

(4) chronic pain-related physician procedure billing codes (Chapter 7, Section 7.4, Appendix 4) in the MCP Claims File. Initially, the algorithms were observed for all available years of the data (1999-2010). The algorithms were then observed for specified time windows to maximize potential chronic disease surveillance utility. A previous study identified up to seven years as the optimal clearance period for recurrent low back pain[202]; therefore, the time windows of between one and seven years were chosen to observe required algorithm spatial and temporal benchmarks.

For the preliminary algorithm sensitivity-testing step, the algorithms were tested for sensitivity on the administrative data of the four pain patient population groups.

For the algorithm validation and selection step, a refined list of algorithms was selected, applied to the Reference Standard Cohort administrative data, and rigorously tested for validity via multiple statistical tests of selection accuracy comparing administrative data case ascertainment to that of the reference standard. In all steps, the administrative data algorithm classified pain patient population group or validation cohort members as having chronic pain if the algorithm criteria were met at any time in the administrative data period (1999-2010). Using the entire data period accommodated both the nature of chronic pain as having no cure and the uncertain timing of diagnosis due to the lack of a standard objective diagnostic test. Fig. 2.1 summarizes the methodology and associated dataflow.

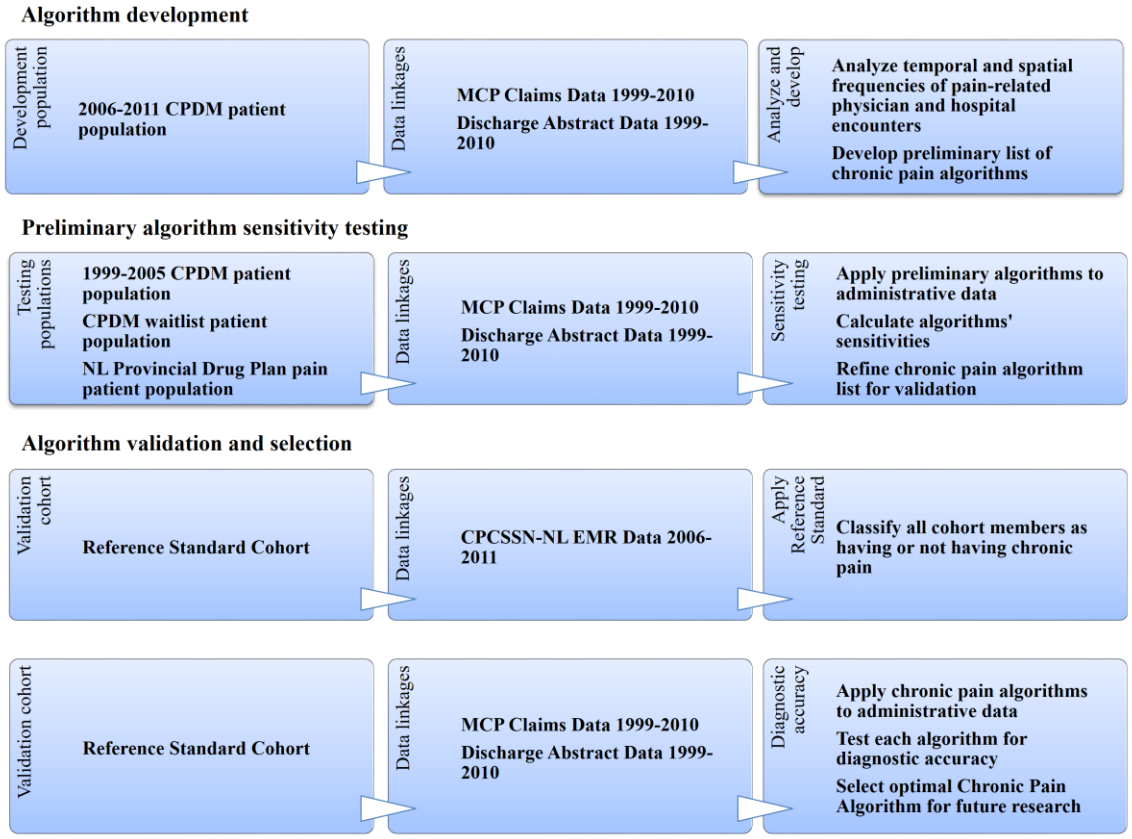

Fig. 2.1. Summary of Methodology and Associated Data Flow

Notes: The CPDM is an interdisciplinary chronic pain rehabilitation program located in St. John's, NL. Members of the CPDM pain patient groups either attended or were waiting to attend the rehabilitation program. The NL Prescription Drug Plan is a financial assistance program covering eligible prescription medications to qualified seniors and low-income individuals/families. Members of the NL Prescription Drug Plan pain patient group were prescribed and dispensed opioid medication used almost exclusively for pain (Chapter 7, Section 7.1, Appendix 1) during the period from 1999-2011 as a subsidized patient of the NL Prescription Drug Program.

Abbreviations: CPDM, Centre for Pain and Disability Management; MCP, Medical Care Plan; NL, Newfoundland and Labrador; CPCSSN, Canadian Primary Care Sentinel Surveillance Network; EMR, Electronic Medical Records.

2.2.5 Algorithm Application to a Provincial Cohort

Once the most performant algorithm to identify chronic pain cases from administrative data was selected, it was applied to the administrative data of a provincial cohort of NL residents. All residents identified as eligible for MCP benefits (approximately 98% of the total NL population) in the MCP Beneficiary File for any fiscal year between 2003 and 2010 were included in the provincial cohort, of which 99.6% had linkages to the MCP Claims File (fee-for-service physician visits) and 65.3% had linkages to the NL Discharge Abstract Data (acute-care hospitalizations).

2.2.6 Data Linkage

The CPCSSN-NL data, the NL Discharge Abstract Data, and the MCP Claims File data were obtained from the NL Centre for Health Information.[239] The CPCSSN-NL data was linked to the Reference Standard Cohort via the unique provincial health insurance (MCP) numbers. Record-level data from the MCP Claims File and NL Discharge Abstract Data were linked to the Reference Standard Cohort, the interdisciplinary chronic pain rehabilitation program patient populations, the NL Prescription Drug Plan pain patient population, and the provincial cohort via the MCP numbers. Analysts at the NL Centre for Health Information performed all data extraction, linkage, cleaning, and de-identification prior to the provision of the linked datasets to the research team for analysis.

2.2.7 Statistical Analysis

Distribution of chronic pain cases as defined by the reference standard in the Reference Standard Cohort were described and compared to those not identified as having chronic pain through a t-test for mean age and Chi-squared tests for proportions (statistical significance defined by $p < 0.05$). Preliminary algorithm sensitivity was calculated in each pain patient population by dividing algorithm-selected cases by the total corresponding pain patient population.

For algorithm validation and selection, the chronic pain algorithms were applied to the administrative data of the Reference Standard Cohort, and algorithm classification performance was compared to that of the reference standard. There are complexities inherent to validating chronic disease administrative data algorithms, including: 1) multiple required health care provider encounters to deem the disease chronic, 2) multiple codes entered for the same medical issue as the provider works to "rule out" other conditions to arrive at the best diagnosis, 3) varying prevalence of the chronic disease in a population based on age, sociodemographics, and geographic location (an indicator of health service availability), and 4) varying severity of disease according to individuals.[66] A broad range of statistical tests for accuracy and their 95% confidence intervals (CI) were calculated for each proposed administrative data algorithm using the classic 2x2 table to adequately account for these complexities and to sufficiently illustrate algorithm performance.[66,243]

Sensitivity and specificity assessed case ascertainment utility, and positive predictive value, negative predictive value, likelihood ratio positive, likelihood ratio

negative, and diagnostic odds ratio assessed selection accuracy.[66,224,244,245] The Kappa agreements between each administrative data algorithm and the CPCSSN reference standard were calculated using the classic 2x2 table.[244,246,247] The area under the Receiver Operating Characteristic curve, also a selection accuracy test, for each proposed algorithm was obtained.

To optimize algorithm functionality in assessing the disease burden of chronic pain, the research team sought to maximize case selection while minimizing false positives. The most performant algorithm was chosen based on the balance between sensitivity and specificity while maximizing positive predictive value,[212,224,248] with the goal of each being greater than 0.70.[54] A plot of calculated sensitivity and specificity values for each algorithm was made and the intersection of the plot lines assisted in choosing the most performant algorithm. Once the selected most performant Chronic Pain Algorithm was applied to the Reference Standard Cohort administrative data, identified false positive and false negative cases were reviewed in further detail. Finally, the most performant Chronic Pain Algorithm was applied to validation cohort strata for age (14 years and under, 15-24 years, 25-34 years, 35-44 years, 45-54 years, 55-64 years, 65-79 years, and 80 years and over) and sex (male and female), and its selection accuracy at each stratum was assessed for potential differences in performance.

SPSS version 24 and Excel 2013 were used for statistical analysis.

2.3 Results

2.3.1 Reference Standard Cohort Description

The reference standard cohort was comprised of 9,715 people, of which 51.3% were female, 23.3% were 65 years or older, and 90.6% lived in the Eastern Regional Health Authority catchment area. Compared to the Statistics Canada 2011 census-reported NL general population (Fig. 2.2),[249-253] the 2011 demographics of the Reference Standard Cohort had similar sex distribution but a higher median age (48.0 years vs. 44.0 years). The Reference Standard Cohort had an overrepresentation of people aged 65 and over and underrepresentation of people aged 14 and under. There was also a higher percentage of people in the Reference Standard Cohort residing in the Eastern Regional Health Authority (mostly urban) catchment area. The Eastern Regional Health Authority is one of four located in NL.

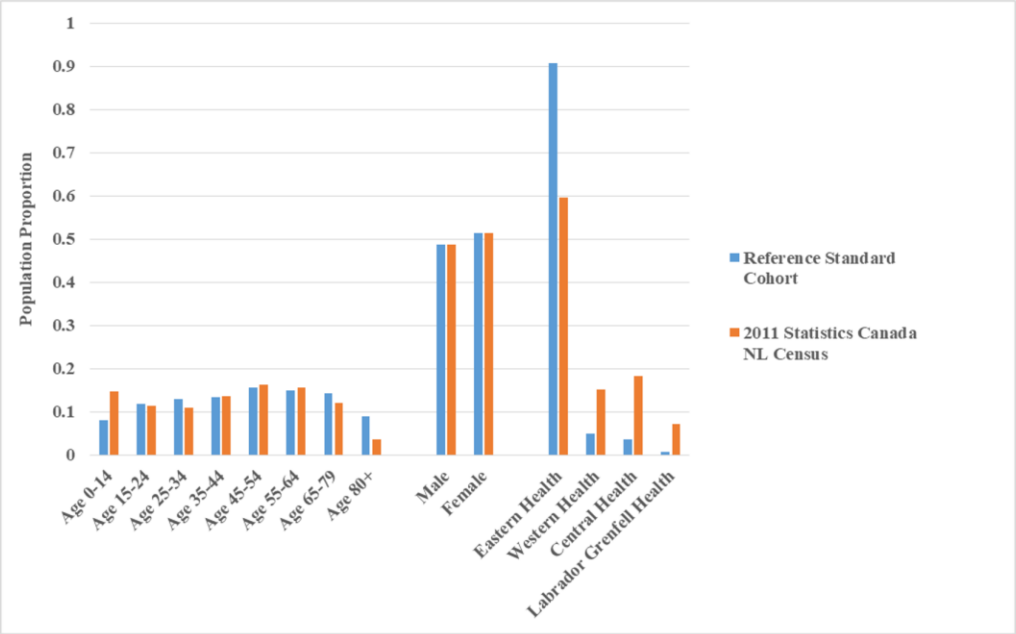

Fig. 2.2. 2011 Demographics of the Reference Standard Cohort versus the Newfoundland and Labrador General Population

Notes: X-axis: age, sex, and regional health authority strata. Y-axis: proportion of each stratum in the corresponding cohort (Reference Standard Cohort and Statistics Canada 2011 census-reported NL population cohort). Eastern, Western, Central, and Labrador-Grenfell are the four Regional Health Authorities in NL.

Abbreviations: NL, Newfoundland and Labrador.

Table 2.1 details the distribution of chronic pain cases in the Reference Standard Cohort. Chronic pain prevalence as defined by the reference standard was 24.6%, of which 58.8% were identified as female and 54.2% were aged 55 or older. Mean age was significantly higher at 55.5 years (19.1 years standard deviation) in the Chronic Pain Group versus 44.1 years (22.9 years standard deviation) in the No Chronic Pain Group ($p < 0.001$).

Table 2.1. 2011 Demographics of Chronic Pain Group vs. No Chronic Pain Group in Reference Standard Cohort

Demographic Characteristic	Chronic Pain Group[a]	No Chronic Pain Group[a]	P-value
	N=2386	N=7329	
	n(% of group)	n(% of group)	
Age Group			
0-14	32(1.3)	755(10.3)	< 0.001
15-24	133(5.6)	1005(13.7)	< 0.001
25-34	206(8.6)	1039(14.2)	< 0.001
35-44	288(12.1)	1019(13.9)	0.0248
45-54	435(18.2)	1081(14.7)	< 0.001
55-64	521(21.8)	934(12.7)	< 0.001
65-79	500(21.0)	892(12.2)	< 0.001
80+	271(11.4)	604(8.2)	< 0.001
Sex			
Male	984(41.2)	3744(51.1)	< 0.001
Female	1402(58.8)	3585(48.9)	< 0.001
Regional Health Authority			
Eastern	2262(94.8)	6548(89.3)	< 0.001
Central	34(1.4)	321(4.4)	< 0.001

Western	84(3.5)	390(5.3)	< 0.001
Labrador-Grenfell	6(0.3)	67(0.9)	0.0018
Pain Conditions[b]			
Musculoskeletal Conditions & Arthritis	1715(71.9)	1853(25.3)	< 0.001
Other Conditions Associated with Chronic Pain	1567(65.7)	1729(23.6)	< 0.001
Neck & Back Pain	1546(64.8)	1412(19.3)	< 0.001
Musculoskeletal Trauma	864(36.2)	883(12.0)	< 0.001
Neuropathic Pain	766(32.1)	531(7.2)	< 0.001
Headaches	700(29.3)	631(8.6)	< 0.001
Bone Disorders	427(17.9)	353(4.8)	< 0.001
Central Pain Syndrome, Chronic Pain, or Chronic Pain Syndrome	98(4.1)	0	< 0.001

Abbreviation: N, total population of group.

[a] The Chronic Pain Group was comprised of members of the Reference Standard Cohort identified by the reference standard, and the No Chronic Pain Group was comprised of members of the Reference Standard Cohort not identified by the reference standard as applied to the Canadian Primary Care Sentinel Surveillance Network-NL data. Chi square tests were used to determine significance of difference between group proportions.

Statistical significance was defined by $p < 0.05$. Difference between the proportions of the Chronic Pain Group and the No Chronic Pain Group in all strata were considered significant.

[b] Inclusion in the pain condition group was defined as an individual having >/= 1 encounter for any condition in the Pain Condition diagnostic group (Chapter 7, Section 7.2 Appendix 2) in the Canadian Primary Care Sentinel Surveillance Network-Newfoundland and Labrador electronic medical record data at any time from January 1, 2006 to December 31, 2011. A cohort member could be counted as a case in more than one Pain Condition diagnostic group.

2.3.2 Administrative Data Algorithm Development and Preliminary Sensitivity Testing

The 2006-2011 interdisciplinary chronic pain rehabilitation patient group consisted of 266 patients. The mean age was 48.0 years and 57.9% were identified as female. After linkages, 256 (97.0%) had at least one physician encounter recording any pain-related diagnostic code in the MCP Claims File and 172 (64.7%) had at least one hospitalization recording at least one pain-related diagnostic code in the NL Discharge Abstract Data (all 16 codes per separation were considered). Twelve people (4.5%) had an entry with the ICD-10-CA code for the diagnosis of acute or chronic pain (R52) in the NL Discharge Abstract Data. After linkages, 96.7% of the 1999-2005 interdisciplinary chronic pain rehabilitation program patient group (N=361, mean age of 52.4 years, 50.1% female), 93.8% of the interdisciplinary chronic pain rehabilitation program waitlist patient group (N=130, mean age of 45.6 years, 64.6% female), and 93.7% of the NL Prescription Drug Plan pain patient group (N=38,532, mean age of 61.0 years, 57.6% female) had at least one encounter or hospitalization recording any pain-related diagnostic code in either the MCP Claims File or the NL Discharge Abstract Data.

Section 2.8.1 Appendix 2.1 provides a complete list of possible algorithm combinations considered, the number of each pain patient group identified by each algorithm, and the calculated sensitivities. The algorithm sensitivities were widely variable, ranging from 0.029 to 0.962, depending on the pain patient group and the algorithm restrictiveness. The algorithm sensitivities were lower in the NL Prescription Drug Plan pain patient group than the interdisciplinary chronic pain rehabilitation

program patient groups. This is possibly due to there being no defined opioid prescription period indicative of long-term use (e.g. 90 days) in the inclusion criteria for the NL Prescription Drug Plan pain patient group.

The first 33 algorithms applied to the administrative data for the pain patient groups explored if known chronic pain cases could be identified from the administrative data in the full data period (1999-2010) time window via physician encounters or hospital admissions recording any pain-related diagnostic code for up to five unique encounter dates. The next 32 algorithms explored if: 1) known cases of chronic pain could be identified in administrative data while meeting the six-month temporal criterion in the full data period time window for up to five physician encounter or hospitalization dates recording any pain-related diagnostic code, and 2) the inclusion of hospital admission dates recording any pain-related diagnostic code significantly improved identification of known chronic pain cases in the full data period time window. Combining hospital admission dates with fee-for-service physician encounter dates to satisfy the six-month temporal criterion was a complex process and minimally improved case ascertainment. However, including hospital admission dates recording any pain-related diagnostic code by a medical specialist to satisfy the medical specialist encounter criterion significantly improved case ascertainment in those tested algorithms. In the interest of parsimony, no hospital admission dates recording any pain-related diagnostic codes were included for algorithm validation, except for the algorithms requiring a medical specialist encounter where hospital admission dates with a medical specialist recording any pain-related diagnostic code could satisfy this criterion. The next 56 algorithms explored if known cases of chronic pain could be identified if the observation window was defined (one- to

seven-year observation windows) while meeting the six-month temporal criterion for a defined number of encounter dates recording any pain-related diagnostic code (two to five dates). The final 56 algorithms explored if including the MCP physician procedure billing codes reserved for anesthesiologist-delivered intervention treatments in a hospital-based chronic pain clinic would have an impact on the utility of the previous 56 algorithms. The final 56 algorithms had the best performance and were selected for the final validation step.

2.3.3 Algorithm Validation and Selection

The most performant 56 administrative data chronic pain algorithms from the administrative data algorithm development step were tested against the reference standard in the Reference Standard Cohort. Section 2.8.2 Appendix 2.2 provides the tested algorithms and their validation statistics.

The highest sensitivity (0.917, 95% CI: 0.906-0.928) resulted from the least restrictive algorithm requiring the lowest required number of encounter dates recording any pain-related diagnostic code (>/=2) in the longest observation time window (7 years). Algorithm sensitivity decreased as the number of required encounter dates increased, the observation time window decreased, or the medical specialist encounter criterion was added. The algorithm with the highest sensitivity had the lowest specificity (0.332, 95% CI: 0.326-0.339) and the highest false positive rate (0.668). The negative predictive value (ranging from 0.783 to 0.925) and the likelihood ratio negative (ranging from 0.852 to 0.249) followed the same trend as the sensitivity.

The highest specificity (0.938, 95% CI: 0.929-0.947) resulted from the most restrictive algorithm requiring the highest number of encounter dates recording any pain-related diagnostic code (>/= 5) in the shortest observation time window (1 year) and requiring an encounter with a medical specialist recording any pain-related diagnostic code. Algorithm specificity decreased as the number of required encounter dates decreased, the observation time window increased, or the specialist encounter criterion was removed. The algorithm with the highest specificity had the lowest sensitivity (0.200, 95% CI: 0.184-0.216) and the lowest false positive rate (0.062). The positive predictive value (ranging from 0.309 to 0.513) and the likelihood ratio positive (ranging from 1.374 to 3.241) followed the same trend as the specificity. The intersection of sensitivity and specificity plot lines was observed at approximately 0.67 (Fig. 2.3).

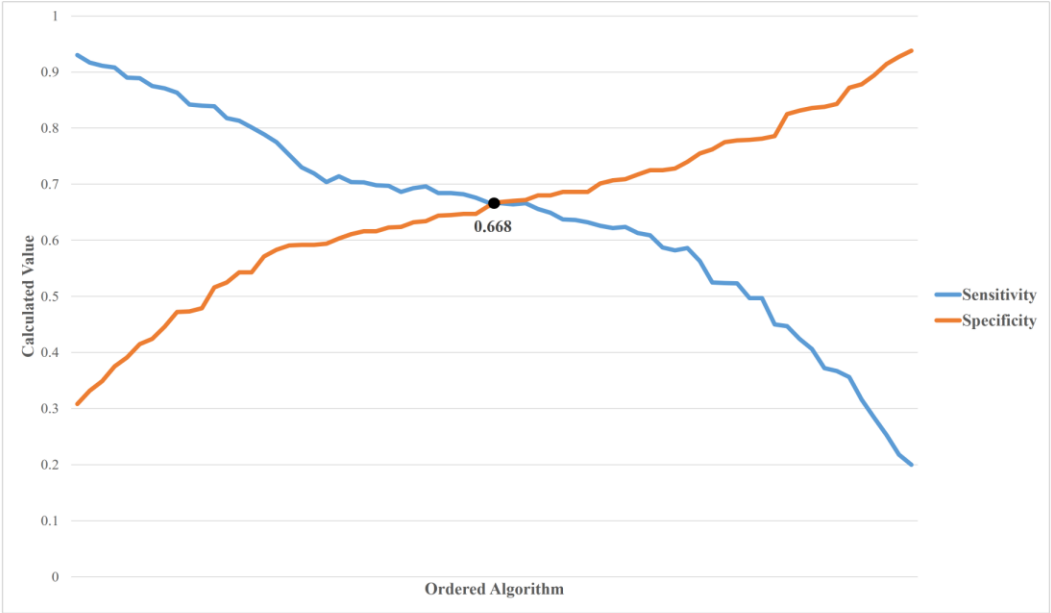

Fig. 2.3. Chronic Pain Algorithm Sensitivity versus Specificity Plot from Validation Step

Notes: X-axis: chronic pain administrative data algorithms ordered by sensitivity and specificity values calculated during the final validation and selection step (algorithms were tested against the reference standard in the Reference Standard Cohort). Y-axis: calculated specificity and sensitivity values. The 0.668 value was a plot value in the intersection of the sensitivity and specificity lines.

The area under the Receiver Operating Characteristic curve ranged from poor (0.569, 95% CI: 0.555-0.583) to acceptable (0.690, 95% CI: 0.678-0.702) selection accuracy of the chronic pain algorithms.[254] The Kappa agreement between the administrative data algorithms and the CPCSSN reference standard ranged from slight (0.150, 95% CI: 0.137-0.163) to fair (0.303, 95% CI: 0.289-0.317).[255]

The most performant algorithm was chosen based on: 1) the sensitivity and specificity being closest to 0.67 (the intersection of the sensitivity and specificity plot lines in Fig. 2.3), 2) the best concurrent positive predictive value, and 3) the consensus of the research team regarding the algorithm functionality in assessing the disease burden of chronic pain. Considering the study's goal and the validation test results, the most performant Chronic Pain Algorithm to identify chronic pain cases in residents attending fee-for-service physician care for pain-related conditions in NL was determined to be: (1) a single encounter date with an anesthesiologist recording a chronic pain-related provincial MCP procedure billing code in the MCP Claims File; OR (2) five or more physician encounter dates recording any pain-related diagnostic code in a five-year period with more than 183 days separating at least two pain-related encounter dates in the MCP Claims File. This algorithm identified 42.3% of the Reference Standard Cohort and 37.6% of the 584,875 people in the provincial cohort. Each cohort member selected by the algorithm had a mean of 2.7, a median of three, and a mode of three unique pain-related diagnostic codes recorded in the five required encounter dates. The five most common and five least common ICD-9 pain-related diagnostic codes recorded in the five required encounter dates for algorithm selection are found in Table 2.2.

Table 2.2. Five Most Common and Five Least Common ICD-9 Pain-related Codes[a] Used for Chronic Pain Algorithm[b] Selection

Most common ICD-9 pain-related diagnostic codes		Least common ICD-9 pain-related diagnostic codes	
ICD-9 Code	**Description**	**ICD-9 Code**	**Description**
724	Other and unspecified disorders of back	738	Other acquired deformity
781	Symptoms Involving nervous and musculoskeletal systems	756	Other congenital musculoskeletal anomalies
715	Osteoarthritis and allied disorders	831	Dislocation of shoulder
564	Functional digestive disorders, not elsewhere classified	846	Sprains and strains of sacroiliac region
714	Rheumatoid arthritis and other inflammatory polyarthopathies	843	Sprains and strains of hip and thigh

Abbreviations: ICD-9, *International Classification of Disease – 9th Revision.*

[a] The ICD-9 pain-related diagnostic codes found in the Medical Care Plan Fee-for-Service Physicians Claims File are found in Chapter 7, Section 7.3, Appendix 3.

[b] Chronic Pain Algorithm was used to identify cases of chronic pain from the Medical Care Plan Physician Fee-for-Service Claims File data of the Reference Standard Cohort and was defined as: 1) a single encounter date with an anesthesiologist recording a chronic pain-related provincial Medical Care Plan procedure billing code (Chapter 7, Section 7.4, Appendix 4) in the Medical Care Plan Fee-for-Service Physicians Claims File; OR 2) five or more encounter dates with a physician recording any pain-related diagnostic code (Chapter 7, Section 7.3, Appendix 3) in a five-year period with more than 183 days separating at least two pain-related encounter dates in the Medical Care Plan Fee-for-Service Physicians Claims File.

The Chronic Pain Algorithm had 0.703 (95% CI: 0.685-0.722) sensitivity, 0.668 (95% CI: 0.657-0.678) specificity, 0.408 (95% CI: 0.393-0.423) positive predictive value, 0.874 (95% CI: 0.865-0.882) negative predictive value, 2.117 (95% CI: 2.030-2.207) likelihood ratio positive, 0.444 (95% CI: 0.474-0.417) likelihood ratio negative, 4.763 (95% CI: 4.308-5.267) diagnostic odds ratio, 0.685 (95% CI: 0.673-0.698) area under the Receiver Operating Characteristic curve (or adequate indicator of selection accuracy),[254] and 0.298 (95% CI: 0.285-0.312) Kappa agreement (or fair).[255] The Chronic Pain Algorithm had 0.601-0.868 sensitivity in the pain patient groups.

Of the 2435 false positive cases, 1794 (73.7%) had at least one encounter with a specialist for any pain-related condition and 34 (1.4%) attended treatment for chronic pain at an organized pain clinic. As well, 758 (31.1%) false positive cases were identified by the Chronic Pain Algorithm in administrative data prior to (but not within) the date range of the CPCSSN-NL data. Of the 708 false negative cases, only 66 (9.3%) did not have at least one encounter in the MCP Claims Data recording any pain-related diagnostic code, and 166 (23.4%) did not meet the benchmark of more than six months between at least two encounter dates recording any pain-related diagnostic code. As well, 651 (62.9%) false negative cases would be selected if fewer treatments were required and/or the observation time window was longer (i.e. a less restrictive algorithm).

The Chronic Pain Algorithm was tested further for selection accuracy in the age and sex strata of the Reference Standard Cohort (Table 2.3). In summary, the Chronic Pain Algorithm had lower sensitivity and higher specificity in selecting people aged 34 and younger, and higher sensitivity and lower specificity in selecting people aged 65 and over when compared to its selection performance in the overall Reference Standard Cohort.

Table 2.3. Selection Accuracy of the Chronic Pain Algorithm[a] in Reference Standard Cohort Age and Sex Strata

Reference Standard Cohort	Prevalence Defined by Reference Standard	Prevalence Defined by Chronic Pain Algorithm	Sensitivity	Specificity	PPV	NPV	LR+	LR-	DOR	Kappa
	24.6%	42.3%	0.703	0.668	0.408	0.874	2.12	0.44	4.76	0.30
Age Group										
14&U	4.1%	7.6%	0.250	0.931	0.133	0.967	3.63	0.81	4.51	0.13
15-24	11.7%	21.2%	0.346	0.805	0.190	0.903	1.77	0.81	2.18	0.11
25-34	16.5%	34.2%	0.576	0.705	0.279	0.894	1.95	0.60	3.26	0.20
35-44	22.0%	38.3%	0.635	0.689	0.366	0.870	2.04	0.53	3.86	0.25
45-54	28.7%	48.6%	0.747	0.619	0.441	0.859	1.96	0.41	4.80	0.30

55-64	35.8%	52.2%	0.738	0.600	0.507	0.805	1.85	0.44	4.24	0.31
65-79	35.9%	59.0%	0.780	0.516	0.475	0.807	1.61	0.43	3.79	0.26
80+	31.0%	64.8%	0.815	0.427	0.390	0.838	1.42	0.43	3.29	0.19
Sex										
Male	20.8%	36.6%	0.652	0.709	0.371	0.886	2.24	0.49	4.58	0.28
Female	28.1%	47.7%	0.738	0.625	0.435	0.859	1.97	0.42	4.69	0.30

Abbreviations: PPV, positive predictive value; NPV, negative predictive value; LR+, likelihood ratio positive; LR-, likelihood ratio negative; DOR, diagnostic odds ratio.

[a] The most performant Chronic Pain Algorithm was defined as: 1) a single encounter date with an anesthesiologist recording a chronic pain-related provincial Medical Care Plan procedure billing code (Chapter 7, Section 7.4, Appendix 4) in the Medical Care Plan Fee-for-Service Physicians Claims File; OR 2) five or more encounter dates recording any pain-related diagnostic code (Chapter 7, Section 7.3, Appendix 3) in a five-year period with more than 183 days separating at least two pain-related encounter dates in the Medical Care Plan Fee-for-Service Physicians Claims File.

2.4 Discussion

There is a critical need to determine the societal burden of chronic pain.[32,40,50,55,154] A validated administrative data algorithm to estimate the epidemiology of chronic pain not only enables financial estimates to be determined,[197] it also enables assessment of the effects of change to health care and population health policy.[248] To help answer policy-level questions being posed,[35] this study was undertaken to develop and test an algorithm to identify cases of chronic pain as a single chronic disease using Canadian health administrative data. By linking data from known chronic pain patient groups and a general population group over an 11-year study period, a chronic pain algorithm was created and its selection performance was assessed at 0.703 sensitivity, 0.668 specificity, and 0.408 positive predictive value. While no tested algorithm met the study goal of >/= 0.70 sensitivity, specificity, and positive predictive value, the algorithm deemed best at ascertaining cases of chronic pain from MCP Claims File data to be used for future study was: (1) a single encounter date with an anesthesiologist recording a chronic pain-related provincial MCP procedure billing code in the MCP Claims File; OR (2) five or more encounter dates with a physician recording any pain-related diagnostic code in a five-year period with more than 183 days separating at least two pain-related encounter dates in the MCP Claims File. This algorithm satisfied both spatial and temporal benchmarks consistent with the diagnosis of chronic pain.[11,66,185,186,224] The algorithm selected 37.6% of a NL population cohort from health administrative data.

2.4.1 Achieving Best Case Ascertainment

The Chronic Pain Algorithm validation performance was comparable to other validation studies assessing health administrative data algorithms for specific chronic pain conditions with respect to the ascertainment measures of sensitivity and specificity. Algorithms identifying cases of neck and back disorders had the best and most consistent performance on tests of selection accuracy (up to 0.71 sensitivity, 0.89 specificity, and 0.83 positive predictive value).[208] That study's population included only people with known chronic pain diagnoses, unlike our study. A validation study examining administrative data of survey respondents found very good specificity (>0.90) but poor sensitivity (0.20-0.55) for arthritis case definitions.[248] Algorithms for other specific and less common chronic pain conditions performed less consistently on validation testing. These included fibromyalgia (0.32-0.42 sensitivity, 0.94-0.97 specificity),[208] painful neuropathy (0.22-0.39 sensitivity, 0.58-0.80 specificity),[206,208] chronic regional pain syndrome (0.04-0.07 sensitivity, 0.93-0.98 specificity),[208] and irritable bowel syndrome (0.112-0.989 sensitivity).[209,232,256] Choice of codes, frequency criteria, and the chosen validation cohort contributed to variability in the validation results of these studies. Since no other study reported validation of administrative data algorithms for chronic pain as a single disease, the present study will form the benchmark against which future studies validating chronic pain algorithms will be compared.

2.4.2 Ascertainment versus Accuracy

The present study overcame significant challenges to create and validate an administrative data algorithm for chronic pain that included all necessary spatial and

temporal benchmarks. There being no measurable objective diagnostic test and no consistent agreement among experts on the diagnostic criteria for chronic pain made for a less explicit reference standard against which to compare the chronic pain administrative data algorithms.[32,86] Algorithm development was further complicated by the discord among physicians regarding best treatment practices for chronic pain conditions,[32,86] as evidenced by the high number of unique three-digit ICD-9 (67 in total) and ICD-10-CA (83 in total) codes used to identify pain-related conditions in the NL administrative data. The Chronic Pain Algorithm identified a high number of false positive and false negative cases, which negatively impacted the selection accuracy tests of positive predictive value, likelihood ratio, and area under the Receiver Operating Characteristic curve. Since the goal of this study was to create an administrative data algorithm to eventually measure the disease burden of chronic pain in the general population, more weight was placed on ascertainment measures (i.e. sensitivity and specificity) than on selection accuracy measures.[212,224,248] As such, the Chronic Pain Algorithm is better suited for assessment of disease distribution and measuring strength of association with other captured administrative data information in Newfoundland and Labrador than assessment of causation, adverse events, and intervention effectiveness.[224]

2.4.3 Algorithm Validity to Study Chronic Pain Distribution

The Chronic Pain Algorithm identified 42.3% of the Reference Standard Cohort, which was higher than the 24.6% identified by the reference standard. The high number of false positives identified by the Algorithm influenced this discrepancy. When considering the overrepresentation of people 65 years and older in the Reference Standard

Cohort, it is possible that the reference standard under-ascertained cases of chronic pain. Selection accuracy results may also be discordant with clinical reality as nearly 74% of false positive cases had at least one encounter with a medical specialist for any pain-related condition. This may indicate that many people receiving care for their chronic pain condition from a specialist may no longer have their pain addressed by their primary care physician. The identification of 37.6% in the NL provincial cohort by the Chronic Pain Algorithm was comparable to the 36% chronic pain prevalence in Atlantic Canada (which includes NL) reported by a survey in 2007 but higher than the 21.5% Atlantic Canada prevalence reported in 2011 by another survey.[45,47] Poor Kappa agreement between survey data and administrative data for identifying cases of a pain condition was previously reported and may influence this observation.[209] Although disagreement between administrative data and medical record or survey data exists, the Chronic Pain Algorithm applied to population-based, widespread administrative data will provide an accurate reflection of geographic and demographic variation of chronic pain distribution in residents attending encounters with fee-for-service physicians in NL.[197]

2.4.4 Strengths and Limitations

The main strength of this study lies in its methodology that followed established guidelines.[66] First, the spatial and temporal patterns in the administrative data of patient groups known to have chronic pain were studied to develop the preliminary chronic pain algorithms. Second, the algorithms were validated by calculating multiple tests of selection accuracy in a general population cohort whose demographics approximated that of the NL general population.[66,227] Third, using the CPCSSN electronic medical record

data to apply the reference standard provided comprehensive clinical information for a sufficient sample size to test sensitivity and specificity of multiple algorithms with 0.02 precision and 0.05 alpha that was economical in terms of funding and human resources when compared to a manual chart audit. Finally, a broad range of validation statistics obtained from testing a large number of administrative data algorithms using different criteria were reported. These can inform future studies on chronic pain that plan to use NL health administrative data to achieve different research goals.

There were several limitations to this study. A chronic limitation for all validation studies involving administrative and medical records data is the dependence of its data accuracy on entry at source.[66,67,231] Algorithm development and case ascertainment may have been impacted by the non-capture of pain-related treatments delivered by allied health professionals, salaried physicians, or those funded by a third party (such as Workers Compensation), and the allowance of only one diagnostic code entry per episode of care per practitioner (a non-pain-related diagnostic code might have been the chosen code entry for a particular visit even if a pain condition was assessed/treated).[208] There was differential misclassification bias of the Chronic Pain Algorithm in age groups 34 years and under and 65 years and older possibly impacting algorithm generalizability in studying chronic pain distribution in these age ranges. Chronic pain prevalence is lower in the younger age groups and higher in the older age groups, which, when combined with the age demographics of the pain patient populations used to develop the preliminary algorithms, factor into the age-related misclassification bias.[43-46,48,58,66] While the CPCSSN electronic medical record data was determined a valid proxy to manual chart audits for the eight chronic diseases with previously validated CPCSSN case definitions

(i.e. hypertension, diabetes mellitus, depression, chronic obstructive pulmonary disease, osteoarthritis, dementia, epilepsy, and Parkinsonism),[230,231] it was not specifically assessed for chronic pain and may impact validation results. Finally, the Chronic Pain Algorithm may bias estimates of disease risk to the NL general population (through measures of incidence and prevalence) or disease burden on the NL health system (through measures of association) associated with chronic pain.[66,224] Any disease risk or burden estimates obtained from using the Chronic Pain Algorithm should be adjusted for this bias as effectively as possible (which may be complex requiring multiple variables).[224] If this is not possible, the risk of bias should be explicitly acknowledged and the resultant estimates should be interpreted with caution.

2.4.5 Generalizability and Future Research

The nature of the NL administrative data and the Chronic Pain Algorithm selection accuracy performance limits its generalizability to extracting disease burden information based on residents attending encounters for pain-related conditions with fee-for-service physicians in NL. Validation of the Chronic Pain Algorithm in target population administrative data is recommended prior to its use in non-NL jurisdictions. The required five-year observation window reduces the practicality of the algorithm for ongoing disease surveillance (due to the long longitudinal data period required to accommodate algorithm application and the recommended four to seven year lead-in period for incidence rate calculations),[202,212] and reduces the sensitivity of the algorithm to assess the impact of critical societal events (e.g. global pandemic) on chronic pain incidence. The methodology used in this study is generalizable to other Canadian jurisdictions due to

similarities in the structure of provincial/territorial physician claims and hospital discharge abstract data.[200]

This is the first study in Canada to derive and validate a health administrative data algorithm for chronic pain as a single chronic disease. To increase algorithm generalizability and maximize the potential of this data source in chronic pain research, future studies are recommended. Future research recommendations include deriving more flexible algorithms to reduce differential misclassification bias based on age, adapting ICD and procedure code lists to specific jurisdictions, assessing the impact of including available administrative pharmacy and allied health data, and exploring the impact of including other medications and procedures used for pain treatment. In the absence of a "gold standard" objective diagnostic test to confirm the presence of chronic pain, it is recommended a reference standard with a practical, robust set of criteria be developed and validated for future use in comprehensive health records, electronic medical records, and cleaned electronic medical record datasets (such as CPCSSN).

2.5 Conclusions

The present study sought to derive and validate an algorithm that identifies cases of chronic pain from provincial administrative data in Canada. The Chronic Pain Algorithm aligned with both spatial and temporal frequency benchmarks indicative of a chronic pain diagnosis, and was the most performant algorithm based on available data to identify cases of chronic pain from residents attending fee-for-service physician encounters for pain-related conditions in NL. The recommended applications of the Chronic Pain Algorithm include assessment of geographic and demographic variation in disease

distribution, and assessment of strength of association with other NL administrative data-derived variables (such as health service use and comorbid conditions). While selection accuracy results preclude use of the Chronic Pain Algorithm for evaluation of interventions, adverse events, and causation, a more restrictive algorithm validated in this study might be considered a more viable option for such research. Further investigation is indicated to fully realize the potential of health administrative data as a valid and efficient source of information to study epidemiology, health care utilization, long-term health outcomes, and effectiveness of policy/health service delivery change associated with chronic pain.

2.6 Acknowledgements

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2.7 Co-authorship Statement

All authors read and approved the submitted version of this chapter. All authors agreed to be personally responsible for their own contribution and ensure that questions related to the accuracy or integrity of any part of the work, even ones in which the author was not personally involved, are appropriately investigated, resolved, and the resolution documented in the literature. Heather E. Foley drafted the work and substantively revised it, and made substantial contributions towards the study design, data acquisition, analysis, and interpretation. Dr. John C. Knight substantively revised the work, and made substantial contributions towards study design, data acquisition, analysis, and interpretation. Dr. Michelle Ploughman substantively revised the work, and made substantial contributions towards study conception and design, and data acquisition and interpretation. Dr. Shabnam Asghari made substantial contributions towards study design, and data acquisition, analysis, and interpretation, and writing of the manuscript. Dr. Rick Audas substantively revised the work, and made substantial contributions to the study design, and data acquisition and interpretation.

2.8 Chapter 2 Appendices

2.8.1 Appendix 2.1. Preliminary Chronic Pain Administrative Data Algorithms and Sensitivity Testing in Pain Patient Populations[a]

Algorithm	06-11 CPDM Patients	99-05 CPDM Patients	CPDM Waitlist Patients	NLPDP Pain Patients
	N=266	N=361	N=130	N=38532
	n(sensitivity)	n(sensitivity)	n(sensitivity)	n(sensitivity)
1 PC ever	95(0.357)	79(0.219)	21(0.162)	1138(0.029)
2 P ever	255 (0.959)	340(0.942)	118(0.908)	33713(0.875)
2 H ever	133(0.500)	149(0.413)	51(0.392)	8056(0.209)
2 P OR 2 H ever	256(0.962)	340(0.942)	119(0.915)	34274(0.889)
2 P OR H ever	256(0.962)	342(0.947)	120(0.923)	34434(0.894)
3 P ever	254(0.955)	336(0.931))	114(0.877)	31941((0.829)
3 H ever	103(0.387)	103(0.285)	26(0.20)	4672(0.121)
3 P OR 3 H ever	255(0.959)	339(0.939)	114(0.877)	32619(0.847)

3 P OR H ever	255(0.959)	339(0.939)	117(0.900)	32929(0.855)
4 P ever	253(0.951)	329(0.911)	112(0.862)	30310(0.787)
4 H ever	80(0.301)	80(0.222)	21(0.162)	2961(0.077)
4 P OR 4 H ever	254(0.955)	332(0.920)	112(0.862)	31193(0.810)
4 P OR H ever	254(0.955)	333(0.922)	113(0.869)	31559(0.819)
5 P ever	248(0.932)	319(0.884)	109(0.838)	28738(0.771)
5 H ever	60(0.226)	60(0.166)	15(0.115)	2003(0.052)
5 P OR 5 H ever	249(0.936)	323(0.895)	109(0.838)	29786(0.773)
5 P OR H ever	250(0.940)	328(0.909)	109(0.838)	30190(0.784)
2 P ever AND >/=1 S ever	244(0.917)	307(0.850)	100(0.769)	24930(0.647)
2 H ever AND >/= 1 S ever	133(0.500)	147(0.407)	51(0.392)	7868(0.204)
2 P OR 2 H ever AND >/= 1 S ever	245(0.921)	307(0.850)	101(0.777)	25336(0.658)
2 P OR H ever with >/= 1 S ever	245(0.921)	309(0.856)	101(0.777)	25465(0.661)
3 P ever AND >/= 1 S ever	244(0.917)	305(0.845)	98(0.754)	24167(0637)
3 H ever AND >/= 1 S ever	103(0.387)	102(0.283)	26(0.20)	4598(0.119)

3 P OR 3 H ever AND >/= 1 S ever	245(0.921)	307(0.850)	98(0.754)	24696(0.641)
3 P OR H ever AND >/= 1 S ever	245(0.921)	307(0.850)	101(0.777)	24963(0.648)
4 P ever AND >/= 1 S ever	244(0.917)	302(0.837)	97(0.746)	23399(0.607)
4 H ever AND >/= 1 S ever	80(0.301)	79(0.219)	21(0.162)	2926(0.076)
4 P OR 4 H ever AND >/= 1 S ever	245(0.921)	304(0.842)	97(0.746)	24071(0.625)
4 P OR H ever AND >/= 1 S ever	245(0.921)	305(0.845)	98(0.754)	24392(0.633)
5 P ever AND >/= 1 S ever	240(0.902)	295(0.817)	97(0.746)	22559(0.585)
5 H ever AND >/= 1 S ever	60(0.226)	59(0.163)	15(0.115)	1987(0.052)
5 P OR 5 H ever AND >/= 1 S ever	241(0.906)	299(0.828)	97(0.746)	23403(0.607)
5 P OR H ever AND >/= 1 S ever	242(0.910)	304(0.842)	97(0.746)	23761(0.617)
2 P ever AND > 183 days between 2 P	253(0.951)	338(0.936)	117(0.900)	32829(0.852)
2 H ever AND P > 183 days between 2 H	133(0.500)	149(0.413)	51(0.392)	7959(0.207)
2 P OR 2 H ever AND > 183 days between 2 P or 2 H	245(0.921)	338(0.936)	118(0.908)	33085(0.859)

2 P OR H ever AND > 183 days between 2 P or H	254(0.955)	340(0.942)	119(0.915)	33220(0.862)
3 P ever AND > 183 days between 2 P	253(0.951)	335(0.928)	113(0.869)	31586(0.820)
3 H ever AND > 183 days between 2 H	103(0.387)	103(0.285)	26(0.200)	4642(0.120)
3 P OR 3 H ever AND > 183 days between 2 P or 2 H	254(0.955)	337(0.934)	113(0.869)	32027(0.831)
3 P OR H ever AND P > 183 days between 2 P or H	254(0.955)	337(0.934)	116(0.892)	32309(0.838)
4 P ever AND > 183 days between 2 P	252(0.947)	329(0.911)	111(0.854)	30134(0.782)
4 H ever AND > 183 days between 2 H	80(0.301)	80(0.222)	21(0.162)	2952(0.077)
4 P OR 4 H ever AND P > 183 days between 2 P or 2 H	253(0.951)	331(0.917)	111(0.854)	30831(0.800)
4 P OR H ever AND > 183 days between 2 P or H	253(0.951)	332(0.920)	112(0.862)	31179(0.809)
5 P ever AND > 183 days between 2 P	247(0.929)	319(0.884)	108(0.831)	28645(0.743)

5 H ever AND > 183 days between 2 H	60(0.226)	60(0.166)	15(0.115)	2002(0.052)
5 P OR 5 H ever AND > 183 days between 2 P or 2 H	248(0.932)	322(0.892)	108(0.831)	29542(0.767)
5 P OR H ever AND > 183 days between 2 P or H	249(0.936)	327(0.906)	108(0.831)	29931(0.777)
2 P ever AND > 183 days between 2 P AND >/= 1 S ever	244(0.917)	305(0.845)	100(0.769)	24534(0.637)
2 H ever AND > 183 days between 2 H AND >/= 1 S ever	133(0.500)	147(0.407)	51(0.392)	7791(0.202)
2 P OR 2 H ever AND > 183 days between 2 P or 2 H AND >/= 1 S ever	245(0.921)	305(0.845)	101(0.777)	24745(0.642)
2 P OR H ever AND > 183 days between 2 P or H AND >/= 1 S ever	245(0.921)	307(0.850)	101(0.777)	24857(0.645)
3 P AND > 183 days between 2 P AND >/= 1 S ever	244(0.917)	304(0.842)	98(0.754)	23980(0.622)

3 H ever AND > 183 days between 2 H AND >/= 1 S ever	103(0.387)	102(0.281)	26(0.200)	4574(0.119)
3 P OR 3 H ever AND > 183 days between 2 P or 2 H AND >/= 1 S ever	245(0.921)	305(0.845)	98(0.754)	24315(0.631)
3 P OR H ever AND > 183 days between 2 P or H AND >/= 1 S ever	245(0.921)	305(0.845)	101(0.777)	24555(0.637)
4 P ever AND > 183 days between 2 P AND >/= 1 S ever	244(0.917)	302(0.837)	97(0.746)	23296(0.605)
4 H ever AND > 183 days between 2 H AND >/= 1 S ever	80(0.301)	79(0.219)	21(0.162)	2917(0.076)
4 P OR 4 H ever AND > 183 days between 2 P or 2 H AND >/= 1 S ever	245(0.921)	303(0.839)	97(0.746)	23810(0.618)
4 P OR H ever AND > 183 days between 2 P or H AND >/= 1 S ever	245(0.921)	304(0.842)	98(0.754)	24116(0.626)

5 P ever AND > 183 days between 2 P AND >/= 1 S ever	240(0.902)	295(0.817)	97(0.746)	22505(0.584)
5 H ever AND > 183 days between 2 H AND >/= 1 S ever	60(0.226)	59(0.163)	15(0.115)	1986(0.052)
5 P OR 5 H ever AND > 183 days between 2 P or 2 H AND >/= 1 S ever	241(0.906)	298(0.825)	97(0.746)	23217(0.603)
5 P OR H ever AND > 183 days between 2 P or H AND >/= 1 S ever	242(0.910)	303(0.839)	97(0.746)	23562(0.611)
2 P AND > 183 days between 2 P in 1 YR	148(0.556)	215(0.596)	68(0.523)	15509(0.402)
2 P AND > 183 days between 2 P in 2 YR	210(0.789)	289(0.801)	100(0.769)	23890(0.620)
2 P AND > 183 days between 2 P in 3 YR	222(0.835)	305(0.845)	108(0.831)	27213(0.706)
2 P AND > 183 days between 2 P in 4 YR	237(0.891)	322(0.892)	111(0.854)	29163(0.757)
2 P AND > 183 days between 2 P in 5 YR	243(0.914)	328(0.909)	114(0.877)	30360(0.788)
2 P AND > 183 days between 2 P in 6 YR	248(0.932)	332(0.920)	116(0.892)	31185(0.809)
2 P AND > 183 days between 2 P in 7 YR	249(0.936)	335(0.928)	117(0.900)	31785(0.825)

3 P AND > 183 days between 2 P in 1 YR	132(0.496)	192(0.532)	62(0.477)	12807(0.332)
3 P AND > 183 days between 2 P in 2 YR	192(0.722)	267(0.740)	86(0.662)	20617(0.535)
3 P AND > 183 days between 2 P in 3 YR	213(0.801)	294(0.814)	95(0.731)	24278(0.630)
3 P AND > 183 days between 2 P in 4 YR	226(0.850)	314(0.870)	101(0.777)	26638(0.691)
3 P AND > 183 days between 2 P in 5 YR	236(0.887)	320(0.886)	107(0.823)	28178(0.731)
3 P AND > 183 days between 2 P in 6 YR	248(0.932)	326(0.903)	111(0.854)	29273(0.760)
3 P AND > 183 days between 2 P in 7 YR	249(0.936)	329(0.911)	112(0.862)	30148(0.782)
4 P AND > 183 days between 2 P in 1 YR	103(0.387)	167(0.463)	51(0.392)	10043(0.261)
4 P AND > 183 days between 2 P in 2 YR	171(0.643)	249(0.690)	77(0.592)	17108(0.444)
4 P AND > 183 days between 2 P in 3 YR	197(0.741)	274(0.759)	89(0.685)	20951(0.544)
4 P AND > 183 days between 2 P in 4 YR	214(0.805)	295(0.817)	94(0.723)	23746(0.616)
4 P AND > 183 days between 2 P in 5 YR	229(0.861)	308(0.853)	101(0.777)	25646(0.666)
4 P AND > 183 days between 2 P in 6 YR	237(0.891)	316(0.875)	108(0.831)	27080(0.703)
4 P AND > 183 days between 2 P in 7 YR	243(0.914)	319(0.884)	109(0.838)	28152(0.731)
5 P AND > 183 days between 2 P in 1 YR	78(0.293)	145(0.402)	42(0.323)	7667(0.199)

5 P AND > 183 days between 2 P in 2 YR	144(0.541)	223(0.618)	68(0.523)	14088(0.366)
5 P AND > 183 days between 2 P in 3 YR	183(0.688)	255(0.706)	81(0.623)	17961(0.466)
5 P AND > 183 days between 2 P in 4 YR	202(0.759)	274(0.759)	88(0.677)	20911(0.543)
5 P AND > 183 days between 2 P in 5 YR	222(0.835)	293(0.812)	92(0.708)	23061(0.598)
5 P AND > 183 days between 2 P in 6 YR	231(0.868)	304(0.842)	100(0.769)	24795(0.643)
5 P AND > 183 days between 2 P in 7 YR	238(0.895)	310(0.859)	104(0.800)	26102(0.677)
2 P AND > 183 days between 2 P in 1 YR AND >/= 1 S ever	144(0.541)	201(0.557)	61(0.469)	12537(0.325)
2 P AND > 183 days between 2 P in 2 YR AND >/= 1 S ever	204(0.767)	268(0.742)	87(0.669)	18662(0.484)
2 P AND > 183 days between 2 P in 3 YR AND >/= 1 S ever	216(0.812)	281(0.778)	94(0.723)	20927(0.543)
2 P AND > 183 days between 2 P in 4 YR AND >/= 1 S ever	231(0.868)	294(0.814)	95(0.731)	22215(0.577)

2 P AND > 183 days between 2 P in 5 YR AND >/= 1 S ever	236(0.887)	298(0.825)	97(0.746)	22958(0.596)
2 P AND > 183 days between 2 P in 6 YR AND >/= 1 S ever	240(0.902)	301(0.834)	99(0.762)	23480(0.609)
2 P AND > 183 days between 2 P in 7 YR AND >/= 1 S ever	241(0.906)	303(0.839)	100(0.769)	23858(0.619)
3 P AND > 183 days between 2 P in 1 YR AND >/= 1 S ever	128(0.481)	183(0.507)	59(0.454)	10678(0.277)
3 P AND > 183 days between 2 P in 2 YR AND >/= 1 S ever	187(0.703)	251(0.695)	79(0.608)	16608(0.431)
3 P AND > 183 days between 2 P in 3 YR AND >/= 1 S ever	208(0.782)	274(0.759)	85(0.654)	19232(0.499)
3 P AND > 183 days between 2 P in 4 YR AND >/= 1 S ever	221(0.831)	289(0.801)	89(0.685)	20826(0.540)

3 P AND > 183 days between 2 P in 5 YR AND >/= 1 S ever	230(0.865)	294(0.814)	92(0.708)	21804(0.566)
3 P AND > 183 days between 2 P in 6 YR AND >/= 1 S ever	240(0.902)	299(0.828)	96(0.738)	22501(0.584)
3 P AND > 183 days between 2 P in 7 YR AND >/= 1 S ever	241(0.906)	299(0.828)	97(0.746)	23071(0.599)
4 P AND > 183 days between 2 P in 1 YR AND >/= 1 S ever	102(0.383)	160(0.443)	49(0.377)	8564(0.222)
4 P AND > 183 days between 2 P in 2 YR AND >/= 1 S ever	168(0.632)	237(0.657)	72(0.554)	14210(0.369)
4 P AND > 183 days between 2 P in 3 YR AND >/= 1 S ever	194(0.729)	261(0.723)	81(0.623)	17088(0.443)
4 P AND > 183 days between 2 P in 4 YR AND >/= 1 S ever	210(0.789)	277(0.767)	83(0.638)	19079(0.495)

4 P AND > 183 days between 2 P in 5 YR AND >/= 1 S ever	225(0.846)	287(0.795)	87(0.669)	20349(0.528)
4 P AND > 183 days between 2 P in 6 YR AND >/= 1 S ever	232(0.872)	292(0.809)	94(0.723)	21296(0.553)
4 P AND > 183 days between 2 P in 7 YR AND >/= 1 S ever	237(0.891)	294(0.814)	95(0.731)	22017(0.571)
5 P AND > 183 days between 2 P in 1 YR AND >/= 1 S ever	78(0.293)	138(0.382)	40(0.308)	6662(0.179)
5 P AND > 183 days between 2 P in 2 YR AND >/= 1 S ever	141(0.530)	213(0.590)	66(0.508)	11961(0.310)
5 P AND > 183 days between 2 P in 3 YR AND >/= 1 S ever	180(0.677)	243(0.673)	77(0.592)	15001(0.389)
5 P AND > 183 days between 2 P in 4 YR AND >/= 1 S ever	199(0.748)	260(0.720)	81(0.623)	17220(0.447)

5 P AND > 183 days between 2 P in 5 YR AND >/= 1 S ever	218(0.820)	276(0.765)	82(0.631)	18756(0.487)
5 P AND > 183 days between 2 P in 6 YR AND >/= 1 S ever	227(0.853)	285(0.789)	89(0.685)	19954(0.518)
5 P AND > 183 days between 2 P in 7 YR AND >/= 1 S ever	233(0.876)	288(0.798)	93(0.715)	20850(0.541)
(1 PC) OR (2 P ever AND > 183 days between 2 P AND >/= 1 S ever)	244(0.917)	305(0.845)	100(0.769)	24388(0.633)
(1 PC) OR (3 P ever AND > 183 days between 2 P AND >/= 1 S ever)	244(0.917)	304(0.842)	98(0.754)	23920(0.621)
(1 PC) OR (4 P ever AND > 183 days between 2 P AND >/= 1 S ever)	244(0.917)	303(0.839)	97(0.746)	23274(0.604)
(1 PC) OR (5 P ever AND > 183 days between 2 P AND >/= 1 S ever)	241(0.906)	298(0.825)	97(0.746)	22501(0.584)

(1 PC) OR (2 P AND > 183 days between 2 P in 1 YR)	191(0.718)	237(0.657)	74(0.569)	15882(0.412)
(1 PC) OR (2 P AND > 183 days between 2 P in 2 YR)	227(0.853)	295(0.817)	101(0.777)	24022(0.623)
(1 PC) OR (2 P AND > 183 days between 2 P in 3 YR)	233(0.876)	307(0.850)	108(0.831)	27275(0.708)
(1 PC) OR (2 P AND > 183 days between 2 P in 4 YR)	240(0.902)	323(0.895)	111(0.854)	29197(0.758)
(1 PC) OR (2 P AND > 183 days between 2 P in 5 YR)	245(0.921)	328(0.909)	114(0.877)	30382(0.788)
(1 PC) OR (2 P AND > 183 days between 2 P in 6 YR)	249(0.936)	332(0.920)	116(0.892)	31200(0.810)
(1 PC) OR (2 P AND > 183 days between 2 P in 7 YR)	250(0.940)	335(0.928)	117(0.900)	31797(0.825)

(1 PC) OR (3 P AND > 183 days between 2 P in 1 YR)	180(0.677)	217(0.601)	70(0.538)	13239(0.344)
(1 PC) OR (3 P AND > 183 days between 2 P in 2 YR)	218(0.820)	276(0.765)	89(0.685)	20800(0.540)
(1 PC) OR (3 P AND > 183 days between 2 P in 3 YR)	230(0.865)	299(0.828)	96(0.738)	24385(0.633)
(1 PC) OR (3 P AND > 183 days between 2 P in 4 YR)	237(0.891)	316(0.875)	102(0.785)	26693(0.693)
(1 PC) OR (3 P AND > 183 days between 2 P in 5 YR)	242(0.910)	320(0.886)	107(0.823)	28211(0.732)
(1 PC) OR (3 P AND > 183 days between 2 P in 6 YR)	249(0.936)	326(0.903)	111(0.854)	29295(0.760)
(1 PC) OR (3 P AND > 183 days between 2 P in 7 YR)	250(0.940)	329(0.911)	112(0.862)	30166(0.783)

(1 PC) OR (4 P AND > 183 days between 2 P in 1 YR)	158(0.594)	197(0.546)	59(0.454)	10559(0.274)
(1 PC) OR (4 P AND > 183 days between 2 P in 2 YR)	205(0.771)	262(0.726)	80(0.615)	17368(0.451)
(1 PC) OR (4 P AND > 183 days between 2 P in 3 YR)	219(0.823)	281(0.778)	90(0.692)	21111(0.548)
(1 PC) OR (4 P AND > 183 days between 2 P in 4 YR)	230(0.865)	299(0.828)	95(0.731)	23843(0.619)
(1 PC) OR (4 P AND > 183 days between 2 P in 5 YR)	237(0.891)	310(0.859)	101(0.777)	25702(0.667)
(1 PC) OR (4 P AND > 183 days between 2 P in 6 YR)	241(0.906)	317(0.878)	108(0.831)	27113(0.704)
(1 PC) OR (4 P AND > 183 days between 2 P in 7 YR)	245(0.921)	320(0.886)	109(0.838)	28174(0.731)

(1 PC) OR (5 P AND > 183 days between 2 P in 1 YR)	143(0.538)	178(0.493)	52(0.400)	8269(0.215)
(1 PC) OR (5 P AND > 183 days between 2 P in 2 YR)	187(0.703)	238(0.659)	73(0.562)	14426(0.374)
(1 PC) OR (5 P AND > 183 days between 2 P in 3 YR)	207(0.778)	264(0.731)	82(0.631)	18173(0.472)
(1 PC) OR (5 P AND > 183 days between 2 P in 4 YR)	220(0.827)	280(0.776)	89(0.685)	21045(0.546)
(1 PC) OR (5 P AND > 183 days between 2 P in 5 YR)[b]	***231(0.868)***	***297(0.823)***	***93(0.715)***	***23151(0.601)***
(1 PC) OR (5 P AND > 183 days between 2 P in 6 YR)	236(0.887)	307(0.850)	100(0.769)	24844(0.645)
(1 PC) OR (5 P AND > 183 days between 2 P in 7 YR)	241(0.906)	313(0.867)	104(0.800)	26135(0.678)

(1 PC) OR ((2 P AND > 183 days between 2 P in 1 YR) AND >/= 1 S ever)	187(0.703)	223(0.618)	67(0.515)	12911(0.335)
(1 PC) OR ((2 P AND > 183 days between 2 P in 2 YR) AND >/= 1 S ever)	221(0.831)	274(0.759)	88(0.677)	18795(0.488)
(1 PC) OR ((2 P AND > 183 days between 2 P in 3 YR) AND >/= 1 S ever)	227(0.853)	283(0.784)	94(0.723)	20990(0.545)
(1 PC) OR ((2 P AND > 183 days between 2 P in 4 YR) AND >/= 1 S ever)	234(0.880)	295(0.817)	95(0.731)	22250(0.577)
(1 PC) OR ((2 P AND > 183 days between 2 P in 5 YR) AND >/= 1 S ever)	238(0.895)	298(0.825)	97(0.746)	22981(0.596)
(1 PC) OR ((2 P AND > 183 days between 2 P in 6 YR) AND >/= 1 S ever)	241(0.906)	301(0.834)	99(0.762)	23496(0.610)
(1 PC) OR ((2 P AND > 183 days between 2 P in 7 YR) AND >/= 1 S ever)	242(0.910)	303(0.839)	100(0.769)	23871(0.620)

(1 PC) OR ((3 P AND > 183 days between 2 P in 1 YR) AND >/= 1 S ever)	176(0.662)	208(0.576)	67(0.515)	11111(0.288)
(1 PC) OR ((3 P AND > 183 days between 2 P in 2 YR) AND >/= 1 S ever)	213(0.801)	260(0.720)	82(0.631)	16797(0.436)
(1 PC) OR ((3 P AND > 183 days between 2 P in 3 YR) AND >/= 1 S ever)	225(0.846)	279(0.773)	86(0.662)	19340(0.502)
(1 PC) OR ((3 P AND > 183 days between 2 P in 4 YR) AND >/= 1 S ever)	232(0.872)	291(0.806)	90(0.692)	20882(0.542)
(1 PC) OR ((3 P AND > 183 days between 2 P in 5 YR) AND >/= 1 S ever)	236(0.887)	294(0.814)	92(0.708)	21838(0.567)
(1 PC) OR ((3 P AND > 183 days between 2 P in 6 YR) AND >/= 1 S ever)	241(0.906)	299(0.828)	96(0.738)	22524(0.585)
(1 PC) OR ((3 P AND > 183 days between 2 P in 7 YR) AND >/= 1 S ever)	242(0.910)	299(0.828)	97(0.746)	23090(0.599)

(1 PC) OR ((4 P AND > 183 days between 2 P in 1 YR) AND >/= 1 S ever)	157(0.590)	190(0.526)	57(0.438)	9081(0.236)
(1 PC) OR ((4 P AND > 183 days between 2 P in 2 YR) AND >/= 1 S ever)	202(0.759)	250(0.693)	75(0.577)	14471(0.376)
(1 PC) OR ((4 P AND > 183 days between 2 P in 3 YR) AND >/= 1 S ever)	216(0.812)	268(0.742)	82(0.631)	17249(0.448)
(1 PC) OR ((4 P AND > 183 days between 2 P in 4 YR) AND >/= 1 S ever)	226(0.850)	281(0.778)	84(0.646)	19177(0.498)
(1 PC) OR ((4 P AND > 183 days between 2 P in 5 YR) AND >/= 1 S ever)	233(0.876)	289(0.801)	87(0.669)	20406(0.530)
(1 PC) OR ((4 P AND > 183 days between 2 P in 6 YR) AND >/= 1 S ever)	236(0.887)	293(0.812)	94(0.723)	21330(0.554)
(1 PC) OR ((4 P AND > 183 days between 2 P in 7 YR) AND >/= 1 S ever)	239(0.898)	295(0.818)	95(0.731)	22040(0.572)

(1 PC) OR ((5 P AND > 183 days between 2 P in 1 YR) AND >/= 1 S ever)	143(0.538)	171(0.474)	50(0.385)	7265(0.189)
(1 PC) OR ((5 P AND > 183 days between 2 P in 2 YR) AND >/= 1 S ever)	184(0.692)	228(0.632)	71(0.546)	12300(0.319)
(1 PC) OR ((5 P AND > 183 days between 2 P in 3 YR) AND >/= 1 S ever)	204(0.767)	252(0.698)	78(0.600)	15214(0.395)
(1 PC) OR ((5 P AND > 183 days between 2 P in 4 YR) AND >/= 1 S ever)	217(0.816)	266(0.737)	82(0.631)	17355(0.450)
(1 PC) OR ((5 P AND > 183 days between 2 P in 5 YR) AND >/= 1 S ever)	227(0.853)	280(0.776)	83(0.638)	18847(0.489)
(1 PC) OR ((5 P AND > 183 days between 2 P in 6 YR) AND >/= 1 S ever)	232(0.872)	288(0.798)	89(0.685)	20004(0.519)
(1 PC) OR ((5 P AND > 183 days between 2 P in 7 YR) AND >/= 1 S ever)	236(0.887)	291(0.806)	93(0.715)	20884(0.542)

Abbreviations: CPDM, Centre for Pain and Disability Management (an interdisciplinary chronic pain rehabilitation program); NLPDP, Newfoundland and Labrador Prescription Drug Plan (a financial assistance program covering eligible prescription medications to qualified seniors and low-income individuals/families); PC, encounter with anesthesiologist-recorded pain clinic Medical Care Plan provincial procedure billing code (Chapter 7, Section 7.4, Appendix 4) in Medical Care Plan Fee-for-Service Physicians Claims File; P, encounter with physician-recorded pain-related diagnostic code (Chapter 7, Section 7.3, Appendix 3) in Medical Care Plan Fee-for-Service Physicians Claims File; H, encounter with physician-recorded pain-related diagnostic code (Chapter 7, Section 7.3, Appendix 3) in Newfoundland and Labrador hospital Discharge Abstract Data; S, encounter with medical specialist-recorded pain-related diagnostic code (Chapter 7, Section 7.3, Appendix 3) in Medical Care Plan Fee-for-Service Physicians Claims File or Newfoundland and Labrador hospital Discharge Abstract Data; YR, year(s).

[a] Inclusion criteria for the pain populations were: 1) attending an interdisciplinary chronic pain rehabilitation program from 2006-2011, 2) attending an interdisciplinary chronic pain rehabilitation program from 1999-2005, 3) being on the waitlist to attend an interdisciplinary chronic pain rehabilitation program on September 1, 2012, or 4) being prescribed and dispensed any opioid medication used almost exclusively for pain (Chapter 7, Section 7.1, Appendix 1) during the period from 1999-2011 as a subsidized patient of the NL Prescription Drug Program.

[b] The most performant Chronic Pain Algorithm

2.8.2 Appendix 2.2. Selection Accuracy of Chronic Pain Algorithms in Reference Standard Cohort[a]

Algorithm	Selected (n)	Test Prevalence n/9715	TP	FP	FN	TN	Sensitivity (95% CI)	Specificity (95% CI)	PPV (95% CI)	NPV (95% CI)	LR+ (95% CI)	LR- (95% CI)	DOR (95% CI)	Kappa (95% CI)	aROC (95% CI)
(1 PC ever) OR (2 P AND > 183 days between 2 P in 1 YR)	2807	0.289	1066	1741	1320	5588	0.447 (0.427,0.467)	0.762 (0.751,0.774)	0.380 (0.362,0.398)	0.809 (0.800,0.818)	1.881 (1.770,1.998)	0.726 (0.698,0.754)	2.592 (2.348,2.856)	0.197 (0.183,0.212)	0.604 (0.591,0.618)
(1 PC ever) OR (2 P AND > 183 days between 2 P in 2 YR)	4850	0.499	1704	3146	682	4183	0.714 (0.696,0.732)	0.571 (0.560,0.581)	0.351 (0.338,0.365)	0.860 (0.850,0.870)	1.664 (1.604,1.726)	0.501 (0.469,0.535)	3.322 (3.006,3.656)	0.211 (0.198,0.225)	0.642 (0.630,0.655)
(1 PC ever) OR (2 P AND > 183 days between 2 P n 3 YR)	5820	0.599	1951	3869	435	3460	0.818 (0.802,0.833)	0.472 (0.463,0.481)	0.335 (0.323,0.347)	0.888 (0.878,0.898)	1.549 (1.505,1.594)	0.386 (0.354,0.422)	4.011 (3.580,4.493)	0.195 (0.182,0.208)	0.645 (0.633,0.657)
(1 PC ever) OR (2 P AND > 183 days between 2 P in 4 YR)	6349	0.654	2060	4289	326	3040	0.863 (0.850,0.877)	0.415 (0.407,0.423)	0.324 (0.313,0.336)	0.903 (0.893,0.913)	1.475 (1.439,1.513)	0.329 (0.297,0.366)	4.479 (3.950,5.079)	0.178 (0.165,0.191)	0.639 (0.627,0.651)
(1 PC ever) OR (2 P AND > 183 days between 2 P in 5 YR)	6703	0.690	2124	4579	262	2750	0.890 (0.878,0.903)	0.375 (0.368,0.382)	0.317 (0.306,0.328)	0.913 (0.903,0.923)	1.425 (1.393,1.457)	0.293 (0.260,0.329)	4.869 (4.246,5.582)	0.165 (0.152,0.178)	0.632 (0.621,0.644)
(1 PC ever) OR (2 P AND > 183 days between 2 P in 6 YR)	6935	0.714	2167	4768	219	2561	0.908 (0.897,0.920)	0.349 (0.343,0.356)	0.312 (0.302,0.323)	0.921 (0.911,0.931)	1.396 (1.367,1.426)	0.263 (0.231,0.299)	5.315 (4.588,6.157)	0.157 (0.144,0.170)	0.629 (0.617,0.640)
(1 PC ever) OR (2 P AND > 183 days between 2 P in 7 YR)	7083	0.729	2189	4894	197	2435	0.917 (0.906,0.928)	0.332 (0.326,0.339)	0.309 (0.298,0.320)	0.925 (0.915,0.935)	1.374 (1.347,1.402)	0.249 (0.217,0.285)	5.529 (4.741,6.447)	0.150 (0.137,0.163)	0.625 (0.612,0.636)
(1 PC ever) OR (3 P AND > 183 days between 2 P in 1 YR)	2061	0.212	876	1185	1510	6144	0.367 (0.348,0.386)	0.838 (0.827,0.849)	0.425 (0.404,0.446)	0.803 (0.794,0.812)	2.271 (2.108,2.445)	0.755 (0.731,0.780)	3.008 (2.711,3.337)	0.215 (0.200,0.230)	0.603 (0.589,0.616)
(1 PC ever) OR (3 P AND > 183 days between 2 P in 2 YR)	3753	0.386	1453	2300	933	5029	0.609 (0.589,0.629)	0.686 (0.675,0.697)	0.387 (0.372,0.403)	0.844 (0.834,0.853)	1.940 (1.852,2.033)	0.570 (0.541,0.601)	3.405 (3.094,3.748)	0.247 (0.233,0.261)	0.647 (0.634,0.660)

(1 PC ever) OR (3 P AND > 183 days between 2 P in 3 YR)	4720	0.486	1741	2979	645	4350	0.730 (0.712,0.747)	0.594 (0.583,0.604)	0.369 (0.355,0.383)	0.871 (0.862,0.880)	1.795 (1.730,1.863)	0.455 (0.425,0.488)	3.941 (3.560,4.363)	0.243 (0.229,0.257)	0.661 (0.649,0.674)
(1 PC ever) OR (3 P AND > 183 days between 2 P in 4 YR)	5391	0.555	1912	3479	474	3850	0.801 (0.785,0.817)	0.525 (0.516,0.534)	0.355 (0.342,0.367)	0.890 (0.881,0.900)	1.688 (1.636,1.742)	0.378 (0.348,0.411)	4.464 (3.997,4.986)	0.229 (0.216,0.243)	0.663 (0.651,0.675)
(1 PC ever) OR (3 P AND > 183 days between 2 P in 5 YR)	5821	0.599	2003	3818	383	3511	0.839 (0.825,0.854)	0.479 (0.486,0.487)	0.344 (0.332,0.356)	0.902 (0.892,0.911)	1.611 (1.567,1.657)	0.335 (0.305,0.368)	4.809 (4.259,5.414)	0.214 (0.201,0.228)	0.659 (0.647,0.671)
(1 PC ever) OR (3 P AND > 183 days between 2 P in 6 YR)	6136	0.632	2079	4057	307	3272	0.871 (0.858,0.885)	0.446 (0.439,0.454)	0.339 (0.327,0.351)	0.914 (0.905,0.923)	1.574 (1.534,1.615)	0.288 (0.259,0.321)	5.462 (4.804,6.210)	0.208 (0.195,0.221)	0.659 (0.647,0.670)
(1 PC ever) OR (3 P AND > 183 days between 2 P in 7 YR)	6339	0.652	2121	4218	265	3111	0.889 (0.876,0.902)	0.424 (0.417,0.432)	0.335 (0.323,0.346)	0.922 (0.912,0.931)	1.545 (1.508,1.582)	0.262 (0.233,0.294)	5.903 (5.153,6.762)	0.201 (0.188,0.214)	0.656 (0.645,0.668)
(1 PC ever) OR (4 P AND > 183 days between 2 P in 1 YR)	1452	0.149	678	774	1708	6555	0.284 (0.266,0.302)	0.894 (0.884,0.905)	0.467 (0.441,0.493)	0.793 (0.785,0.802)	2.691 (2.454,2.950)	0.800 (0.779,0.822)	3.362 (2.994,3.775)	0.206 (0.190,0.221)	0.589 (0.575,0.603)
(1 PC ever) OR (4 P AND > 183 days between 2 P in 2 YR)	2804	0.289	1186	1618	1200	5711	0.497 (0.477,0.517)	0.779 (0.768,0.791)	0.423 (0.405,0.441)	0.826 (0.817,0.835)	2.252 (2.123,2.388)	0.645 (0.619,0.673)	3.488 (3.165,3.845)	0.261 (0.246,0.275)	0.638 (0.625,0.651)
(1 PC ever) OR (4 P AND > 183 days between 2 P in 3 YR)	3686	0.379	1494	2192	892	5137	0.626 (0.607,0.646)	0.701 (0.690,0.712)	0.405 (0.389,0.421)	0.852 (0.843,0.861)	2.094 (1.998,2.194)	0.533 (0.505,0.563)	3.925 (3.563,4.324)	0.276 (0.262,0.290)	0.663 (0.651,0.676)
(1 PC ever) OR (4 P AND > 183 days between 2 P in 4 YR)	4397	0.453	1716	2681	670	4648	0.719 (0.701,0.737)	0.634 (0.624,0.644)	0.390 (0.376,0.405)	0.874 (0.865,0.883)	1.966 (1.890,2.045)	0.443 (0.414,0.473)	4.440 (4.013,4.913)	0.275 (0.261,0.289)	0.676 (0.664,0.689)
(1 PC ever) OR (4 P AND > 183 days between 2 P in 5 YR)	4906	0.505	1850	3056	536	4273	0.775 (0.759,0.792)	0.583 (0.573,0.593)	0.377 (0.364,0.391)	0.889 (0.880,0.897)	1.859 (1.796,1.925)	0.385 (0.357,0.416)	4.826 (4.337,5.370)	0.264 (0.251,0.278)	0.679 (0.667,0.691)
(1 PC ever) OR (4 P AND > 183 days between 2 P in 6 YR)	5287	0.544	1939	3348	447	3981	0.813 (0.797,0.828)	0.543 (0.534,0.552)	0.367 (0.354,0.380)	0.899 (0.890,0.908)	1.779 (1.724,1.836)	0.345 (0.316,0.376)	5.158 (4.608,5.753)	0.252 (0.239,0.266)	0.678 (0.666,0.689)
(1 PC ever) OR (4 P AND > 183 days between 2 P in 7 YR)	5554	0.572	2009	3545	377	3784	0.842 (0.827,0.857)	0.516 (0.508,0.525)	0.362 (0.349,0.374)	0.909 (0.901,0.918)	1.741 (1.690,1.793)	0.306 (0.278,0.337)	5.688 (5.049,6.408)	0.247 (0.234,0.261)	0.679 (0.667,0.691)

(1 PC ever) OR (5 P AND > 183 days between 2 P in 1 YR)	1057	0.109	521	536	1865	6793	0.218 (0.202,0.235)	0.927 (0.917,0.936)	0.493 (0.463,0.523)	0.785 (0.776,0.793)	2.986 (2.671,3.337)	0.843 (0.825,0.862)	3.540 (3.106,4.036)	0.179 (0.163.0.194)	0.572 (0.559,0.586)
(1 PC ever) OR (5 P AND > 183 days between 2 P in 2 YR)	2118	0.218	968	1150	1418	6179	0.406 (0.386,0.425)	0.843 (0.832,0.854)	0.457 (0.436,0.478)	0.813 (0.805,0.822)	2.586 (2.406,2.778)	0.705 (0.681,0.730)	3.668 (3.308,4.066)	0.259 (0.244,0.273)	0.624 (0.611,0.638)
(1 PC ever) OR (5 P AND > 183 days between 2 P in 3 YR)	2902	0.299	1252	1650	1134	5679	0.525 (0.505,0.545)	0.775 (0.763,0.786)	0.431 (0.413,0.449)	0.834 (0.825,0.842)	2.331 (2.201,2.468)	0.613 (0.587,0.641)	3.800 (3.448,4.188)	0.279 (0.265,0.293)	0.650 (0.636,0.663)
(1 PC ever) OR (5 P AND > 183 days between 2 P in 4 YR)	3555	0.366	1483	2072	903	5257	0.622 (0.602,0.641)	0.717 (0.706,0.728)	0.417 (0.401,0.433)	0.853 (0.845,0.862)	2.198 (2.095,2.307)	0.528 (0.500,0.557)	4.167 (3.781,4.592)	0.291 (0.277,0.305)	0.669 (0.656,0.682)
(1 PC ever) OR (5 P AND > 183 days between 2 P in 5 YR)[b]	***4113***	***0.423***	***1678***	***2435***	***708***	***4894***	***0.703 (0.685,0.722)***	***0.668 (0.657,0.678)***	***0.408 (0.393,0.423)***	***0.874 (0.865,0.882)***	***2.117 (2.030,2.207)***	***0.444 (0.417,0.474)***	***4.763 (4.308,5.267)***	***0.298 (0.285,0.312)***	***0.685 (0.673,0.698)***
(1 PC ever) OR (5 P AND > 183 days between 2 P in 6 YR)	4553	0.469	1794	2759	592	4570	0.752 (0.735,0.769)	0.624 (0.614,0.633)	0.394 (0.380,0.408)	0.885 (0.877,0.894)	1.997 (1.924,2.073)	0.398 (0.370,0.428)	5.020 (4.523,5.571)	0.287 (0.274,0.301)	0.688 (0.676,0.700)
(1 PC ever) OR (5 P AND > 183 days between 2 P in 7 YR)	4881	0.502	1883	2998	503	4331	0.789 (0.773,0.806)	0.591 (0.582,0.600)	0.386 (0.372,0.399)	0.896 (0.887,0.905)	1.929 (1.864,1.997)	0.357 (0.329,0.386)	5.408 (4.850,6.030)	0.281 (0.268,0.295)	0.690 (0.678,0.702)
(1 PC ever) OR ((2 P AND > 183 days between 2 P in 1 YR) AND >/= 1 S ever)	2089	0.215	887	1202	1499	6127	0.372 (0.352,0.391)	0.836 (0.825,0.847)	0.425 (0.403,0.446)	0.803 (0.795,0.812)	2.267 (2.106,2.439)	0.751 (0.727,0.776)	3.016 (2.720,3.345)	0.217 (0.202,0.232)	0.604 (0.590,0.617)
(1 PC ever) OR ((2 P AND > 183 days between 2 P in 2 YR) AND >/= 1 S ever)	3360	0.346	1343	2017	1043	5312	0.563 (0.543,0.583)	0.725 (0.713,0.736)	0.400 (0.383,0.416)	0.836 (0.827,0.845)	2.045 (1.943,2.153)	0.603 (0.575,0.633)	3.391 (3.081,3.732)	0.253 (0.239,0.267)	0.644 (0.631,0.657)
(1 PC ever) OR ((2 P AND > 183 days between 2 P in 3 YR) AND >/= 1 S ever)	3920	0.403	1517	2403	869	4926	0.636 (0.616,0.655)	0.672 (0.661,0.683)	0.387 (0.372,0.402)	0.850 (0.841,0.859)	1.939 (1.854,2.028)	0.542 (0.513,0.573)	3.579 (3.249,3.941)	0.253 (0.239,0.267)	0.654 (0.641,0.667)
(1 PC ever) OR ((2 P AND > 183 days between 2 P in 4 YR) AND >/= 1 S ever)	4190	0.431	1585	2605	801	4724	0.664 (0.645,0.683)	0.645 (0.634,0.655)	0.378 (0.364,0.393)	0.855 (0.846,0.864)	1.869 (1.792,1.949)	0.521 (0.491,0.552)	3.588 (3.255,3.956)	0.246 (0.232,0.260)	0.654 (0.642,0.667)
(1 PC ever) OR ((2 P AND > 183 days between 2 P in 5 YR) AND >/= 1 S ever)	4388	0.452	1628	2760	758	4569	0.682 (0.664,0.701)	0.623 (0.613,0.634)	0.371 (0.357,0.385)	0.858 (0.848,0.867)	1.812 (1.740,1.886)	0.510 (0.479,0.542)	3.555 (3.223,3.923)	0.238 (0.224,0.252)	0.653 (0.640,0.665)

(1 PC ever) OR ((2 P AND > 183 days	4508	0.464	1654	2854	732	4475	0.693	0.611	0.367	0.859	1.780	0.502	3.543	0.234	0.652
between 2 P in 6 YR) AND >/= 1 S ever)							(0.675,0.712)	(0.600,0.621)	(0.353,0.381)	(0.850,0.869)	(1.712,1.851)	(0.472,0.535)	(3.209,3.911)	(0.220,0.248)	(0.639,0.664)
(1 PC ever) OR ((2 P AND > 183 days	4579	0.471	1666	2913	720	4416	0.698	0.603	0.364	0.860	1.757	0.501	3.508	0.230	0.650
between 2 P in 7 YR) AND >/= 1 S ever)							(0.680,0.717)	(0.592,0.613)	(0.350,0.378)	(0.850,0.869)	(1.690,1.826)	(0.470,0.534)	(3.177,3.873)	(0.216,0.243)	(0.638,0.663)
(1 PC ever) OR ((3 P AND > 183 days	1645	0.169	753	892	1633	6437	0.316	0.878	0.458	0.798	2.593	0.779	3.328	0.217	0.597
between 2 P in 1 YR) AND >/= 1 S ever)							(0.297,0.334)	(0.868,0.889)	(0.434,0.482)	(0.789,0.806)	(2.381,2.824)	(0.757,0.802)	(2.977,3.719)	(0.201,0.232)	(0.583,0.611)
(1 PC ever) OR ((3 P AND > 183 days	2812	0.289	1186	1626	1200	5703	0.497	0.778	0.422	0.826	2.240	0.646	3.466	0.260	0.637
between 2 P in 2 YR) AND >/= 1 S ever)							(0.477,0.517)	(0.767,0.790)	(0.404,0.440)	(0.817,0.835)	(2.112,2.376)	(0.620,0.674)	(3.145,3.821)	(0.245,0.274)	(0.624,0.651)
(1 PC ever) OR ((3 P AND > 183 days	3417	0.352	1399	2018	987	5311	0.586	0.725	0.409	0.843	2.129	0.571	3.730	0.271	0.655
between 2 P in 3 YR) AND >/= 1 S ever)							(0.567,0.606)	(0.713,0.736)	(0.393,0.426)	(0.834,0.852)	(2.025,2.239)	(0.543,0.600)	(3.388,4.107)	(0.256,0,286)	(0.642,0.668)
(1 PC ever) OR ((3 P AND > 183 days	3810	0.392	1509	2301	877	5028	0.632	0.686	0.396	0.851	2.014	0.536	3.760	0.265	0.659
between 2 P in 4 YR) AND >/= 1 S ever)							(0.613,0.652)	(0.675,0.697)	(0.381,0.412)	(0.842,0.861)	(1.925,2.108)	(0.507,0.566)	(3.413,4.142)	(0.251,0.279)	(0.646,0.672)
(1 PC ever) OR ((3 P AND > 183 days	4047	0.417	1566	2481	820	4848	0.656	0.661	0.387	0.855	1.939	0.520	3.732	0.257	0.659
between 2 P in 5 YR) AND >/= 1 S ever)							(0.637,0.675)	(0.651,0.672)	(0.372,0.402)	(0.846,0.864)	(1.857,2.024)	(0.490,0.550)	(3.386,4.113)	(0.243,0.271)	(0.646,0.671)
(1 PC ever) OR ((3 P AND > 183 days	4225	0.435	1613	2612	773	4717	0.676	0.644	0.382	0.859	1.897	0.503	3.768	0.254	0.660
between 2 P in 6 YR) AND >/= 1 S ever)							(0.657,0.695)	(0.633,0.654)	(0.367,0.396)	(0.850,0.868)	(1.820,1.977)	(0.474,0.535)	(3.416,4.157)	(0.235,0.268)	(0.647,0.672)
(1 PC ever) OR ((3 P AND > 183 days	4331	0.446	1636	2695	750	4634	0.686	0.632	0.378	0.861	1.865	0.497	3.751	0.249	0.659
between 2 P in 7 YR) AND >/= 1 S ever)							(0.667,0.704)	(0.622,0.643)	(0.363,0.392)	(0.851,0.870)	(1.791,1.942)	(0.467,0.529)	(3.399,4.139)	(0.236,0.263)	(0.646,0.671)
(1 PC ever) OR ((4 P AND > 183 days	1231	0.127	603	628	1783	6701	0.253	0.914	0.490	0.790	2.949	0.817	3.609	0.200	0.583
between 2 P in 1 YR) AND >/= 1 S ever)							(0.235,0.270)	(0.904,0.924)	(0.462,0.518)	(0.781,0.799)	(2.664,3.265)	(0.798,0.837)	(3.190,4.082)	(0.184,0.215)	(0.569,0.597)
(1 PC ever) OR ((4 P AND > 183 days	2253	0.232	1012	1241	1374	6088	0.424	0.831	0.449	0.816	2.505	0.693	3.613	0.260	0.627
between 2 P in 2 YR) AND >/= 1 S ever)							(0.404,0.444)	(0.819,0.842)	(0.429,0.470)	(0.807,0.825)	(2.338,2.684)	(0.669,0.719)	(3.264,4.000)	(0.245,0.274)	(0.614,0.641)
(1 PC ever) OR ((4 P AND > 183 days	2857	0.294	1248	1608	1138	5721	0.523	0.781	0.437	0.834	2.384	0.611	3.902	0.285	0.652
between 2 P in 3 YR) AND >/= 1 S ever)							(0.503,0.543)	(0.769,0.792)	(0.419,0.455)	(0.825,0.843)	(2.250,2.526)	(0.585,0.638)	(3.539,4.302)	(0.270,0.299)	(0.638,0.665)

(1 PC ever) OR ((4 P AND > 183 days between 2 P in 4 YR) AND >/= 1 S ever)	3307	0.340	1400	1907	986	5422	0.587 (0.567,0.607)	0.740 (0.729,0.751)	0.423 (0.407,0.440)	0.846 (0.837,0.855)	2.255 (2.142,2.374)	0.559 (0.532,0.587)	4.037 (3.665,4.447)	0.289 (0.275,0.303)	0.663 (0.650,0.676)
(1 PC ever) OR ((4 P AND > 183 days between 2 P in 5 YR) AND >/= 1 S ever)	3622	0.373	1490	2132	896	5197	0.624 (0.605,0.644)	0.709 (0.698,0.720)	0.411 (0.395,0.427)	0.853 (0.844,0.862)	2.147 (2.047,2.251)	0.530 (0.502,0.559)	4.054 (3.679,4.466)	0.284 (0.270,0.298)	0.667 (0.654,0.679)
(1 PC ever) OR ((4 P AND > 183 days between 2 P in 6 YR) AND >/= 1 S ever)	3847	0.396	1548	2299	838	5030	0.649 (0.630,0.668)	0.686 (0.675,0.697)	0.402 (0.387,0.418)	0.857 (0.848,0.866)	2.068 (1.977,2.163)	0.512 (0.484,0.542)	4.042 (3.666,4.455)	0.278 (0.264,0.292)	0.667 (0.655,0.680)
(1 PC ever) OR ((4 P AND > 183 days between 2 P in 7 YR) AND >/= 1 S ever)	4005	0.412	1588	2417	798	4912	0.666 (0.647,0.684)	0.670 (0.659,0.681)	0.397 (0.381,0.412)	0.860 (0.851,0.869)	2.018 (1.933,2.107)	0.499 (0.471,0.529)	4.044 (3.667,4.462)	0.273 (0.259,0.287)	0.668 (0.655,0.680)
(1 PC ever) OR ((5 P AND > 183 days between 2 P in 1 YR) AND >/= 1 S ever)	931	0.096	478	453	1908	6876	0.200 (0.184,0.216)	0.938 (0.929,0.947)	0.513 (0.481,0.546)	0.783 (0.774,0.791)	3.241 (2.875,3.654)	0.852 (0.835,0.870)	3.803 (3.312,4.366)	0.174 (0.159,0.190)	0.569 (0.555,0.583)
(1 PC ever) OR ((5 P AND > 183 days between 2 P in 2 YR) AND >/= 1 S ever)	1787	0.184	849	938	1537	6391	0.356 (0.337,0.375)	0.872 (0.861,0.883)	0.475 (0.452,0.498)	0.806 (0.797,0.815)	2.780 (2.565,3.013)	0.739 (0.716,0.762)	3.764 (3.377,4.194)	0.249 (0.234,0.264)	0.614 (0.600,0.627)
(1 PC ever) OR ((5 P AND > 183 days between 2 P in 3 YR) AND >/= 1 S ever)	2356	0.243	1073	1283	1313	6046	0.450 (0.430,0.470)	0.825 (0.814,0.836)	0.455 (0.435,0.476)	0.822 (0.813,0.830)	2.569 (2.403,2.746)	0.667 (0.642,0.693)	3.851 (3.482,4.259)	0.276 (0.261,0.290)	0.637 (0.624,0.651)
(1 PC ever) OR ((5 P AND > 183 days between 2 P in 4 YR) AND >/= 1 S ever)	2815	0.290	1250	1565	1136	5764	0.524 (0.504,0.544)	0.786 (0.775,0.798)	0.444 (0.426,0.462)	0.835 (0.827,0.844)	2.453 (2.315,2.601)	0.605 (0.579,0.632)	4.053 (3.675,4.469)	0.293 (0.278,0.307)	0.655 (0.642,0.668)
(1 PC ever) OR ((5 P AND > 183 days between 2 P in 5 YR) AND >/= 1 S ever)	3183	0.328	1389	1794	997	5535	0.582 (0.562,0.602)	0.755 (0.744,0.767)	0.436 (0.419,0.454)	0.847 (0.839,0.856)	2.378 (2.256,2.507)	0.553 (0.527,0.581)	4.298 (3.900,4.737)	0.303 (0.289,0.317)	0.668 (0.656,0.681)
(1 PC ever) OR ((5 P AND > 183 days between 2 P in 6 YR) AND >/= 1 S ever)	3457	0.356	1462	1994	923	5335	0.613 (0.594,0.633)	0.728 (0.717,0.739)	0.423 (0.407,0.440)	0.853 (0.844,0.861)	2.254 (2.146,2.367)	0.531 (0.504,0.560)	4.241 (3.848,4.673)	0.296 (0.282,0.310)	0.670 (0.658,0.683)
PC ever) OR ((5 P AND > 183 days between 2 P in 7 YR) AND >/= 1 S ever)	3665	0.377	1519	2146	867	5183	0.637 (0.617,0.656)	0.707 (0.696,0.718)	0.414 (0.399,0.430)	0.857 (0.848,0.866)	2.174 (2.075,2.278)	0.514 (0.486,0.543)	4.231 (3.839,4.664)	0.291 (0.277,0.305)	0.672 (0.659,0.684)

Abbreviations: TP, true positive; FP, false positive; FN, false negative; TN, true negative; CI, confidence interval; PPV, positive predictive value; NPV, negative predictive value; LR+, likelihood ratio positive; LR-, likelihood ratio negative; DOR, diagnostic odds ratio; aROC, area under the Receiver Operating Characteristic curve; PC, encounter with anesthesiologist-recorded pain clinic Medical Care Plan provincial procedure billing code (Chapter 7, Section

7.4, Appendix 4) in Medical Care Plan Fee-for-Service Physicians Claims File; P, encounter with physician-recorded pain-related diagnostic code (Chapter 7, Section 7.3, Appendix 3) in Medical Care Plan Fee-for-Service Physicians Claims File; YR, year(s); S, encounter with medical specialist-recorded pain-related diagnostic code (Chapter 7, Section 7.3, Appendix 3) in Medical Care Plan Fee-for-Service Physicians Claims File or Newfoundland and Labrador Provincial hospital Discharge Abstract Data.

[a] The Reference Standard Cohort was comprised of primary care patients of all ages who met the inclusion criteria of implied consent to participate in the Canadian Primary Care Sentinel Surveillance Network-Newfoundland and Labrador since December 31, 2009 or earlier and had a minimum of two years of electronic medical record data for analysis.

[b] The most performant Chronic Pain Algorithm.

Chapter 3 Incidence and Prevalence of Chronic Pain in Newfoundland and Labrador, Canada: A Retrospective Cohort Study Using Health Administrative Data

Foley HE, Knight JC, Ploughman M, Asghari S, Audas R. Incidence and Prevalence of Chronic Pain in Newfoundland and Labrador, Canada: A Retrospective Cohort Study Using Health Administrative Data.

Preliminary results of this chapter were presented in a teleconference to the Provincial Pain Management Advisory Council on June 11, 2019, and as an oral presentation at the 2019 PriFor Conference in St. John's, NL, on June 28, 2019. Preliminary results from this chapter were accepted for a poster presentation at the 41st Annual Scientific Meetings of the Canadian Pain Society that were scheduled for May 19-22, 2020 but cancelled due to the global pandemic. As the first author of this manuscript, please note that I retain the right to include it in my doctoral thesis. This manuscript was submitted to the Journal of Pain for consideration for publication.

Abstract:

Background: Survey estimates are widely variable for chronic pain prevalence, deficient for incidence, and often exclusory of less populous jurisdictions, which is a knowledge gap potentially filled using health administrative data.

Aim: To describe incidence and prevalence of chronic pain in Newfoundland and Labrador, Canada using provincial health administrative data.

Methods: An algorithm validated to ascertain chronic pain cases among residents attending fee-for-service physician encounters for pain-related conditions was applied to the Medical Care Plan Fee-for-Service Physician Claims data of a cohort including 98% of the provincial population. Annual prevalence and incidence rates for the 2006-2010 fiscal years were calculated, as were the 2009/10 prevalence for rural/urban and regional health authority residential location strata.

Results: Age-standardized chronic pain incidence rates (4585 per 100,000 person-years in 2009/10) remained relatively stable over the four fiscal years, but age-standardized prevalence steadily increased from 32,716 to 37,469 per 100,000 population. Other important findings included: significantly higher chronic pain prevalence and incidence rates in females (p-value < 0.01), significantly increasing prevalence and incidence rates with increasing age (p-value < 0.05), and significantly higher prevalence in urban (p-value < 0.001) and the Eastern Regional Health Authority residential locations (p-value < 0.001).

Conclusions: Previously undetermined demographic and geographic strata-specific chronic pain estimates were obtained from health administrative data, and indicated a

high number of people in Newfoundland and Labrador are impacted by this disabling condition, especially females, older persons, and urban residents.

Keywords: chronic pain, epidemiology, incidence rate, prevalence, health administrative data

3.1 Introduction

Pain is defined as "an unpleasant sensory and emotional experience" and is said to become chronic after it persists beyond what is considered normal recovery time.[11,14,15,] Past research defined the temporal criterion for chronic pain as up to six months post onset, but the International Association for the Study of Pain recently formalized the chronic pain definition as "pain that lasts or recurs for longer than three months".[11,86,257] Referred to as "the hidden epidemic"[183] affecting people at all stages of life,[39,58,190] chronic pain has grown to be one of the most complex,[5,10,76] pervasive,[32,40,50] and expensive[26,41,154] health issues worldwide. Direct health care costs for chronic pain treatment in Canada were estimated at $7.2 billion in 2014, with an increased incremental health care cost of 51% attributable to a chronic pain diagnosis.[169] The significant burden chronic pain exerts on the community, economy, and health care system motivated the Government of Canada in 2019 to establish the Canadian Pain Task Force to investigate and advise government on best practice for prevention and management.[35] The first step in addressing chronic pain is to obtain detailed national and regional epidemiological statistics.[37] Wide variation exists in national estimates of chronic pain prevalence, both globally (2-54%)[39-42] and in Canada (14-29%).[43-49] The variation is even wider when considering municipal, provincial, or regional chronic pain prevalence estimates with reports ranging from 6.5-44% in Canada depending on geographical location and data source/methodology,[37,53-56] and with smaller provincial populations frequently excluded or pooled and reported as a region.[45-47,49] Furthermore, most estimates excluded young children, making the profile of chronic pain somewhat incomplete.[44-46,55] In terms of the

incidence of new cases of chronic pain, there has been only one study in Canada, which reported annual incidence from a national longitudinal survey ranging from 5.4% to 7.8% of those aged 25 and older.[57] Aging demographics, higher chronic disease rates, and poorer population health indicators in NL compared to other Canadian jurisdictions (including the other three Atlantic provinces) may contribute to higher chronic pain rates.[188,189] This highlights the importance of determining NL-specific chronic pain disease distribution for the purposes of public health initiatives and resource planning.

Most epidemiological statistics on chronic pain in Canada were derived from cross-sectional and/or longitudinal survey data.[37,45,47,53,56,57] Longitudinal data is required for estimates of disease incidence and can be expensive to obtain in terms of cost, time, and labor.[65] In contrast, health administrative data, which is continuously recorded, less resource intensive in terms of time and cost, and population-based, is routinely utilized for chronic disease surveillance in Canada via validated algorithms.[65,200] Previous studies obtaining chronic pain estimates from administrative data utilized code sets or case algorithms that were not validated in either the study jurisdiction or at all[41,54,185] contrary to current methodological standards.[65,255] The objective of the present study was to describe prevalence and incidence of chronic pain in NL for each fiscal year from 2006/07 to 2009/10 as defined by an algorithm validated to identify cases in the NL provincial health administrative data.

3.2 Methodology

3.2.1 Setting, Design, and Population Cohort

A retrospective cohort study design using provincial health administrative data was performed in the province of NL, Canada, which had a population of 516,729 in 2009.[259] All residents identified as eligible for Medical Care Plan (MCP) benefits for one or more fiscal years between 2003/04 and 2009/10 were included in the provincial cohort, comprising over 98% of the NL population for each fiscal year (Canadian Armed Forces personnel, Royal Canadian Mounted Police members, and international students were ineligible for benefits and, therefore, excluded).[260] Each member of the provincial cohort was followed annually from birth, migration to the NL jurisdiction, or the first eligible fiscal year (2003/04) until death, migration from the NL jurisdiction, or the end of the study (2009/10).

3.2.2 Administrative Data Sources

Two administrative data sources were used in the study: 1) the MCP Fee-for-Service Physicians Claims Database File containing data on claims for health services by fee-for-service physicians in NL, including one diagnostic code (recorded using the three-digit *International Classification of Disease – 9th Revision* (ICD-9) code) and one provincial billing code, was used to identify cases of chronic pain, while 2) the MCP Beneficiary Registration Database was used to extract benefits eligibility and demographic information on the provincial cohort. Data in the MCP Claims File was considered complete due to its collection for service remuneration.[218] Minimal missing data was anticipated in the MCP Beneficiary Database as regular checks were made by

the administrators to ensure completeness and accuracy of information.[217] All required record-level administrative data from January 1, 1999 to March 31, 2010 (the latest available data at the time of study initiation) was obtained from these datasets. Information on MCP benefits eligibility was available for each fiscal year (April – March) from 2003 onwards.

Information regarding eligibility for benefits, age, and sex was obtained for each fiscal year. Regional health authority and rural/urban residential classification was based on the community of residence, which was determined by the postal code recorded in the MCP Beneficiary Database for each cohort member. The four regional health authorities in NL were Eastern, Central, Western, and Labrador-Grenfell; each catchment area was defined by the Department of Health and Community Services of the Government of NL. For the purposes of this study, individuals were considered to have an urban place of residence if their community of residence had a population of 4000 or more people in the 2011 Statistics Canada Census, while those from communities with less than 4000 people were considered rural. A cut off of 4000 was used because it better represented community level access to health services in NL compared to the Statistics Canada population center cut off of 1000 or census agglomeration cut off of 10,000.[261,262]

3.2.3 Chronic Pain Case Identification

The development and validation of a health administrative data algorithm (the Chronic Pain Algorithm) to identify cases of chronic pain from residents attending fee-for-service physician encounters for pain-related conditions in NL was described in Chapter 2. The Chronic Pain Algorithm had 70.3% sensitivity, 66.8% specificity, 40.8%

positive predictive value, and 87.4% negative predictive value when validated against a primary care electronic medical records data audit of a NL general population sample. The Chronic Pain Algorithm was considered appropriate to assess geographic and demographic variation in chronic pain distribution in NL. The algorithm was defined as: 1) a single encounter date with an anesthesiologist recording a chronic pain-related provincial MCP procedure billing code (Chapter 7, Section 7.4, Appendix 4) in the MCP Claims File, OR 2) five or more encounter dates with any physician recording any pain-related diagnostic code (Chapter 7, Section 7.3, Appendix 3) in a five-year period with more than 183 days separating at least two pain-related encounter dates in the MCP Claims File. A chronic pain case for the purposes of this study was defined as any provincial cohort member identified by the Chronic Pain Algorithm.

The algorithm was applied to the provincial cohort MCP Claims File data for the 1999-2010 fiscal years. The first cases of chronic pain were identified in the 2003/04 fiscal year because this was the first year MCP benefits eligibility was recorded and the Chronic Pain Algorithm required five years of data (although five full years of MCP Claims File data were not available to identify cases for the 2003/04 fiscal year (identified from the April 1, 1999 - March 31, 2004 data)). Cases eligible for MCP benefits for each remaining fiscal year were identified from five full years of MCP Claims File data up to and including the 2009/10 fiscal year (i.e. cases for the 2004/05 fiscal year were identified from the April 1, 1999 - March 31, 2005 data, and so on up until cases for the 2009/10 fiscal year were identified from the April 1, 2004 - March 31, 2010 data). The prevalence and incidence rate was reported from the 2006/07 to 2009/10 fiscal years to allow for a

three-year run-in period approximating that recommended by other studies reporting chronic disease epidemiology from Canadian administrative data.[202,263]

3.2.4 Statistical Analysis

Demographics (2009/10 fiscal year data) were described for the overall provincial cohort, the Chronic Pain Group (members of the cohort identified by the Chronic Pain Algorithm), and the No Chronic Pain Group (members of the cohort not identified by the Chronic Pain Algorithm for demographic comparison). Group differences were tested using a t-test for mean age and Chi-squared tests for categorical variable proportions (statistical significance defined as $p < 0.05$).

Once identified by the Chronic Pain Algorithm, a case was counted as a prevalent case for each eligible fiscal year in the remainder of the study period given the status of chronic pain as a chronic disease with no cure.[86,264] A person was considered an incident case in the fiscal year containing the earliest eligible date that they were identified by the Chronic Pain Algorithm. The crude chronic pain prevalence per 100,000 population, incidence rate per 100,000 person-years at risk, and the 95% confidence interval (CI) were calculated for the overall population and sex strata for each fiscal year from 2006/07 to 2009/10; identified eligible chronic pain cases served as the numerator and the Statistics Canada reported NL population estimates[259] served as the denominator to provide population estimates for chronic pain distribution in NL. Any prevalent case ineligible for MCP benefits in a fiscal year was excluded from the prevalence numerator for that fiscal year. Prevalence and incidence rates were age-standardized to the 2011

Canadian census population using the direct method to compare between fiscal years and sex strata.

Since the regional health authority and rural/urban residential designation was extracted only for the final fiscal year (2009/10) of the data study period, the crude chronic pain prevalence and 95% CI per 100,000 population for the regional health authority and rural/urban strata were calculated only for that year. Eligible 2009/10 prevalent chronic pain cases in each regional health authority stratum served as the numerator and the 2009 population estimates, being the best available regional health authority population estimates,[259] served as the denominator for crude chronic pain prevalence. The crude prevalence was age-and sex-standardized to the 2011 Canadian census population using the direct method to compare between the four regional health authorities. Since Statistics Canada population data were unavailable for rural/urban residential designation in NL as defined by the 4000-population cut-off, only crude prevalence and 95% CI was calculated. Eligible 2009/10 prevalent chronic pain cases in each rural/urban stratum served as the numerator and the total provincial cohort eligible for MCP benefits per rural/urban stratum in the 2009/10 fiscal year served as the denominator. Cases with missing category data were omitted from the numerator for regional health authority and rural/urban prevalence calculations.

Tests of significant difference in prevalence and incidence rates were performed using Z-score tests for significance. Tests were performed for differences in: 1) age-standardized prevalence and incidence rates between fiscal years and sex strata; 2) crude prevalence and incidence rates between age groups and between fiscal year and sex strata for each age group; 3) age- and sex-standardized 2009/10 prevalence between the four

regional health authority strata; and 4) crude 2009/10 prevalence between rural and urban strata. Statistical significance was defined by $p < 0.05$.

SPSS version 24 and Excel 2013 were used for the statistical analyses.

3.2.5 Ethics Approval and Consent to Participate

The Health Research Ethics Board of the Health Research Ethics Authority of NL provided full approval of the study protocol (HREB Ref#2017.273). The Secondary Uses Committee of the NL Centre for Health Information and the Research Proposals Approval Committee of the Eastern Regional Health Authority also reviewed and approved the study protocol following Health Research Ethics Board approval. Since the health administrative data analyzed was part of routine data collection and normal operations of the NL Centre for Health Information, and the data was then de-identified, individual patient and/or NL resident consent was not required.

3.3 Results

3.3.1 Provincial Cohort Characteristics

The provincial cohort was comprised of 584,875 people, of which 50.6% were female, 17.4% were 65 years or older, 54.7% lived in urban locations, 58.0% lived in the Eastern Regional Health Authority catchment area, and 99.6% had linkages to the MCP Claims File (fee-for-service physicians visits). Each member of the provincial cohort was followed for a mean of 6.27 fiscal years (1.58 years standard deviation) and a range of 1-7 fiscal years for a total of 3,669,440 person-years. The Chronic Pain Group was comprised of 219,798 people or 37.6% of the provincial cohort (Table 3.1). Proportions in the

female, 45 years and older age groups, urban residential location, Eastern Regional Health Authority residential location, and each pain condition group strata were all significantly higher in the Chronic Pain Group compared to the No Chronic Pain Group using the Chi square test for significance (p-value < 0.001 for all comparisons). The mean age was significantly higher at 51.7 years (19.3 years standard deviation) in the Chronic Pain Group versus 38.3 years (21.8 years standard deviation) in the No Chronic Pain Group (p-value < 0.001) using the t-test for significance. Prevalent chronic pain cases lost to follow up due to death or outmigration included 4,100 cases in the 2007/08 fiscal year, 5,040 cases in the 2008/09 fiscal year, and 3,762 cases in the 2009/10 fiscal year.

Table 3.1. 2009/10 Fiscal Year Characteristics of the Chronic Pain Group and No Chronic Pain Group in Newfoundland and Labrador, Canada (N=584,875)

Demographic Characteristics	Chronic Pain Group[a]	No Chronic Pain Group[a]
	N_{group} = 219,798	N_{group} = 365,077
	n(% of N_{group})	n(% of N_{group})
Age Group (years)		
0-14	5,369(2.4)[b]	55,827(15.3)
15-24	15,573(7.1)[b]	57,243(15.7)
25-34	22,955(10.4)[b]	59,292(16.2)
35-44	32,637(14.8)	54,229(14.9)
45-54	43,903(20.0)[b]	50,819(13.9)
55-64	44,300(20.2)[b]	40,638(11.1)
65-79	36,492(16.6)[b]	31,645(8.7)
80+	18,569(8.4)[b]	15,383(4.2)
Sex		
Female	129,655(59.0)[b]	166,278(45.5)
Male	90,143(41.0)[b]	198,798(54.5)
Rural/Urban		
Urban	129,032(58.7)[b]	190,716(52.4)
Rural	90,244(41.1)[b]	173,514(47.5)
Missing Category Data	522(0.2)	847(0.2)

Regional Health Authority		
Eastern	144,050(65.5)[b]	195,067(53.4)
Central	39,908(18.2)[b]	71,024(19.5)
Western	31,305(14.2)[b]	61,770(16.9)
Labrador-Grenfell	4,013(1.8)[b]	36,369(9.8)
Missing Category Data	522(0.2)	847(0.2)
Pain Condition[c]		
Other Conditions Associated with Chronic Pain	194,235(88.4)[b]	136,480(37.4)
Musculoskeletal Pain/Arthritis	171,309(77.9)[b]	87,736(24.0)
Back/Neck	142,093(64.6)[b]	60,932(16.7)
Headaches	108,214(49.2)[b]	53,591(14.7)
Musculoskeletal Trauma	62,812(28.6)[b]	28,893(7.9)
Neuropathic	53,418(24.3)[b]	20,044(5.5)
Bone Disease	24,191(11.0)[b]	7,078(1.9)

Abbreviations: N_{group}, total population of group.

[a] The Chronic Pain Group was comprised of members of the cohort identified by the Chronic Pain Algorithm, and the No Chronic Pain Group was comprised of members of the cohort not identified by the Chronic Pain Algorithm in the Medical Care Plan Physicians Fee-for-Service Claims File data. The Chronic Pain Algorithm was defined as: 1) a single encounter date with an anesthesiologist recording a chronic pain-related provincial MCP procedure billing code (Chapter 7, Section 7.4, Appendix 4), OR 2) five

or more encounter dates with any physician recording any pain-related diagnostic code (Chapter 7, Section 7.3, Appendix 3) in a five-year period with more than 183 days separating at least two pain-related encounter dates.

[b] Proportion of the stratum in the Chronic Pain Group significantly different from that of the No Chronic Pain Group using Chi square test for significance (p-value < 0.001 for all comparisons indicated as significant). Statistical significance defined as $p < 0.05$.

[c] Inclusion in the pain condition group was defined as an individual having >/= 1 encounter recording a diagnosis in the pain condition diagnostic group (Chapter 7, Section 7.3, Appendix 3) in the Medical Care Plan Physician Fee-for-Service Claims File data from 1999-2010. A cohort member could be counted as a case for multiple pain condition groups.

3.3.2 Prevalence

Age-standardized prevalence of chronic pain per 100,000 (Table 3.2) in the overall population steadily and significantly (p-value < 0.001 for all between year comparisons) increased from 32,716 (95% CI: 32,595-32,838) in 2006/07 to 37,469 (95% CI: 37,347-37,591) in 2009/10 using Z-score test for significance. The same growth pattern (Table 3.2) was observed in sex strata with significantly higher age-standardized prevalence per 100,000 population (p-value < 0.001) observed in females (43,278 (95% CI: 43,108-43,448) in 2009/10) than males (31,418 (95% CI: 31,248-31,588) in 2009/10).

Table 3.2. Crude and Age-Standardized Chronic Pain Prevalence for the 2006-2010 Fiscal Years in Newfoundland and Labrador, Canada

Fiscal Year	Prevalence per 100,000 (95% CI)[a]					
	Overall population		Female		Male	
	Crude	Age-Standardized[b]	Crude	Age-Standardized[b]	Crude	Age-Standardized[b]
2006/07	33,099(32,970-33,228)	32,716(32,595-32,838)	39,130(38,942-39,318)	38,165(37,991-38,339)[d]	26,888(26,715-27,062)	27,021(26,854-27,189)
2007/08	35,230(35,099-35,361)	34,590(34,468-34,713)[c]	41,415(41,225-41,605)	40,156(39,982-40,330)[c,d]	28,842(28,664-29,019)	28,759(28,590-28,929)[c]
2008/09	36,818(36,686-36,951)	35,975(35,853-36,098)[c]	43,158(42,967-43,348)	41,679(41,505-41,853)[c,d]	30,274(30,094-30,453)	30,009(29,839-30,179)[c]
2009/10	38,522(38,389-38,654)	37,469(37,347-37,591)[c]	44,962(44,772-45,152)	43,278(43,108-43,448)[c,d]	31,880(31,698-32,061)	31,418(31,248-31,588)[c]

Abbreviations: CI, confidence interval.

[a] Selection by the Chronic Pain Algorithm in the Medical Care Plan Physicians Fee-for-Service Claims File data determined case status. The Chronic Pain Algorithm was defined as: 1) a single encounter date with an anesthesiologist recording a chronic pain-related provincial Medical Care Plan procedure billing code (Chapter 7, Section 7.4, Appendix 4), OR 2) five or more encounter dates with any physician recording any pain-related diagnostic code (Chapter 7, Section 7.3, Appendix 3) in a five-year period with more than 183 days separating at least two pain-related encounter dates.

[b] Tests for statistical difference between fiscal years and sex performed for age-standardized prevalence only.

[c] Estimated age-standardized chronic pain prevalence was significantly higher than the previous fiscal year in the same stratum using Z-score test for significance (p-value < 0.001 for all comparisons indicated as significant). Statistical significance defined as $p < 0.05$.

[d] Estimated age-standardized chronic pain prevalence was significantly higher in the female stratum than the male stratum in the same fiscal year using Z-score test for significance (p-value < 0.001 for all comparisons indicated as significant). Statistical significance defined as $p < 0.05$.

Chronic pain prevalence in each age group of the overall population and sex strata increased significantly (p-value < 0.05) each year over the four fiscal years (Section 3.8.1, Chapter 3 Appendix), except the 0-14 age group. The highest increase occurred in the 80 and over age group for a total difference of 8,482 per 100,000 population from 2006/07 to 2009/10 in the overall population. The prevalence for females was significantly higher than males in all age groups (p-value < 0.001), except the 0-14 age group. Within each fiscal year, prevalence significantly increased with increasing age (p-value < 0.05) in the overall population and sex strata (as illustrated in Fig. 3.1 for the 2009/10 fiscal year). An exception was a consistent and small decrease in chronic pain prevalence between the 55-64 age group and the 65-79 age group in the female stratum, which was significant in the 2007/08 and 2008/09 fiscal years (p-value < 0.05). Chronic pain was most prevalent in females aged 80 and over, peaking at 66,339 (95% CI: 65,464-67,214) per 100,000 population in the 2009/10 fiscal year.

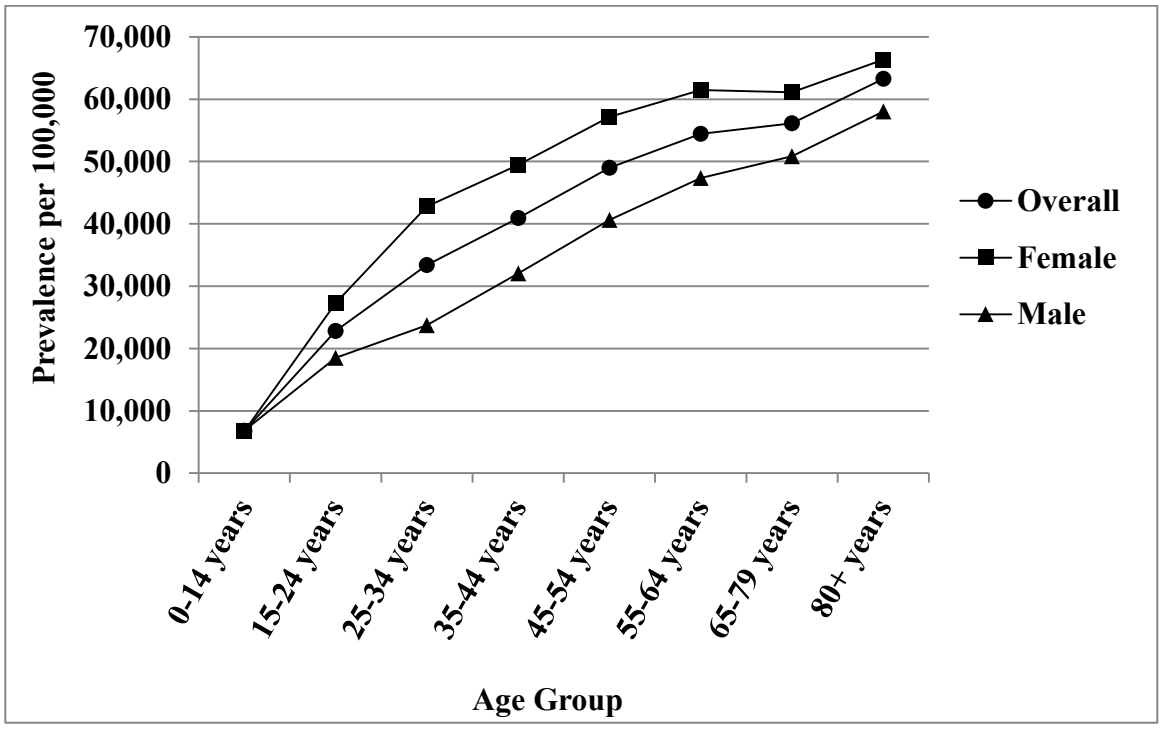

Fig. 3.1. 2009/10 Fiscal Year Chronic Pain Prevalence per 100,000 by Age Group in Newfoundland and Labrador, Canada

Notes: X-axis: age group strata. Y-axis: estimated 2009/10 fiscal year prevalence per 100,000 population in each age group stratum for the overall eligible NL population and for males and females. Data table for the displayed prevalence and the 95% confidence intervals is found in Section 3.8.1, Chapter 3 Appendix. Selection by the Chronic Pain Algorithm in the MCP Physicians Fee-for-Service Claims File data determined case status. The Chronic Pain Algorithm was defined as: 1) a single encounter date with an anesthesiologist recording a chronic pain-related provincial MCP procedure billing code (Chapter 7, Section 7.4, Appendix 4), OR 2) five or more encounter dates with any physician recording any pain-related diagnostic code (Chapter 7, Section 7.3, Appendix 3) in a five-year period with more than 183 days separating at least two pain-related

encounter dates. The estimated chronic pain prevalence in each age group was significantly higher than the next younger age group in all strata (p-value < 0.05), except between the 55-64 years and the 65-79 years age groups in the female stratum, using Z-score test for significance. The estimated chronic pain prevalence in the female stratum was significantly higher than the male stratum for all age groups (p-value < 0.001), except the 0-14 age group, using Z-score test for significance. Statistical significance was defined as $p < 0.05$.

Abbreviation: MCP, Medical Care Plan.

Age- and sex-standardized chronic pain prevalence (Table 3.3) was significantly higher in the Eastern region compared to the other three regions, and was significantly lower in the Labrador-Grenfell region compared to the other three regions (p-value < 0.001 for all comparisons). Age-and sex-standardized prevalence was significantly higher in the Central region compared to the Western region (p-value < 0.001). Crude prevalence per 100,000 population was significantly higher in urban areas at 42,281 (95% CI: 42,097-42,464) compared to rural areas at 35,953 (95% CI: 35,756-36,136) (p-value < 0.001).

Table 3.3. 2009/10 Fiscal Year Crude and Age-standardized Prevalence for the Regional Health Authorities in Newfoundland and Labrador, Canada

Regional Health Authority	Prevalence per 100,000 (95% CI)[a]	
	Crude	Age- and Sex-Standardized[b]
Eastern	43,029(42,854-43,205)	42,371(42,213-42,529)[c]
Central	37,288(36,981-37,596)	34,861(34,581-35,142)[c]
Western	36,013(35,679-36,348)	33,827(33,524-34,131)[c]
Labrador-Grenfell	9,670(9,370-9,971)	10,224(9,906-10,541)[c]

Abbreviations: CI, confidence interval.

[a] Selection by the Chronic Pain Algorithm in the Medical Care Plan Physicians Fee-for-Service Claims File data determined case status. The Chronic Pain Algorithm was defined by: 1) a single encounter date with an anesthesiologist recording a chronic pain-related provincial Medical Care Plan procedure billing code (Chapter 7, Section 7.4, Appendix 4), OR 2) five or more encounter dates with any physician recording any pain-related diagnostic code (Chapter 7, Section 7.3, Appendix 3) in a five-year period with more than 183 days separating at least two pain-related encounter dates.

[b] Statistical tests for significance of the difference between the Newfoundland and Labrador regional health authorities was performed only for the age- and sex-standardized prevalence.

[c] Age-standardized prevalence was significantly different from the other three regional health authorities using the Z-score test for significance (p-value < 0.001 for all comparisons). Statistical significance was defined by $p < 0.05$.

3.3.3 Incidence Rate

Age-standardized incidence rates of chronic pain in NL remained stable over the observed fiscal years for the overall population and sex strata (Table 3.4), with the exception of a small but statistically significant increase in the rates for the 2009/10 fiscal year using the Z-score test for significance (p-value < 0.001). Age-standardized rates per 100,000 person-years at risk for the overall population ranged from 4,363 (95% CI: 4,290-4,436) in 2008/09 to 4,585 (95% CI: 4,510-4,661) in the 2009/10 fiscal year. The age-standardized incidence rate per 100,000 person-years at risk for females (5,491 (95% CI: 5,370-5,612) in 2009/10) was significantly higher than that for males (3,846 (95% CI: 3,751-3,942) in 2009/10) in all four fiscal years (p-value < 0.001).

Table 3.4. Crude and Age-standardized Chronic Pain Incidence Rates per 100,000 Person-years at Risk for the 2006-2010 Fiscal Years in Newfoundland and Labrador, Canada

Fiscal Year	Incidence Rate per 100,000 person-years at risk (95% CI)[a]					
	Overall population		Female		Male	
	Crude	Age-Standardized[b]	Crude	Age-Standardized[b]	Crude	Age-Standardized[b]
2006/07	4,130(4,005-4,257)	4,457(4,386-4,529)	4,942(4,806-5,081)	5,330(5,217-5,443)[d]	3,422(3,309-3,538)	3,707(3,617-3,798)
2007/08	4,084(3,960-4,211)	4,420(4,347-4,492)	4,930(4,794-5,069)	5,335(5,219-5,451)[d]	3,353(3,241-3,468)	3,644(3,553-3,736)
2008/09	4,016(3,893-4,142)	4,363(4,290-4,436)	4,884(4,748-5,022)	5,319(5,201-5,437)[d]	3,273(3,162-3,387)	3,566(3,474-3,657)
2009/10	4,210(4,084-4,339)	4,585(4,510-4,661)[c]	5,012(4,875-5,152)	5,491(5,370-5,612)[c,d]	3,532(3,417-3,650)	3,846(3,751-3,942)[c]

Abbreviations: CI, confidence interval.

[a] Selection by the Chronic Pain Algorithm in the Medical Care Plan Physicians Fee-for-Service Claims File data determined case status. The Chronic Pain Algorithm was defined as: 1) a single encounter date with an anesthesiologist recording a chronic pain-related provincial Medical Care Plan procedure billing code (Chapter 7, Section 7.4, Appendix 4), OR 2) five or more encounter dates with any physician recording any pain-related diagnostic code (Chapter 7, Section 7.3, Appendix 3) in a five-year period with more than 183 days separating at least two pain-related encounter dates.

[b] Tests for statistical difference between fiscal years and sex performed for age-standardized incidence rates only.

[c] Estimated incidence rate was significantly higher than the previous fiscal year in the same stratum using Z-score test for significance (p-value < 0.05 for all comparisons indicated as significant). Statistical significance defined as $p < 0.05$.

[d] Estimated incidence rates were significantly different higher in the female stratum than the male stratum in the same fiscal year using Z-score test for significance (p-value < 0.001 for all comparisons indicated as significant). Statistical significance defined as $p < 0.05$.

Incidence rates in age strata remained relatively stable over the first three years for the overall population and sex strata (Section 3.8.1, Chapter 3 Appendix). There was a small but statistically significant increase in incidence rate in 2009/10 compared to that in 2008/09 for age groups between 15-44 years and 55-79 years (p-value < 0.05). The incidence rate of chronic pain was significantly higher in females than males in all age groups (p-value < 0.01), except the 0-14 age group. Within each fiscal year, rates significantly increased as age increased (p-value < 0.05) in the general population and sex strata (as illustrated in Fig. 3.2 for the 2009/10 fiscal year). An exception was a consistent, small, but statistically insignificant decrease in chronic pain incidence rate between the 45-54 and the 55-64 age groups in the female stratum. Incidence rate of chronic pain in NL was highest in females 80 years and older, peaking at 8,966 (95% CI: 8,143-9,788) per 100 000 person-years at risk in the 2007/08 fiscal year.

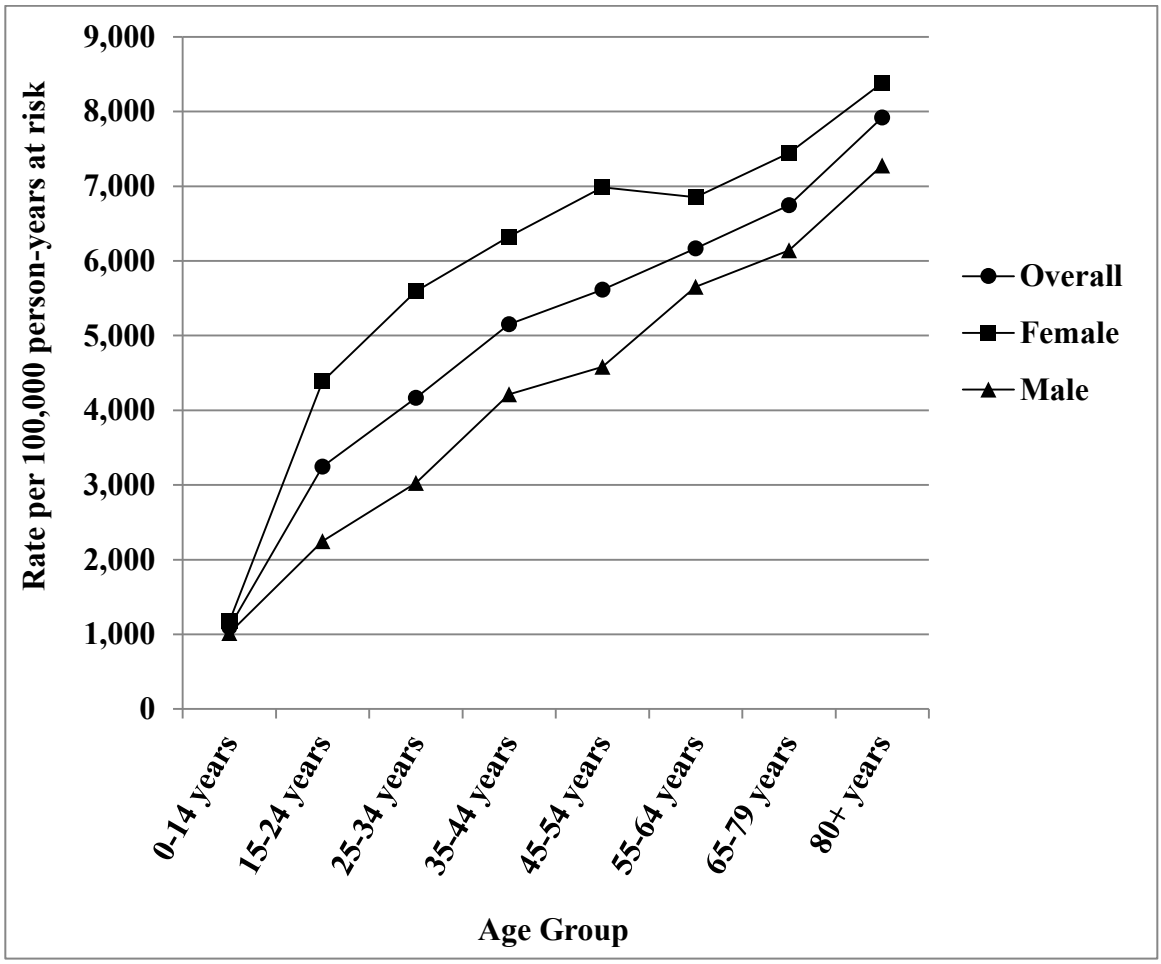

Fig. 3.2. 2009/10 Fiscal Year Chronic Pain Incidence Rate per 100,000 Person-years at Risk by Age Group in Newfoundland and Labrador, Canada

Notes: X-axis: age group strata. Y-axis: estimated 2009/10 fiscal year incidence rate per 100,000 person-years at risk in each age group stratum for the overall eligible NL population and for males and females. Data table for the displayed incidence rates and the 95% confidence intervals is found in Section 3.8.1, Chapter 3 Appendix. Selection by the Chronic Pain Algorithm in the MCP Physicians Fee-for-Service Claims File data determined case status. The Chronic Pain Algorithm was defined as: 1) a single encounter date with an anesthesiologist recording a chronic pain-related provincial MCP procedure

billing code (Chapter 7, Section 7.4, Appendix 4), OR 2) five or more encounter dates with any physician recording any pain-related diagnostic code (Chapter 7, Section 7.3, Appendix 3) in a five-year period with more than 183 days separating at least two pain-related encounter dates. The estimated chronic pain incidence rate for each age group was significantly higher than the next younger age group in all strata (p-value < 0.05), except between the 45-54 and the 55-64 age groups in the female stratum, using Z-score test for significance. The estimated chronic pain incidence rates in the female stratum was significantly higher than the male stratum for all age groups (p-value < 0.01), except the 0-14 age group, using Z-score test for significance. Statistical significance defined by $p < 0.05$.

Abbreviation: MCP, Medical Care Plan.

3.4 Discussion

The present study outlines for the first time detailed epidemiological estimates on chronic pain as a single chronic condition in a Canadian province extracted from health administrative data utilizing a validated algorithm. Although possible bias introduced by the Chronic Pain Algorithm may overestimate chronic pain prevalence, the estimated 37.5% age-standardized NL chronic pain prevalence as defined by the Chronic Pain Algorithm in 2009/10 was within the upper range of that reported from surveys in Canada (11-44%).[37,43,45,47,53,56] The estimated 4.6% age-standardized NL chronic pain incidence as defined by the Chronic Pain Algorithm in the 2009/10 fiscal year was in the mid-range of that reported globally and in Canada (1.8-11.1%).[52,57,60,62] The age-standardized 2009/10 chronic pain statistics were much higher than that reported for other chronic diseases in NL in 2009/10 using similar methodology, including diabetes (8.2% prevalence, 0.8% incidence), hypertension (30.7% prevalence, 3.5% incidence), and ischemic heart disease (8.5% prevalence, 0.8% incidence).[265] The study had four main findings. First, although incidence rates of chronic pain were relatively stable, the prevalence steadily increased over the four observed fiscal years. Second, chronic pain prevalence and incidence rates were higher for females than males in all four fiscal years for all age groups (except the 0-14 age group). Third, chronic pain prevalence and incidence rates in NL increased with increasing age, peaking in those 80 years and older. And finally, 2009/10 chronic pain prevalence was highest in urban locations.

3.4.1 Chronic Pain Prevalence Over Time

Utilizing health administrative data that was population-based with widespread coverage revealed a steady increase in chronic pain prevalence over four observed fiscal years for the overall population and all strata (except the 0-14 age group). Considered a chronic, non-fatal disease with no cure,[32,84,86] chronic pain case status for the purposes of this study only changed with mortality or outmigration from the NL jurisdiction. The consistent annual incidence combined with the low rate of lost prevalent cases contributed to the increase in annual chronic pain prevalence, a phenomenon observed for other chronic diseases surveyed by the Canadian Chronic Disease Surveillance System using similar data sources and methodology.[265] However, this finding contrasted with that reported by studies using Canadian national survey data from either the population-based longitudinal cohort study (National Population Health Survey) or the repeated cross-sectional study (Canadian Community Health Survey).[46,49,57] Chronic pain case status in these studies depended on the response to one question on each national survey cycle that had no temporal component (i.e. how long pain was experienced), which classified a respondent as having chronic pain based on their pain experience at a point in time. This resulted in fluctuations in reported chronic pain prevalence each cycle between ranges of 15.3-19.5%[57] in the National Population Health Survey and 16.3-21.0%[46,49] in the Canadian Community Health Survey. The chronic pain case definition and measurement utilized in surveys has been cited as a potential contributor to the wide variation in reported chronic pain epidemiological statistics.[40,45] This is a limitation that can potentially be minimized through consistent case ascertainment from health

administrative data via validated algorithms that include a temporal component to ensure chronicity of the disease, such as that used in this study and in the Canadian Chronic Disease Surveillance System.[200]

3.4.2 Sex-related Differences in Chronic Pain Distribution

Chronic pain prevalence was up to 49% higher and incidence rates were up to 96% higher in females than males for all four fiscal years and for all age group strata (except the 0-14 age group). Most other studies reporting sex-related differences observed higher chronic pain prevalence in females (prevalence ranging from 13% to 66.7% in Canada) versus males (prevalence ranging from 8% to 57.1% in Canada), both overall and at different ages across the lifespan.[45-48,57,59] Females were observed to have higher chronic pain incidence (6.0%-8.7%) versus males (4.8%-7.1%) in the National Population Health Survey, although the difference was reported as statistically insignificant.[57] It was previously described that females report suffering from chronic pain and pain-related interference more often than males[60,192-194] and have associated higher health care utilization,[47,194] a phenomenon supported by the present study's analysis of physician billing data. Sex- and gender-related differences with respect to pain experiences are described as complex, and include biological, psychological, and social processes.[192,193,195] Examining the link between these processes and health care utilization will foster more effective sex-and gender-informed individualized pain management practices.

3.4.3 Age-related Differences in Chronic Pain Distribution

The nature of health administrative data allowed examination of chronic pain distribution across the lifespan, which was previously rarely reported.[41,55] Most population-based surveys had low or no representation in children under 12 years or adults over 75 years[39,45,57] with rates for these age ranges provided mostly by age-specific studies.[58,59,61,190] The present study demonstrated a significant age-related rise in prevalence and incidence rates across all age groups. The marked rate increase from children (the 0-14 age group) to the young working-age adults (the 15-24 and 25-34 age groups), particularly in females, followed by the continued increase in chronic pain rates up to 65 years, may have a negative impact on the workforce and economy in NL in terms of long-term disability, high sick leave levels, and reduced work productivity.[32,47,53,58,64]

Chronic pain rates continued to increase in adults over 65 years, peaking in those 80 years and older. These findings from physician billing data support other studies that described adults over 75 years as having the highest chronic pain prevalence,[37,44,60] seeking and receiving treatment for pain-related conditions more often,[266] consuming more opioid medication,[43] and requiring more medical management of other chronic diseases[266] leading to more frequent physician encounters. High rates of chronic pain in older adults could have a crippling impact on healthy aging and health care delivery for NL's rapidly aging population.[259] These findings stress the societal and economic importance of addressing age-specific pain management needs.

3.4.4 Rural/urban Differences in Chronic Pain Distribution

The finding of higher chronic pain prevalence in urban locations differs from that previously reported from Canadian surveys (either no difference[57] in rural/urban or higher rural[56] chronic pain prevalence). In Canada, there are typically two remuneration methods for medical care: fee-for service and alternate payment plan (which includes salary).[267] The Chronic Pain Algorithm identified residents who attended encounters with fee-for-service physicians for pain-related conditions, and so may not capture cases who primarily had their pain-related conditions managed by physicians practicing under alternate payment plans. Up to 75% of physicians (especially family physicians) practicing in rural areas of NL[267] and 90% practicing in the Labrador-Grenfell Regional Health Authority (unpublished data) receive 90% or more of their payments by alternate payment plans, which would contribute to possible under-ascertainment of cases and lower calculated rates in these areas. The higher chronic pain rates in urban centers (such as in the Eastern Regional Health Authority (69% of which is urban) versus the other health authorities (25-45% of which is urban)) (unpublished data) could also be related to access to pain management services. Such services are more comprehensive in urban locations resulting in higher per capita health care utilization.[56,62,260,268,269] It was previously postulated that people move from rural to urban locations for increased health service access to meet their growing health care needs.[268] Additional research into the regional disparities in chronic pain rates and treatment access is warranted.

3.4.5 Strengths, Limitations, and Generalizability

The present study had two main strengths. First, using the MCP Claims File (containing physician encounter information on approximately 98% of the NL population) as the main data source made this study truly population-based. Second, this study followed established guidelines by using an algorithm validated in the target population to select cases of chronic pain as a single chronic disease from health administrative data.[66] The similarities between incidence rate and prevalence findings presented here and that reported in the literature further endorses the utility of this methodology for the purpose of studying disease distribution of chronic pain in NL.

There were three main limitations to this study. First, a limitation of all studies involving the secondary use of administrative data is related to such data not being collected for research purposes and its data accuracy being dependent on entry at source.[66] The data was, therefore, subject to potential coding entry errors resulting from lack of staff training, inconsistent application of coding definitions, and variations in clinical practice patterns, which can contribute to over- or under- ascertainment of cases.[66] Second, the Chronic Pain Algorithm was determined the most performant to identify cases of chronic pain from available NL health administrative data sources, but its moderate performance on tests for selection accuracy during validation (70.3% sensitivity, 66.8% specificity, and 40.8% positive predictive value) makes it a source of misclassification bias. Age-related differential misclassification bias was pronounced in people aged 34 and under (with 25.0-57.8% sensitivity and 70.5-93.1% specificity, the Chronic Pain Algorithm possibly underestimated disease prevalence), and in people aged

65 and over (with 78.0-81.5% sensitivity and 42.7-51.6% specificity, the Chronic Pain Algorithm possibly overestimated disease prevalence). Misclassification bias was further influenced by the unavailability of data collected from visits to pharmacies (i.e. medication data), emergency rooms, salaried physicians, allied health professionals, and those funded by third-party payers. This likely impacted Chronic Pain Algorithm development/validation, case ascertainment, and incidence/prevalence estimation particularly in rural and/or non-Eastern Regional Health Authority areas.[270] Third, adjusting for the potential bias to chronic pain incidence and prevalence estimates introduced by the Chronic Pain Algorithm (potential overestimation) and the non-fee-for-service physician data unavailability (potential underestimation)[270] would be complex and require access to variables and datasets outside the scope of this thesis.[224,270] While the Chronic Pain Algorithm illustrated the potential for chronic pain prevalence overestimation during its validation, the estimates provided for NL (nearly two out of five population) being higher than the overall reported global estimate (approximately one out of five adults)[40,50] is not excessive given the wide range of estimates reported globally in different population samples (even within a single study)[39,42] and the nature of NL demographics that may contribute to higher chronic pain rates (e.g. older population, higher rates of chronic disease, and poorer population health indicators).[188,189] The incidence and prevalence estimates provided in this study should be interpreted as an illustration of chronic pain disease distribution and the associated demographic and geographic variation in NL and not as an exact case count per stratum. Caution should be exercised not to over-interpret statistical significance of incidence and prevalence

estimate differences between strata given the large, inclusive population sample size and large number of identified cases.

The chronic pain incidence and prevalence reported for NL in this study should not be generalized to the Canadian population, especially given regional disparities in chronic disease distribution in Canada.[265] The estimates provided are representative for the NL population up to the 2009/10 fiscal year. Given that patterns of disease may have shifted in the last decade, the present study provides a baseline against which to compare future estimations using the presented methodology. It is recommended the Chronic Pain Algorithm undergo validation in target population health administrative data prior to its utilization in non-NL jurisdictions.[66] Similarity in the structure of health service delivery and physician claims datasets across Canadian jurisdictions increases the generalizability of the case ascertainment methods presented in this study.[67,200,208,271] Since this is the first attempt in Canada to use this methodology to determine population estimates of chronic pain distribution, this study provides an incipient point from which other Canadian studies can adapt and utilize a chronic pain algorithm with stronger validation performance that is generalizable across jurisdictions to obtain epidemiological information on chronic pain.

3.5 Conclusions

Using a validated health administrative data case definition, this study showed that nearly four out of ten people in NL accessed fee-for-service physician care for pain treatment and were identified as having chronic pain in 2009/10, much higher than that identified for other chronic diseases using similar data sources and methodology.[265] With

available multiyear data for most of the NL population, previously unknown detailed demographic and geographic estimates on chronic pain rates were provided, and illustrated stable incidence rates but increasing prevalence over four years. There were progressively increasing chronic pain prevalence and incidence rates with increasing age. Rates were also consistently higher in females and in residents of urban locations. While these results should be interpreted with caution, the similarity in consistency and pattern of chronic pain prevalence and incidence rates in NL compared to survey data globally and in Canada reinforced this method as providing an accurate reflection of chronic pain distribution, and affirmed its status as a potentially effective but less expensive population-based alternative to survey methods.[197]

3.6 Acknowledgements

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3.7 Co-Authorship Statement

All authors read and approved the submitted version of this chapter. All authors agreed to be personally responsible for their own contribution and ensure that questions related to the accuracy or integrity of any part of the work, even ones in which the author was not personally involved, are appropriately investigated, resolved, and the resolution documented in the literature. Heather E. Foley drafted the work and substantively revised it, and made substantial contributions towards the study design, data acquisition, analysis, and interpretation. Dr. John C. Knight substantively revised the work, and made substantial contributions towards study design, data acquisition, analysis, and interpretation. Dr. Michelle Ploughman substantively revised the work, and made substantial contributions towards study conception and design, and data acquisition and interpretation. Dr. Shabnam Asghari substantively revised the work, and made substantial contributions towards study design, and data acquisition, analysis, and interpretation. Dr. Rick Audas substantively revised the work, and made substantial contributions to the study design, and data acquisition and interpretation.

3.8 Chapter 3 Appendix

3.8.1 Chapter 3 Appendix. 2006-2010 Fiscal Year Crude Chronic Pain[a] Prevalence and Incidence Rates for Each Age Group in Newfoundland and Labrador, Canada

	Prevalence per 100,000(95% CI)[a]				Incidence Rate per 100,000 person-years at risk(95% CI)[a]			
Fiscal Year	2006/07	2007/08	2008/09	2009/10	2006/07	2007/08	2008/09	2009/10
0-14 years								
Overall	6,638(6,463-6,813)	6,806(6,627-6,984)	6,834(6,655-7,011)	6,811(6,633-6,988)	1,089(1,014-1,164)	1,153(1,076-1,231)	1,062(988-1,137)	1,093(1,018-1,169)
Male	6,732(6,487-6,977)	6,915(6,664-7,165)	6,896(6,646-7,146)	6,859(6,610-7,108)	1,079(975-1,183)	1,102(996-1,208)	1,012(910-1,114)	1,016(914-1,118)
Female	6,539(6,290-6,788)	6,691(6,438-6,944)	6,768(6,513-7,022)	6,760(6,506-7,013)	1,100(992-1,208)	1,208(1,094-1,322)	1,115(1,006-1,225)	1,173(1,061-1,285)[d]
15-24 years								
Overall	20,263(19,959-20,568)[c]	21,246(20,932-21,559)[b,c]	21,925(21,607-22,245)[b,c]	22,822(22,497-23,147)[b,c]	2,984(2,841-3,125)[c]	2,914(2,771-3,057)[c]	3,000(2,853-3,146)[c]	3,246(3,093-3,400)[b,c]
Male	15,624(15,239-16,009)[c]	16,702(16,302-17,103)[b,c]	17,487(17,077-17,897)[b,c]	18,510(18,088-18,931)[b,c]	2,023(1,862-2,184)[c]	1,971(1,809-2,133)[c]	1,981(1,817-2,145)[c]	2,247(2,071-2,423)[b,c]

Female	25,087(24,618-25,561)[c,d]	25,957(25,478-26,436)[b,c,d]	26,547(26,061-27,033)[b,c,d]	27,301(26,808-27,793)[b,c,d]	4,085(3,842-4,327)[c,d]	3,991(3,748-4,235)[c,d]	4,164(3,913-4,416)[c,d]	4,385(4,125-4,644)[c,d]
25-34 years								
Overall	29,218(28,858-29,577)[c]	31,192(30,821-31,562)[b,c]	31,938(31,566-32,310)[b,c]	33,403(33,029-33,777)[b,c]	4,068(3,886-4,250)[c]	3,914(3,731-4,097)[c]	3,818(3,636-4,000)[c]	4,164(3,974-4,354)[b,c]
Male	20,166(19,713-20,618)[c]	21,860(21,388-22,333)[b,c]	22,507(22,031-22,983)[b,c]	23,715(23,234-24,196)[b,c]	2,828(2,621-3,034)[c]	2,831(2,619-3,042)[c]	2,716(2,509-2,924)[c]	3,027(2,809-3,246)[b,c]
Female	37,954(37,416-38,492)[c,d]	40,128(39,579-40,676)[b,c,d]	41,033(40,482-41,583)[b,c,d]	42,773(42,223-43,324)[b,c,d]	5,564(5,251-5,878)[c,d]	5,234(4,921-5,548)[c,d]	5,180(4,865-5,494)[c,d]	5,592(5,263-5,920)[b,c,d]
35-44 years								
Overall	35,632(35,300-35,963)[c]	37,710(37,371-38,049)[b,c]	39,254(38,909-39,599)[b,c]	40,956(40,606-41,307)[b,c]	4,726(4,547-4,905)[c]	4,712(4,528-4,895)[c]	4,797(4,608-4,986)[c]	5,153(4,953-5,352)[b,c]
Male	27,719(27,276-28,161)[c]	29,459(29,002-29,916)[b,c]	30,549(30,082-31,016)[b,c]	32,047(31,571-32,523)[b,c]	3,971(3,748-4,194)[c]	3,663(3,443-3,883)[b,c]	3,722(3,496-3,947)[c]	4,216(3,972-4,459)[b,c]
Female	43,214(42,734-43,693)[c,d]	45,575(45,088-46,063)[b,c,d]	47,515(47,023-48,008)[b,c,d]	49,438(48,940-49,935)[b,c,d]	5,631(5,343-5,918)[d]	5,976(5,671-6,281)[c,d]	6,113(5,797-6,430)[c,d]	6,326(5,996-6,655)[c,d]
45-54 years								

Overall	43,030(42,698-43,362)[c]	45,265(44,391-45,598)[b,c]	47,195(46,860-47,530)[b,c]	48,969(48,635-49,304)[b,c]	5,697(5,497-5,897)[c]	5,717(5,513-5,921)[c]	5,652(5,445-5,859)[c]	5,614(5,405-5,824)[c]
Male	35,668(35,210-36,126)[c]	37,392(36,929-37,854)[b,c]	39,117(38,651-39,583)[b,c]	40,620(40,152-41,087)[b,c]	4,699(4,453-4,945)[c]	4,616(4,369-4,864)[c]	4,612(4,361-4,863)[c]	4,581(4,328-4,833)[c]
Female	50,159(49,689-50,629)[c,d]	52,914(52,444-53,384)[b,c,d]	55,062(54,593-55,531)[b,c,d]	57,153(56,867-57,620)[b,c,d]	6,916(6,590-7,243)[c,d]	7,102(6,762-7,442)[c,d]	6,991(6,645-7,336)[c,d]	6,983(6,630-7,337)[c,d]
55-64 years								
Overall	46,992(46,620-47,365)[c]	50,212(49,846-50,578)[b,c]	52,246(51,887-52,605)[b,c]	54,424(54,073-54,775)[b,c]	6,048(5,811-6,285)[c]	6,129(5,888-6,370)[c]	5,794(5,558-6,030)	6,166(5,923-6,410)[b,c]
Male	40,280(39,762-40,798)[c]	43,310(42,796-43,824)[b,c]	45,312(44,485-45,819)[b,c]	47,325(46,826-47,824)[b,c]	5,417(5,116-5,718)[c]	5,449(5,145-5,753)[c]	5,080(4,786-5,375)[b,c]	5,654(5,345-5,963)[b,c]
Female	53,673(53,148-54,199)[c,d]	57,051(56,540-57,562)[b,c,d]	59,119(58,620-59,618)[b,c,d]	61,454(60,970-61,938)[b,c,d]	6,845(6,468-7,223)[d]	7,004(6,616-7,392)[d]	6,724(6,340-7,107)[d]	6,851(6,460-7,241)[d]
65-79 years								
Overall	48,049(47,622-48,476)[c]	50,558(50,136-50,980)[b]	53,357(52,943-53,771)[b,c]	56,144(55,740-56,548)[b,c]	6,503(6,220-6,785)[c]	6,175(5,895-6,455)	6,265(5,980-6,550)[c]	6,744(6,447-7,042)[b,c]
Male	42,597(41,987-43,207)[c]	45,411(44,803-46,018)[b,c]	47,962(47,364-48,561)[b,c]	50,825(50,239-51,411)[b,c]	5,819(5,449-6,189)[c]	5,704(5,332-6,076)	5,642(5,270-6,014)[c]	6,141(5,752-6,530)[c]

Female	53,083(52,492-53,675)[d]	55,305(54,723-55,888)[b,c,d]	58,335(57,768-58,902)[b,c,d]	61,086(60,535-61,637)[b,d]	7,263(6,830-7,695)[d]	6,700(6,277-7,123)[b,d]	6,973(6,535-7,411)[d]	7,442(6,985-7,900)[c,d]
80 years and over								
Overall	54,792(54,042-55,543)[c]	58,138(57,402-58,875)[b,c]	60,930(60,205-61,655)[b,c]	63,274(62,565-63,984)[b,c]	8,051(7,466-8,636)[c]	8,149(7,544-8,754)[c]	7,975(7,357-8,592)[c]	7,921(7,291-8,550)[c]
Male	49,053(47,806-50,300)[c]	52,502(51,268-53,736)[b,c]	55,200(53,982-56,418)[b,c]	58,010(56,812-59,208)[b,c]	6,923(6,067-7,779)[c]	6,970(6,089-7,850)[c]	6,911(6,016-7,807)[c]	7,278(6,341-8,215)[c]
Female	58,096(57,163-59,030)[c,d]	61,382(60,470-62,295)[b,c,d]	64,268(63,372-65,164)[b,c,d]	66,339(65,464-67,214)[b,c,d]	8,824(8,032-9,615)[c,d]	8,966(8,143-9,788)[c,d]	8,736(7,892-9,580)[c,d]	8,382(7,535-9,229)[c,d]

Abbreviations: CI, confidence interval.

[a] Selection by the Chronic Pain Algorithm in the Medical Care Plan Physicians Fee-for-Service Claims File data determined case status. The Chronic Pain Algorithm was defined as: 1) a single encounter date with an anesthesiologist recording a chronic pain-related provincial Medical Care Plan procedure billing code (Chapter 7, Section 7.4, Appendix 4), OR 2) five or more encounter dates with any physician recording any pain-related diagnostic code (Chapter 7, Section 7.3, Appendix 3) in a five-year period with more than 183 days separating at least two pain-related encounter dates.

[b] Estimated prevalence or incidence rate was significantly different from previous fiscal year in the same sex and age group stratum (p-value < 0.05 for all comparisons indicated as significant) using Z-score tests of significance.

[c] Estimated prevalence or incidence rate was significantly different from next younger age group in the same sex and fiscal year stratum (p-value < 0.05 for all comparisons indicated as significant) using Z-score tests of significance.

[d] Estimated prevalence or incidence rate was significantly different in the female stratum than the male stratum in the same fiscal year and age group stratum (p-value < 0.001 for all prevalence comparisons indicated as significant and p-value < 0.01 for all incidence rate comparisons indicated as significant) using Z-score tests of significance. Statistical significance defined by p < 0.05.

Chapter 4 Association of Chronic Pain with Comorbidities and Health Care Utilization: A Retrospective Cohort Study using Health Administrative Data

Foley HE, Knight JC, Ploughman M, Asghari S, Audas R. Association of Chronic Pain with Comorbidities and Health Care Utilization: A Retrospective Cohort Study using Health Administrative Data.

Preliminary results from this chapter were presented in a teleconference to the Provincial Pain Management Advisory Council on June 11, 2019, and as an oral presentation at the 2019 PriFor Conference in St. John's, NL, on June 28, 2019. As the first author of this manuscript, please note that I retain the right to include it in my doctoral thesis. This manuscript was submitted to *Pain* for consideration for publication.

Abstract:

Background: Multi-morbidity and health care utilization are measurable indicators associated with the high disease burden exerted by chronic pain, and were not previously quantified in smaller Canadian jurisdictions.

Aim: This study aimed to use health administrative data to estimate comorbidity prevalence and annual health care utilization for chronic pain in Newfoundland and Labrador, Canada.

Methods: A validated chronic pain algorithm applied to provincial Fee-for-Service Physician Claims File data (1999-2009) established the Chronic Pain and No Chronic Pain comparator groups. Applying the Canadian Chronic Disease Surveillance System coding algorithms to Claims File and Provincial Discharge Abstract Data (1999-2009) determined the prevalence of 16 comorbidities. The 2009/10 risk and person-year rate of physician and diagnostic imaging visits and hospital admissions were calculated and adjusted using robust Poisson model with log link function for risks and negative binomial model for rates.

Results: The Chronic Pain Group had significantly higher prevalence of all comorbidities and up to four times the odds of multi-morbidity (p-value < 0.001). Chronic Pain Group members accounted for 58.8% of all physician visits, 57.6% of all diagnostic imaging visits, and 54.2% of all hospital admissions in 2009/10, but only 12-16% of these were for pain-related conditions. The Chronic Pain Group had significantly higher rates of physician visits and high-cost hospital admission/diagnostic imaging visits (p-value < 0.001) when adjusted for demographics and comorbidities.

Conclusions: The strong association of chronic pain with multi-morbidity and health care utilization indicate possible service delivery changes are required to meet the complex needs of this population.

Keywords: chronic pain, chronic comorbidities, health care utilization, health administrative data

4.1 Introduction

Effective treatment for chronic pain is historically elusive.[1,3] While research and treatment techniques continue to evolve,[6,7] most chronic pain conditions remain poorly understood and managed, which negatively impacts all facets of a sufferer's life.[10,16,17] Prolonged moderate to severe pain heightens a person's desperation for relief resulting in increased utilization of various and increasingly specialized health services.[18,23] Overall annual direct health care costs for chronic pain were estimated up to €32 billion in Europe,[41,166] $261-300 billion in the United States,[26] and CAD$15.1-17.2 billion in Canada.[28] Indirect annual societal costs in terms of lost productivity are even higher,[23] estimated at $299-335 billion in the United States[26] and CAD$23.2 billion in Canada.[28] Attempts to effectively treat pain was one of several factors that contributed to the unintended public health and societal fallout from opioid diversion and problematic opioid use, such as opioid use disorder and overdose.[155,156] Problematic opioid use was considered responsible for an incurred estimated cost in 2014 of CAD$313.1 million in health care and CAD$1.83 billion in lost productivity in Canada.[157] The importance of mitigating the devastating cost of chronic pain to individuals, families, communities, and society at large is clear.

Multiple risk factors are postulated to influence the overall cost escalation of chronic pain.[179,272,273] From an epidemiological perspective, chronic pain prevalence globally (2-54%)[39-42] and in Canada (6.5-44%)[37,45,46,53,54] represents a high volume of people impacted. From a behavioral perspective,[272] overall costs are amplified when excess utilization of health care resources by people with chronic pain, such as hospital

admissions, emergency department visits, and health practitioner encounters, are multiplied by this high prevalence.[26,41,169,172,180] From a needs perspective,[272] people with chronic pain are consistently measured to have higher comorbidity index scores,[175,274,275] higher prevalence of specific comorbidities (such as mood disorder, coronary artery disease, and chronic pulmonary disease),[168,276,277] and higher odds of multi-morbidity,[178] which are reported to significantly increase the likelihood of frequent physician consultations.[278] These three cost drivers (high prevalence, high per person health care utilization, and multi-morbidity) represent measurable indicators for impact evaluation of any public health policy or health care practice change.

Chronic pain advisory groups were struck in Canada in 2019 to survey how pain is being managed federally and provincially, and provide recommendations for service improvement.[35] An important first step is determining baseline epidemiological and health care utilization estimates.[36-38] Studies in other jurisdictions achieved this through data analysis from sources such as surveys,[26,180,275] electronic medical records,[182] and administrative datasets.[41,169,207,279] Neither health care utilization nor economic costs related to chronic pain were quantified in the setting of Newfoundland and Labrador, Canada, limiting the ability of its Provincial Pain Management Advisory Council to make informed recommendations for service delivery change. Health administrative data, an economical data source with wide coverage, presents considerable potential to identify people with a complex condition like chronic pain, determine its epidemiological distribution, and quantify health care utilization in any jurisdiction.[66,70] Previous work involved validating an algorithm to identify chronic pain cases in provincial health administrative data (described in Chapter 2), which was utilized to estimate provincial

incidence and prevalence (described in Chapter 3). The objectives of this study were to: 1) characterize and compare comorbidity prevalence in chronic pain-identified members to non-chronic pain-identified members of a provincial cohort; and 2) characterize and compare the 2009/10 fiscal year health care utilization of chronic pain-identified members to non-chronic pain-identified members of a provincial cohort. The study hypotheses were: (1) being identified as having chronic pain would be strongly associated with being identified with other comorbid conditions; and (2) being identified as having chronic pain would be strongly associated with having a higher utilization of publicly funded health care resources.

4.2 Methodology

4.2.1 Setting, Design, and Population Cohort

A retrospective cohort study design using health administrative data was performed in the province of Newfoundland and Labrador (NL), Canada, which had a population of 516,729 in 2009.[259] All residents identified as eligible for Medical Care Plan (MCP) benefits for the 2009/10 fiscal year (April to March) were included in the provincial cohort, comprising approximately 98% of the NL population for that year (Canadian Armed Forces personnel, Royal Canadian Mounted Police members, and international students were ineligible for benefits and, therefore, excluded).[260] Provincial cohort follow-up was based on MCP eligibility status that is released once each fiscal year, rather than birth/death or migration. Thus, physician visits and hospital admissions for

each provincial cohort member were followed for one fiscal year from April 1, 2009 to March 31, 2010 with no assumed loss to follow up.

4.2.2 Health Administrative Data Sources

The three administrative data sources used in the study were previously described (summarized in Chapter 7, Section 7.5, Appendix 5).[199] The data from all three datasets were organized via each resident's unique health insurance number.[199,239] The data sources were: 1) the MCP Fee-for-Service Physicians Claims Database File to identify cases of chronic pain, identify cases of comorbid conditions, and determine the number and type of physician service visits per person; 2) the Provincial Discharge Abstract Database (PDAD), the NL component of the Canadian Institute of Health Information national Discharge Abstracts Database, to identify cases of comorbid conditions and to determine admissions per person (number, type, and most responsible reason); and 3) the MCP Beneficiary Registration Database to identify benefits eligibility and demographics of the provincial cohort. All required record-level administrative data from January 1, 1999 to March 31, 2010 (the latest available data at the time of study initiation) were obtained from these datasets.

The MCP Claims File and PDAD data are regularly used for research and surveillance of multiple injuries and disease states.[200] Data in the MCP Claims File is considered complete due to its collection for service remuneration.[218] Rigorous quality control procedures are applied to the PDAD on an annual basis.[215,216,218] The MCP Beneficiary Database has minimal missing data due to regular checks made by the administrators to ensure completeness and accuracy of information.[217]

4.2.3 Data Linkage

The MCP Claims File, the PDAD, and the MCP Beneficiary Database are held at the NL Centre for Health Information. The health insurance numbers (MCP numbers) of the provincial population cohort were linked to the MCP Beneficiary File, the PDAD, and the MCP Claims File. Analysts at the NL Centre for Health Information performed all data extraction, linkage, cleaning, and de-identification prior to provision of the linked dataset to the research team for analysis.

4.2.4 Chronic Pain Case Identification

The exposure of interest in this study was the presence of chronic pain as defined by a validated health administrative data algorithm (Chronic Pain Algorithm) applied to the MCP Claims File for the 1999-2009 fiscal years. The Chronic Pain Algorithm identifies chronic pain cases from residents attending fee-for-service physician encounters for pain-related conditions in NL. Development and validation of the Chronic Pain Algorithm was previously described in Chapter 2, and had 70.3% sensitivity, 66.8% specificity, 40.8% positive predictive value, and 87.4% negative predictive value when validated against a primary care electronic medical records data audit of a NL general population sample. Assessing the strength of association between NL health administrative data-derived variables and the presence of chronic pain as defined by the Chronic Pain Algorithm was considered an appropriate use of the Algorithm. The Chronic Pain Algorithm was defined as: 1) a single claim date with an anesthesiologist recording a chronic pain-related provincial MCP procedure billing code (Chapter 7, Section 7.4, Appendix 4), OR 2) five or more claim dates with any physician recording any pain-related diagnostic code

(Chapter 7, Section 7.3, Appendix 3) in a five-year period with more than 183 days separating at least two pain-related claim dates.

Since a prevalence-based approach was used in this study,[169,280] all provincial cohort members identified by the Chronic Pain Algorithm from 1999-2009 was counted as a chronic pain case and formed the Chronic Pain Group. All members of the provincial cohort not identified by the Chronic Pain Algorithm from 1999-2009 formed the No Chronic Pain Group.

4.2.5 Independent Variables

4.2.5.1 Demographics

Information regarding sex, age, regional health authority, and rural/urban residential classification was obtained for the 2009/10 fiscal year from the MCP Beneficiary file. Sex classification (male/female) was determined by the cohort member's registration in the MCP Beneficiary file. Age as of September 1, 2009 was classified into four categorical age groups representing children and youth (0-24 years), young adults (25-44 years), older adults (45-64 years), and seniors (65 and over). Regional health authority and rural/urban residential classification was based on the community of residence, which was determined by the postal code recorded in the MCP Beneficiary Database for each cohort member. There were four health authority regions of residence, and the Department of Health and Community Services of the NL Government defined the catchment area for each. They were the Eastern, Central, Western, and Labrador-Grenfell Regional Health Authorities. For the purposes of this study, individuals were considered to have an urban residential location if their community of residence had a population of 4000 or more

people in the 2011 Statistics Canada Census, while those from communities with less than 4000 people were considered rural. A cut off of 4000 was used because it better represented community level access to health services in NL compared to the Statistics Canada population center cut off of 1000 or census agglomeration cut off of 10,000.[261,262]

4.2.5.2 Comorbid Conditions

The presence of mental illness, mood and anxiety disorders, hypertension, diabetes, ischemic heart disease, chronic obstructive pulmonary disease, asthma, heart failure, acute myocardial infarction, stroke, hip fracture, epilepsy, dementia, Parkinsonism, and multiple sclerosis was determined by applying the Canadian Chronic Disease Surveillance System (CCDSS) administrative data case definitions to the cohort's 1999-2009 MCP Claims File and PDAD data (summarized in Chapter 7, Section 7.6, Appendix 6).[265] These fifteen case definitions are coding algorithms used by the Public Health Agency of Canada to provide annual federal and provincial/territorial estimates on chronic disease distribution for health care resource and policy planning.[200] These chronic disease case definitions were chosen for this study because, at the time of data analysis initiation, they were 15 of 22 case definitions validated for use in claims and discharge abstract data in the Canadian provinces (including NL) that were known to be associated with chronic pain with diagnostic codes not included in the chronic pain case definition.[44,48,108,112,113,116,117,200,281] The CCDSS case definitions for mental illness and mood and anxiety disorders annually identify individuals who used health services for but are not necessarily diagnosed with these mental health conditions.[282] Comorbid condition case status for mental illness and mood and anxiety disorders for the purposes of this study

was defined as any provincial cohort member identified by the corresponding CCDSS case definition. The presence of cancer as another comorbid condition related to pain[119] was determined by the recording of one or more entries in any one or more of the 16 allowable diagnostic codes per admission in the PDAD of one or more cancer *International Classification of Disease – 10th Revision(Canadian)* (ICD-10-CA) diagnostic codes[283] published by the Public Health Agency of Canada.

Since all Public Health Agency of Canada codes and coding algorithms are published on the public domain of the Government of Canada website,[265,283] permission was not required to use them for non-commercial activities as long as the Public Health Agency of Canada source was cited (personal communication). Comorbid case status was determined prior to the health care utilization observation period of the 2009/10 fiscal year to evaluate its impact on health care utilization. Since a prevalence-based approach was used for this study,[169,280] all cohort members identified by the CCDSS case definitions from 1999-2009 were counted as a comorbid condition case.

4.2.6 Dependent Variables

4.2.6.1 Physician Claims-related Health Care Utilization

The MCP Claims File data for the provincial cohort was searched for all visits made from April 1, 2009 to March 31, 2010. For the purposes of this study, a visit was defined as any assessment, intervention, or procedure billed to the MCP by a fee-for-service physician in NL. Frequency of visits by physician type was captured based on the physician specialty code, and was classified as: 1) family physician only, and 2) physician from another specialty. Frequency of visits by reason for encounter was captured based

on the associated three-digit *International Classification of Disease – 9th Revision* (ICD-9) diagnostic code, and was classified as: 1) all-cause, and 2) pain-related (Chapter 7, Section 7.3, Appendix 3). The diagnostic codes used to classify a visit as pain- versus non-pain-related were validated as part of the Chronic Pain Algorithm. Frequency of diagnostic imaging visits was captured based on MCP Provincial Procedure Billing Codes (Chapter 7, Section 7.7, Appendix 7), and was classified as: 1) general radiograph, 2) computed tomography scan, and 3) magnetic resonance imaging scan.

4.2.6.2 Hospital Admission-related Health Care Utilization

The PDAD for the provincial cohort was searched for all hospital admissions occurring from April 1, 2009 to March 31, 2010. Frequency of admissions by service type was captured, and was classified as: 1) day surgery admission (defined as the admission and discharge dates being the same day indicating no overnight stay), and 2) inpatient admission (defined as the admission and discharge dates not being on the same day indicating an overnight stay of at least one night). Frequency of admissions by most responsible diagnosis (i.e. reason for admission) was captured based on the associated ICD-10-CA diagnostic code, and was classified as: 1) all-cause, and 2) pain-related (Chapter 7, Section 7.3, Appendix 3). The diagnostic codes used to classify an admission as pain- versus non-pain-related were validated as part of the Chronic Pain Algorithm.

4.2.7 Statistical Analysis

The 2009/10 fiscal year characteristics for the Chronic Pain Group and the No Chronic Pain Group were described by calculating mean and standard deviation for age, and frequency and percentage for age group, sex, regional health authority, and

rural/urban residential location. Frequency and percentage for seven pain condition categories (other conditions associated with chronic pain, arthritis and musculoskeletal pain, back and neck pain, headaches, musculoskeletal trauma and related conditions, painful neuropathy, and bone disorders) were calculated for the Chronic Pain Group and the No Chronic Pain Group. Pain condition category case status was determined by an individual having at least one visit in the MCP Claims File data or at least one hospitalization in the PDAD (all 16 allowable diagnostic codes per admission considered) with a diagnostic code from the pain condition category diagnostic code group (Chapter 7, Section 7.3, Appendix 3) from 1999-2010. Cohort members could be counted as a case for multiple pain condition categories. The diagnostic code groupings used to identify a case in each pain condition category were informed by the literature,[41,68,71,72,185,186,206,208,232-237] utilized for descriptive purposes only, and comprised of pain-related diagnostic codes validated as part of the Chronic Pain Algorithm. However, the diagnostic code groupings did not undergo a specific validation process. Between group differences for mean age were tested using t-test, and for categorical variable proportions using Chi-squared test (statistical significance defined as $p < 0.05$).

Prevalence of each comorbid condition in the Chronic Pain Group and the No Chronic Pain Group was calculated. Prevalence of being in the Chronic Pain Group for comorbid condition cases and non-cases was calculated. Since chronic pain and comorbid condition case status was determined by March 31, 2009, the unadjusted odds ratio (95% confidence interval (CI)) between the Chronic Pain Group and the No Chronic Pain Group was calculated and reported for each comorbid condition. Each odds ratio was adjusted for the covariates of sex, regional health authority, and rural/urban residential

location using a logistic regression model. Age group was not included as a covariate in the logistic regression due to collinearity with the case status of several comorbid conditions (age was an algorithm inclusion/exclusion criterion for several comorbid conditions. See Chapter 7, Section 7.6, Appendix 6). Collinearity was tested using a correlation matrix and the variables were considered collinear if the correlation coefficient was 0.80 or higher. Number of comorbid conditions was classified into groupings of 0, 1, 2, or 3 or more. Since the codes for the use of health services for mood and anxiety disorders coding algorithm were included in the codes for the use of health services for mental illness coding algorithm, mood and anxiety disorders were not counted as a separate comorbid condition for the purpose of these groupings.[265,282] Odds of having 1, 2, or 3 or more comorbid conditions and the unadjusted odds ratio (95% CI) between the Chronic Pain Group and the No Chronic Pain Group were calculated and reported. Each odds ratio was adjusted for the covariates of sex, regional health authority, and rural/urban residential location using a logistic regression model.

Risks for having a physician visit, a diagnostic imaging visit, and a hospital admission and the unadjusted relative risk ratio (95% CI) between the Chronic Pain Group and the No Chronic Pain Group were calculated and reported. The dependent variable was binary (yes/no), therefore, each relative risk ratio was adjusted for the covariates of age group, sex, regional health authority, rural/urban residential location, and comorbid condition grouping using a robust Poisson regression model with log link function of the generalized linear model family (determined to be superior to the log binomial regression model in providing unbiased estimates of relative risk ratios).[284] Statistical significance was defined by $p < 0.05$ that being in the Chronic Pain Group was

predictive of risk of using each health service as measured by the relative risk ratio while controlling for the measured covariates.

The mean rates of physician visits, diagnostic imaging visits, and hospital admissions per 100 person-years and the unadjusted rate ratio (95% CI) between the Chronic Pain Group and the No Chronic Pain in 2009/10 were calculated and reported. Each rate ratio was adjusted for the covariates of age group, sex, regional health authority, rural/urban residential location, and comorbid condition grouping using a negative binomial regression model of the generalized linear model family. It was considered the most parsimonious model with good performance when assessed for predicted versus observed probabilities of each dependent variable count value.[175,285] The negative binomial model performed superior to the Poisson and zero-inflated Poisson models and closely comparable/superior to the zero-inflated negative binomial model. Statistical significance was defined by $p < 0.05$ that being in the Chronic Pain Group was predictive of the mean annual rates of visits and admissions per 100 person-years as measured by the rate ratio while controlling for the measured covariates.

The categorical covariates for the regression analyses were age group (reference category: 0-24 years), sex (reference category: male), regional health authority (reference category: Eastern Regional Health Authority), rural/urban residential location (reference category: urban), and comorbid condition grouping (reference category: 0 comorbid conditions). Cohort members with missing age, sex, regional health authority, or rural/urban category data were omitted from the regression models.

Statistical Package for Social Sciences version 25 by IBM and StataIC16 by StataCorp were used for the data analysis.

4.2.8 Ethics Approval and Consent to Participate

The Health Research Ethics Board of the Health Research Ethics Authority of NL provided full approval of the study protocol (HREB Ref#2017.273). The Secondary Uses Committee of the NL Centre for Health Information and the Research Proposals Approval Committee of the Eastern Regional Health Authority also reviewed and approved the study protocol following Health Research Ethics Board approval. Since the health administrative data analyzed was part of routine data collection and normal operations of the NL Centre for Health Information, and the data was then de-identified, individual patient and/or NL resident consent was not required.

4.3 Results

4.3.1 Provincial Cohort Characteristics

The provincial cohort was comprised of 504,693 people (or 97.7% of the 2009 Census Canada reported NL population)[259] with a mean (standard deviation) age of 42.4 (21.1) years, and of which 50.9% were female, 24.2% were 24 years or younger, 15.4% were 65 years or older, 55.1% lived in urban locations, and 58.9% lived in the Eastern Regional Health Authority catchment area. With respect to health care utilization, each member of the provincial cohort was followed from April 1, 2009 to March 31, 2010 for a total of 504,693 person-years and no assumed loss to follow up. The Chronic Pain Group was comprised of 184,580 people or 36.6%% of the provincial cohort (Table 4.1). Proportions in the female, 45 years and older age groups, urban residential location, Eastern Regional Health Authority residential location, and each pain condition group

stratum were all significantly higher in the Chronic Pain Group compared to the No Chronic Pain Group (p-value < 0.001 for all comparisons) using the Chi square test. The mean age was significantly higher at 50.8 years (18.1 years standard deviation) in the Chronic Pain Group versus 37.5 years (21.1 years standard deviation) in the No Chronic Pain Group (p-value < 0.001) using the t-test for significance.

Table 4.1. 2009/10 Fiscal Year Characteristics of the Provincial Cohort in Newfoundland and Labrador, Canada (N=504,693)

Demographic Characteristics	Chronic Pain Group[a]	No Chronic Pain Group[a]	P-value[b]
	N_{group} = 184,580	N_{group} = 320,113	
	n(% of N_{group})	n(% of N_{group})	
Age group			
0-24 years	17,353(9.4)	104,433(32.6)	<0.001
25-44 years	46,937(25.4)	93,326(29.2)	<0.001
45-64 years	78,930(42.8)	86,112(26.9)	<0.001
65 and over years	41,360(22.4)	36,241(11.3)	<0.001
Missing Category Data		1	
Sex			
Female	110,024(59.6)	146,742(45.8)	<0.001
Male	74,556(40.4)	173,370(54.2)	<0.001
Missing Category Data		1	
Rural/urban[c]			
Urban	109,202(59.2)	168,720(52.7)	<0.001
Rural	75,258(40.8)	151,193(47.2)	<0.001
Missing Category Data	120(0.1)	200(0.1)	
Regional health authority[d]			
Eastern	122,433(66.4)	174,681(54.6)	<0.001

Central	33,033(17.9)	60,766(19.0)	<0.001
Western	25,701(13.9)	53,429(16.7)	<0.001
Labrador-Grenfell	3,293(1.8)	31,037(9.7)	<0.001
Missing Category Data	120(0.1)	200(0.1)	
Pain condition group[e]			
Other Conditions Associated with Chronic Pain	165,674(89.8)	138,976(43.4)	<0.001
Musculoskeletal/Arthritis	147,211(79.8)	89,511(28.0)	<0.001
Back/Neck	124,385(67.4)	62,762(19.6)	<0.001
Headaches	94,183(51.0)	54,618(17.1)	<0.001
Musculoskeletal Trauma	56,633(30.7)	31,276(9.8)	<0.001
Neuropathic	50,496(27.4)	22,323(7.0)	<0.001
Bone Disorders	21,885(11.9)	7,535(2.4)	<0.001

Abbreviations: N_{group}, total population of group; n, number selected in stratum.

[a] Selection by the Chronic Pain Algorithm applied to 1999-2009 provincial cohort Newfoundland and Labrador Medical Care Plan Fee-for-Service Physician Claims File data determined Chronic Pain Group or No Chronic Pain Group membership. The Chronic Pain Algorithm was defined as: 1) a single encounter date with an anesthesiologist recording a chronic pain-related provincial Medical Care Plan procedure billing code (Chapter 7, Section 7.4, Appendix 4), OR 2) five or more encounter dates with any physician recording any pain-related diagnostic code (Chapter 7, Section 7.3,

Appendix 3) in a five-year period with more than 183 days separating at least two pain-related encounter dates.

[b] Statistical significance was defined as $p < 0.05$ via Chi square test.

[c] Urban residential location was defined by the community of residence having a population of 4000 or more people in the 2011 Statistics Canada Census, while communities with less than 4000 people were considered rural.

[d] Regional health authority residential classification was defined by the community of residence being in one of four of the Newfoundland and Labrador Department of Health and Community Services-defined regions.

[e] Inclusion in the pain condition group was defined as an individual having at least one encounter in the Medical Care Plan Claims File data or at least one admission in the Provincial Discharge Abstract Data (any one of the 16 allowable diagnostic codes per admission) recording a diagnosis from the pain condition diagnostic group (Chapter 7, Section 7.3, Appendix 3) from 1999-2010 (cohort members could be counted as a case for more than one pain condition group).

4.3.2 Comorbid Conditions

The prevalence of each comorbid condition as identified at any time from 1999-2009 by the CCDSS case definitions was significantly higher in the Chronic Pain Group than in the No Chronic Pain Group (Fig. 4.1a). The prevalence of being in the Chronic Pain Group was significantly higher for cases compared to non-cases of each comorbid condition (Fig. 4.1b). The odds of having each comorbid condition was significantly higher for the Chronic Pain Group compared to the No Chronic Pain Group as determined by the adjusted odds ratio and 95% CI (Table 4.2) via logistic regression. The adjusted odds ratio for each comorbid condition (adjusted for sex, regional health authority, and rural/urban residential location) ranged from 1.40 (95% CI: 1.36-1.43) to 4.27 (95% CI: 3.55-5.14).

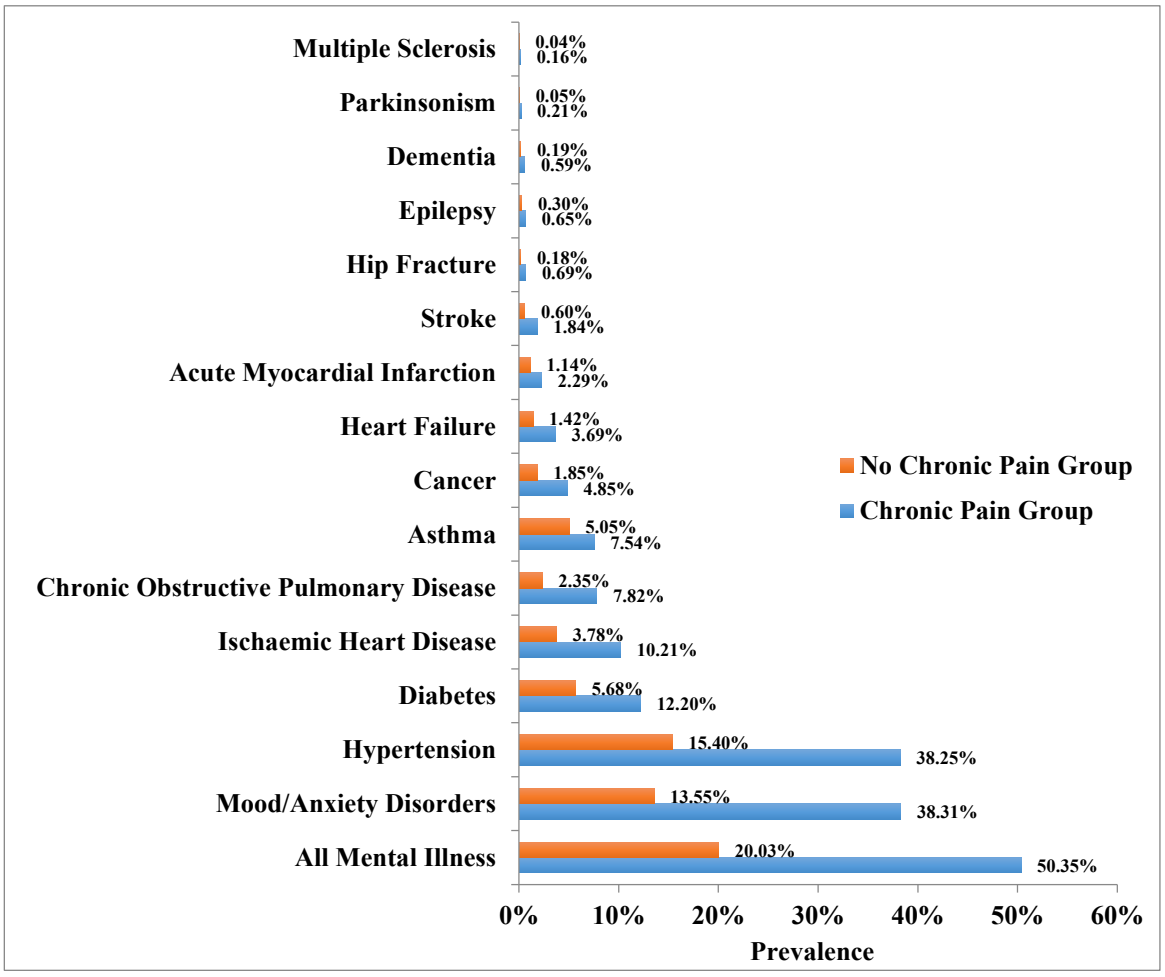

Fig. 4.1a. Comorbid Condition Prevalence by Chronic Pain Case Status in Newfoundland and Labrador, Canada

Notes: X-axis: estimated prevalence of each comorbid condition in the Chronic Pain Group and No Chronic Pain Group. Y-axis: comorbid conditions. Selection by the corresponding Canadian Chronic Disease Surveillance System case definition (Chapter 7, Section 7.6, Appendix 6) applied to the 1999-2009 provincial cohort NL MCP Fee-for-Service Physician Claims File and Provincial Discharge Abstract Data determined comorbid condition case status. Selection by the Chronic Pain Algorithm applied to 1999-

2009 provincial cohort NL MCP Fee-for-Service Physician Claims File data determined Chronic Pain Group or No Chronic Pain Group membership. The Chronic Pain Algorithm was defined as: 1) a single encounter date with an anesthesiologist recording a chronic pain-related provincial MCP procedure billing code (Chapter 7, Section 7.4, Appendix 4), OR 2) five or more encounter dates with any physician recording any pain-related diagnostic code (Chapter 7, Section 7.3, Appendix 3) in a five-year period with more than 183 days separating at least two pain-related encounter dates.

Abbreviations: NL, Newfoundland and Labrador; MCP, Medical Care Plan.

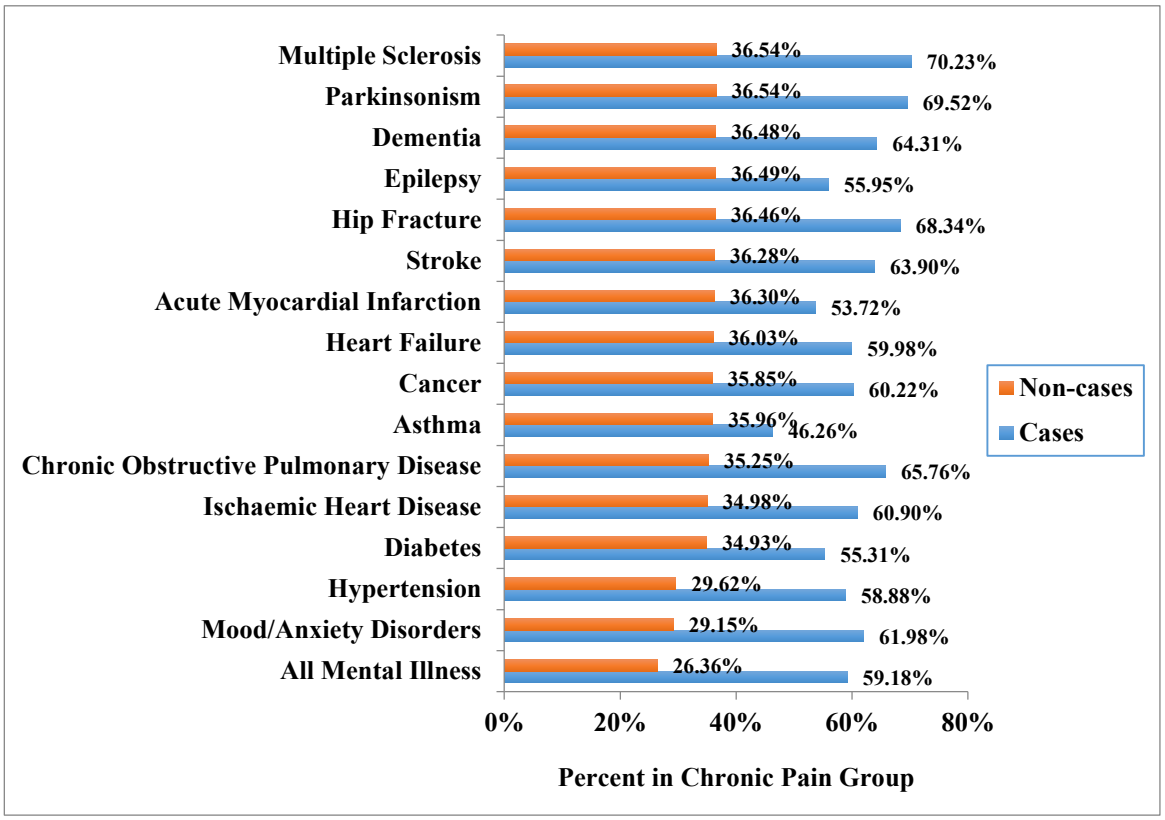

Fig. 4.1b. Chronic Pain Group Percentage by Comorbid Condition Case Status in Newfoundland and Labrador, Canada

Notes: X-axis: estimated percentage of the cases and non-cases of each comorbid condition identified by the Chronic Pain Algorithm. Y-axis: comorbid conditions. Selection by the corresponding Canadian Chronic Disease Surveillance System case definition (Chapter 7, Section 7.6, Appendix 6) applied to the 1999-2009 provincial cohort NL MCP Fee-for-Service Physician Claims File and Provincial Discharge Abstract Data determined comorbid condition case status. Selection by the Chronic Pain Algorithm applied to 1999-2009 provincial cohort NL MCP Fee-for-Service Physician Claims File data determined Chronic Pain Group membership. The Chronic Pain Algorithm was defined as: 1) a single encounter date with an anesthesiologist recording a chronic pain-

related provincial MCP procedure billing code (Chapter 7, Section 7.4, Appendix 4), OR 2) five or more encounter dates with any physician recording any pain-related diagnostic code (Chapter 7, Section 7.3, Appendix 3) in a five-year period with more than 183 days separating at least two pain-related encounter dates.

Abbreviations: NL, Newfoundland and Labrador; MCP, Medical Care Plan.

Table 4.2. Association between Comorbid Conditions[a] and Chronic Pain[b] in Newfoundland and Labrador, Canada

Co-morbid Condition	Unadjusted Odds Ratio (95% CI)	Adjusted[c] Odds Ratio (95% CI)	P-value[d]
All Mental Illness	4.05(4.00-4.10)	**3.62(3.58-3.67)**	< 0.001
Mood/Anxiety Disorders	3.96(3.91-4.02)	**3.51(3.46-3.56)**	< 0.001
Hypertension	3.40(3.36-3.45)	**3.25(3.21-3.30)**	< 0.001
Diabetes	2.31(2.26-2.35)	**2.35(2.30-2.40)**	< 0.001
Ischemic Heart Disease	2.89(2.83-2.96)	**3.20(3.12-3.29)**	< 0.001
Chronic Obstructive Pulmonary Disease	3.53(3.43-3.63)	**3.67(3.57-3.78)**	< 0.001
Asthma	1.53(1.50-1.57)	**1.40(1.36-1.43)**	< 0.001
Cancer	2.71(2.62-2.80)	**2.75(2.65-2.84)**	< 0.001
Heart Failure	2.66(2.56-2.76)	**3.15(3.02-3.27)**	< 0.001
Acute Myocardial Infarction	2.04(1.95-2.13)	**2.31(2.20-2.41)**	< 0.001
Stroke	3.11(2.94-3.29)	**3.30(3.12-3.50)**	< 0.001
Hip Fracture	3.76(3.41-4.15)	**3.31(3.00-3.66)**	< 0.001
Epilepsy	2.21(2.03-2.41)	**2.27(2.08-2.48)**	< 0.001
Dementia	3.14(2.84-3.47)	**2.89(2.61-3.20)**	< 0.001
Parkinsonism	3.96(3.31-4.74)	**4.27(3.55-5.14)**	< 0.001

Multiple Sclerosis	4.10(3.33-5.04)	**4.00(3.22-4.95)**	< 0.001

Abbreviations: CI, confidence interval.

[a] Selection by the corresponding Canadian Chronic Disease Surveillance System case definition (Chapter 7, Section 7.6, Appendix 6) applied to the 1999-2009 provincial cohort Newfoundland and Labrador Medical Care Plan Fee-for-Service Physician Claims File and Provincial Discharge Abstract Data determined comorbid condition case status

[b] Selection by the Chronic Pain Algorithm applied to 1999-2009 provincial cohort Newfoundland and Labrador Medical Care Plan Fee-for-Service Physician Claims File data determined chronic pain case status. The Chronic Pain Algorithm was defined as: 1) a single encounter date with an anesthesiologist recording a chronic pain-related provincial billing Medical Care Plan procedure code (Chapter 7, Section 7.4, Appendix 4), OR 2) five or more encounter dates with any physician recording any pain-related diagnostic code (Chapter 7, Section 7.3, Appendix 3) in a five-year period with more than 183 days separating at least two pain-related encounter dates.

c. Adjusted for sex, regional health authority, and rural/urban residential location using a logistic regression model.

d. Statistical significance was defined as $p < 0.05$.

An estimated 74.7% of the Chronic Pain Group were identified to have at least one comorbid condition between 1999 and 2009, and 16.9% were identified to have at least three comorbid conditions. The Chronic Pain Group members were identified to have a mean (standard deviation) of 1.41 (1.30) comorbid conditions (range 0-10), compared to the No Chronic Pain Group members who were identified to have a mean (standard deviation) of 0.58 (0.93) comorbid conditions (range 0-9). The likelihood of being identified as having one, two, or three or more comorbid conditions was significantly higher in the Chronic Pain Group than in the No Chronic Pain Group as determined by the odds ratio and 95% CI adjusted for the covariates of sex, regional health authority, and rural/urban residential location. The adjusted odds ratio between the Chronic Pain Group and the No Chronic Pain Group of having one comorbid condition from 1999-2009 was 1.56 (95% CI: 1.54-1.58), of having two comorbid conditions was 2.87 (95% CI: 2.83-2.93), and of having three or more comorbid conditions was 4.25 (95% CI: 4.16-4.34).

4.3.3 Health Care Utilization

In the 2009/10 fiscal year, 73.0% (95% CI: 72.9-73.2%) of the overall provincial cohort had at least one family physician visit, 58.3% (95% CI: 58.1-58.4%) had at least one other specialty physician visit, 37.3% (95% CI: 37.2-37.5%) had at least one general radiograph assessment visit, 9.3% (95% CI: 9.2-9.4%) had at least one computed tomography scan visit, and 2.2% (95% CI: 2.2-2.3%) had at least one magnetic resonance imaging scan visit. In the 2009/10 fiscal year, 11.0% (95% CI: 10.9-11.1%) of the

provincial cohort had at least one day surgery admission, and 7.1% (95% CI: 7.1-7.2%) had at least one inpatient admission.

In 2009/10, there was a significantly higher likelihood (Table 4.3) of Chronic Pain Group members than No Chronic Pain Group members to have a physician visit (94.6% (95% CI: 94.5-94.7%) versus 74.5% (95% CI: 74.3-74.6%), adjusted relative risk ratio: 1.12 (95% CI: 1.12-1.13)), a diagnostic imaging visit (62.5% (95% CI: 62.3-62.7%) versus 35.0% (95% CI: 34.8-35.1%), adjusted relative risk ratio: 1.41 (95% CI: 1.40-1.42)), or a hospital admission (23.0% (95% CI: 22.8-23.1%) versus 12.7% (95% CI: 12.6-12.8%), adjusted relative risk ratio: 1.40 (95% CI: 1.38-1.42)) as determined by the relative risk ratio, adjusted for age group, sex, regional health authority, rural/urban residential location, and number of comorbid conditions using a robust Poisson regression model with log link function. As expected, the relative risk ratio for visits (2.14 (95% CI: 2.12-2.16)) and admissions (3.07 (95% CI: 2.92-3.23)) for pain-related conditions (based on the diagnostic code associated with the visit or admission being classified as pain-related (Chapter 7, Section 7.3, Appendix 3)) between Chronic Pain Group members and No Chronic Pain Group members was higher than the relative risk ratio for all-cause visits (1.12 (95% CI: 1.12-1.13)) and admissions (1.40 (95% CI: 1.38-1.42)).

Table 4.3. Risk to Utilize Health Services in Newfoundland and Labrador, Canada in 2009/10

Health Service Type	Chronic Pain Group[a]	No Chronic Pain Group[a]	Unadjusted Relative Risk Ratio (95% CI)	Adjusted[b] Relative Risk Ratio (95% CI)	P-value[c]
	N=184,580	N=320,113			
	% risk (95% CI)	% risk (95% CI)			
All-cause reason					
Any Family Physician visit	90.2 (90.1-90.4)	63.1 (63.0-63.3)	1.43(1.42-1.43)	**1.20(1.20-1.21)**	<0.001
Any Specialist[d] Visit	75.9 (75.7-76.1)	48.1 (47.9-48.2)	1.58(1.57-1.59)	**1.28(1.28-1.29)**	<0.001
Any Day Surgery Admission	16.3 (16.2-16.5)	8.0 (7.9-8.1)	2.05(2.02-2.09)	**1.55(1.52-1.57)**	<0.001
Any Inpatient Admission	9.3 (9.2-9.5)	5.9 (5.8-5.9)	1.59(1.56-1.62)	**1.20(1.18-1.23)**	<0.001
Pain-related reason[e]					
Any Family Physician Visit	52.9 (52.7-53.1)	19.1 (19.0-19.3)	2.77(2.74-2.79)	**2.21(2.19-2.23)**	<0.001
Any Specialist Visit	16.1 (15.9-16.3)	4.2 (4.2-4.3)	3.81(3.73-3.88))	**2.74(2.68-2.80)**	<0.001
Any Day Surgery Admission	1.9 (1.9-2.0)	0.5 (0.5-0.5)	4.03(3.80-4.27)	**3.24(3.04-3.46)**	<0.001

Any Inpatient Admission	1.3 (1.2-1.3)	0.4 (0.3-0.4)	3.65(3.41-3.92)	**2.89(2.68-3.13)**	<0.001
Diagnostic Imaging					
Any General Radiograph Assessment	53.2 (52.9-53.4)	28.2 (28.1-28.4)	1.88(1.87-1.90)	**1.46(1.45-1.47)**	<0.001
Any Computed Tomography Scan	15.2 (15.1-15.4)	5.9 (5.8-5.9)	2.60(2.55-2.65)	**1.72(1.69-1.76)**	<0.001
Any Magnetic Resonance Imaging Scan	3.7 (3.6-3.8)	1.4 (1.3-1.4)	2.66(2.57-2.77)	**2.05(1.96-2.14)**	<0.001

Abbreviations: N, total number in group; CI, confidence interval.

[a] Selection by the Chronic Pain Algorithm applied to 1999-2009 provincial cohort Newfoundland and Labrador Medical Care Plan Fee-for-Service Physician Claims File data determined Chronic Pain Group or No Chronic Pain Group membership. The Chronic Pain Algorithm was defined as: 1) a single encounter date with an anesthesiologist recording a chronic pain-related provincial Medical Care Plan procedure billing code (Chapter 7, Section 7.4, Appendix 4), OR 2) five or more encounter dates with any physician recording any pain-related diagnostic code (Chapter 7, Section 7.3, Appendix 3) in a five-year period with more than 183 days separating at least two pain-related encounter dates.

[b] Adjusted for the covariates of age group, sex, regional health authority, rural/urban residential location, and number of comorbid conditions using a robust Poisson regression model with log link function.

[c] Statistical significance was defined as $p < 0.05$.

[d] Specialist defined as any physician from another specialty than family medicine.

[e] Presence of a pain-related diagnostic code (Chapter 7, Section 7.3, Appendix 3) with the physician claim or as the Most Responsible Reason for admission.

In 2009/10, the mean all-cause visit rates per 100 person-years for the overall provincial cohort was 478 (95% CI: 476-480) family physician visits, 418 (95% CI: 415-420) other specialty physician visits, 92 (95% CI: 91-92) general radiograph assessment visits, 21 (95% CI: 21-21) computed tomography scan visits, and 6 (95% CI: 6-6) magnetic resonance imaging visits. The mean all-cause admission rates per 100 person-years in 2009/10 for the overall provincial cohort was 15 (95% CI: 15-15) day surgery admissions and 10 (95% CI: 10-10) inpatient admissions. Pain-related visits/admissions comprised 17.4% of all family physician visits, 6.9% of all specialist visits, 9.9% of all day surgery admissions, and 7.6% of all inpatient admissions.

In 2009/10, 58.8% of all physician visits, 57.6% of all diagnostic imaging visits, and 54.2% of all hospital admissions were attributed to the Chronic Pain Group. Proportion of all visits/admissions attributed to pain-related conditions was higher for the Chronic Pain Group compared to the No Chronic Pain Group, comprising 21.5% versus 11.6% of all per group family physician visits, 8.7% versus 4.4% of all per group specialist visits, 13.1% versus 5.6% of all per group day surgery admissions, and 10.4% versus 4.9% of all per group inpatient admissions.

In 2009/10, the mean all-cause rates and 95% CI per 100 person-years (Table 4.4) was significantly higher for the Chronic Pain Group compared to the No Chronic Pain Group for physician visits (1440 (95% CI: 1432-1448) versus 582 (95% CI: 579-584), adjusted rate ratio: 1.63 (95% CI: 1.62-1.65)), diagnostic imaging visits (260 (95% CI: 258-262) versus 110 (95% CI: 109-111), adjusted rate ratio: 1.64 (95% CI: 1/62-1/66)), and hospital admissions (36 (95% CI: 36-37) versus 18 (95% CI: 18-18), adjusted rate ratio: 1.50 (95% CI: 1.47-1.52)) as determined by the rate ratio adjusted for age group,

sex, regional health authority, rural/urban residential location, and number of comorbidities using a negative binomial regression model. As expected, the adjusted rate ratio for pain-related physician visits (3.28 (95% CI: 3.24-3.32)) and hospital admissions (3.72 (95% CI: 3.52-3.93)) between Chronic Pain Group members and No Chronic Pain Group members was higher than the adjusted rate ratio for all-cause physician visits (1.63 (95% CI: 1.62-1.65)) and admissions (1.50 (95% CI: 1.47-1.52)).

Table 4.4. 2009/10 Fiscal Year Health Service Utilization Rates in Newfoundland and Labrador, Canada

Health Service Type	Chronic Pain Group[a]	No Chronic Pain Group[a]	Unadjusted Rate Ratio (95% CI)	Adjusted[b] Rate Ratio (95% CI)	P-value[c]
	Mean rate (95% CI) per 100 person-years	Mean rate (95% CI) per 100 person-years			
All-cause reason					
Family Physician Visits	770 (766-775)	309 (308-311)	2.49(2.47-2.51)	**1.71(1.70-1.72)**	<0.001
Specialist[d] Visits	669 (664-675)	272 (270-273)	2.46(2.43-2.48)	**1.57(1.56-1.59)**	<0.001
Day Surgery Admissions	23 (23-23)	10 (10-10)	2.32(2.28-2.36)	**1.68(1.65-1.72)**	<0.001
Inpatient Admissions	13 (13-14)	8 (8-8)	1.71(1.67-1.75)	**1.24(1.20-1.27)**	<0.001
Pain-related reason[e]					
Family Physician Visits	166 (165-167)	36 (35-36)	4.64(4.59-4.70)	**3.34(3.30-3.38)**	<0.001
Specialist Visits	58 (57-59)	12 (12-12)	4.83(4.71-4.96)	**3.12(3.03-3.21)**	<0.001

Day Surgery Admissions	3 (3-3)	0.6 (0.5-0.6)	5.39(5.05-5.75)	**4.17(3.88-4.49)**	<0.001
Inpatient Admissions	1 (1-1)	0.4 (0.4-0.4)	3.64(3.39-3.91)	**2.94(2.71-3.19)**	<0.001
Diagnostic Imaging					
General Radiograph Assessment	145 (143-146)	61 (61-61)	2.37(2.34-2.39)	**1.71(1.70-1.73)**	<0.001
Computed Tomography Scans	34 (34-35)	13 (13-13)	2.60(2.54-2.67)	**1.68(1.64-1.73)**	<0.001
Magnetic Resonance Imaging Scans	10 (10-10)	4 (4-4)	2.69(2.55-2.84)	**2.13(2.01-2.26)**	<0.001

Abbreviations: CI, confidence interval.

[a] Selection by the Chronic Pain Algorithm applied to 1999-2009 provincial cohort Newfoundland and Labrador Medical Care Plan Fee-for-Service Physician Claims File data determined Chronic Pain Group or No Chronic Pain Group membership. The Chronic Pain Algorithm was defined as: 1) a single encounter date with an anesthesiologist recording a chronic pain-related provincial Medical Care Plan procedure billing code (Chapter 7, Section 7.4, Appendix 4), OR 2) five or more encounter dates

with any physician recording any pain-related diagnostic code (Chapter 7, Section 7.3, Appendix 3) in a five-year period with more than 183 days separating at least two pain-related encounter dates.

[b] Adjusted for the covariates of age group, sex, regional health authority, rural/urban residential location, and number of comorbid conditions using a negative binomial regression model.

[c] Statistical significance was defined as $p < 0.05$.

[d] Specialist defined as any physician from another specialty than family medicine.

[e] Presence of a pain-related diagnostic code (Chapter 7, Section 7.3, Appendix 3) with the physician claim or as the Most Responsible Reason for admission.

4.4 Discussion

The present study used a validated health administrative data case definition to create population-based chronic pain comparator groups, and measured prevalence of comorbid conditions and one-year levels of hospitalizations and fee-for-service physician visits by using province-level health administrative datasets in Canada. There were three main findings. First, the Chronic Pain Group (36.6% of the provincial cohort) accounted for significantly higher total utilization of measured publicly funded health care, including physician visits (58.8%), diagnostic imaging visits (57.6%), and hospital admissions (54.2%). Second, even after controlling for potential confounding variables, the Chronic Pain Group had about 2-4 times the odds of being identified as having other comorbid conditions, most notably mental health, cardiovascular, and neurodegenerative conditions. And finally, additional data analysis exposed the clinically unexpected finding that physician visits and hospital admissions for pain-related conditions formed a small percentage of the total measured utilization, even for the Chronic Pain Group.

4.4.1 Chronic Pain and Excess Health Care Utilization

When adjusting for demographics and comorbid conditions, the Chronic Pain Group had a 24-113% higher rate of public health service use in 2009/10 than the No Chronic Pain Group. While variation in sample characteristics and health service availability described in other Canadian and global studies make it difficult to compare statistics,[169,171,180,273,286,287] the present study adds to the body of knowledge that the presence of chronic pain is strongly associated with increased health care

utilization.[169,171,172] Multiple factors are cited to contribute to this excess service use, including provider practice patterns, increased health service availability, higher pain-related interference, multi-morbidity, and lower socioeconomic status.[179,273,288] Health care utilization is also known to increase with use of prescribed opioids,[289] for which multi-morbidity[290] and increased psychological distress[291] are known risk factors. It was beyond the scope of the administrative data and this study to investigate all contributing factors and determine causation, but some confounding was mitigated by controlling for the age and sex predisposing factors, the residential location enabling factor, and the comorbidity need factor.[179,272,280]

Health care utilization statistics can serve as a proxy for cost estimates, the more services utilized the higher the direct health care costs.[203,292] Chronic Pain Group members had particularly high usage of expensive services (specialist assessments, hospital admissions, and specialized imaging tests), which increase overall direct health care costs.[176,179] Appropriate management of chronic pain conditions might have necessitated high utilization of these services.[175] However, it's more likely that lack of satisfactory pain control and subsequent reduced quality of life contributed to the increased family physician visits, multiple specialist referrals, and multiple diagnostic imaging requisitions.[62,175] Coordinated management of chronic pain emphasizing self-management/pain self-efficacy reduces pain-related interference on function reducing reliance on acute and specialized health care resources.[41,175,179-181] The present study provides estimated health care utilization levels in one province in Canada against which to compare when recommended changes to policy, resource allocation, and clinical management occur.[293]

4.4.2 Chronic Pain and Comorbid Conditions

The aging demographics, higher chronic disease rates, and poorer population health indicators in NL compared to other Canadian jurisdictions highlight the importance of measuring the association between chronic pain and comorbid conditions for the purposes of public health initiatives and resource planning.[188,189] Provincial cohort members in the Chronic Pain Group had up to four times the odds of having any single comorbid condition and four times the odds of having three or more comorbid conditions than members in the No Chronic Pain Group. The findings from the NL data support other studies describing the strong association between chronic pain and other chronic diseases, despite varying methods of case ascertainment and data sources.[108,178,275] Reports indicate a comorbid condition prevalence of 4.2% to 76.1% in chronic pain populations, depending on the comorbid condition,[296,287] and a chronic pain prevalence of 13%-94%[44,48,108-111] in people with specific comorbid conditions. There is commonality in the complex biological, psychological, social, cultural, and genetic processes involved in the development of the comorbid conditions measured in this study and chronic pain.[32,38,101,277,294] Regardless of whether chronic pain was the primary or secondary chronic disease diagnosis, its effect on stress levels, physical activity, and overall quality of life negatively impacts a person's ability to maximize recovery and effectively manage chronic disease in the long term.[109,113,295-297] Concurrent management of pain with chronic disease may improve clinical outcomes and mitigate the negative effects on quality of life.[293]

4.4.3 Pain-related Versus Non-pain-related Care

Not surprisingly, the Chronic Pain Group had 3.64-5.39 times (unadjusted) the rate of physician visits and hospitalizations for pain-related conditions compared to the No Chronic Pain Group. However, only 15.6% of the physician claims and 12.1% of the hospital admissions attributed to the Chronic Pain Group were for pain-related conditions. Studies previously reported more than 50% of physician and hospital encounters in other jurisdictions were for non-pain-related reasons.[24,279] Chronic pain has a strong association with multi-comorbidity, and chronic diseases - such as diabetes - necessitate more frequent medical follow-up to monitor treatment effectiveness (e.g. medication or lifestyle changes) over time.[179,286,298] Pain developing secondary to some chronic diseases may represent disease progression requiring more advanced care management (e.g. specialist referral, hospitalization, or advanced diagnostic testing).[293] Since only one diagnostic code was allowed per claim, the attending physician may have recorded the code for the worsening chronic disease rather than the pain related to it.[208] However, coding errors may have resulted, in part, from delayed recognition of pain as the primary issue, thus recording the non-pain-related diagnosis as the primary reason for the encounter/admission.[180,182,299] The discord in care versus the patient's needs is known to delay appropriate referral to pain management services prolonging suffering, which influences higher utilization of acute care services.[111,295,300] Despite multiple studies highlighting the significant impact of pain on chronic disease management, clinical practice guidelines frequently do not include pain management in the

recommendations.[171,279,301] Clearly, people identified as having chronic pain in NL have complex health needs requiring complex, interdisciplinary care.

4.4.4 Strengths, Limitations, and Generalizability

There were two main strengths to this study. First, the NL health administrative data sources used in this study had wide coverage and regular data quality checks,[216,218] and it was not subject to the recall bias, sampling errors, or low response rates that can plague survey data.[65,302] The large sample size, large number of identified chronic pain cases, and large number of observations allowed for tests for significance of association between chronic pain and many variables (involving comorbidities and health care utilization types) while minimizing the risk of Type 1 error. Second, the chronic pain and comorbid condition coding algorithms were validated in the same datasets (MCP Fee-for-Service Physicians Claims File and NL PDAD) and were subjected to the same data limitations, which increased internal reliability of results.

There were six main limitations in this study. First, a limitation for all studies involving secondary use of health administrative data is the dependence of its data accuracy on entry at source.[66,67,231] Second, there was non-differential misclassification bias between the chronic pain and the comorbid condition case definitions in the NL claims data when assessing strength of association in this study, with contributions from potential coding errors, undiagnosed chronic conditions, and one code entry per claim limit.[66,199,270] Third, the strength of the association between chronic pain and comorbid conditions were, in part, influenced by medical surveillance bias where regular health care encounters to manage one condition increased the likelihood of identifying presence

of another.[303] Fourth, the unavailability of data collected from visits to pharmacies (i.e. medication data), emergency rooms, salaried physicians, allied health professionals, and those funded by third-party payers likely negatively impacted chronic pain and comorbid condition case ascertainment, particularly in rural and/or non-Eastern Regional Health Authority areas.[169,172,176,267,270] The large range of unavailable health service data also significantly narrowed the descriptive scope of health care utilization associated with chronic pain from a geographic and demographic patterns of behavior perspective. Fifth, adjusting for the potential bias to the chronic pain exposure measurement introduced by the Chronic Pain Algorithm (potential over-ascertainment) and the non-fee-for-service physician data unavailability (potential under-ascertainment)[270] would be complex and require access to variables and datasets outside the scope of this thesis.[224,270] Therefore, the measures of the chronic pain disease burden on the health care system should be interpreted with caution. Finally, subjective data describing important factors impacting health care utilization, such as self-reports of pain severity/interference,[181] were not captured by the administrative data sources.

The health care utilization rates reported in this study should not be generalized to the Canadian population due to potential differences in regional practice and remuneration patterns.[197,267] The comorbid condition presence and health care utilization estimates provided are representative for the NL population up to the 2009/10 fiscal year. Given that patterns of disease may have shifted in the last decade, the present study provides a baseline against which to compare future estimations using the presented methodology. While assessing the strength of association between NL health administrative data-derived variables and the presence of chronic pain as determined by

the Chronic Pain Algorithm was considered an appropriate use of the Algorithm, its performance on selection accuracy testing precludes its utility in assessing causation with chronic pain as the exposure or outcome. It is recommended the Chronic Pain Algorithm undergo validation in target population health administrative data prior to its utilization in non-NL jurisdictions.[66] However, similarity in the structure of health service delivery and physician claims/hospital discharge datasets across Canadian jurisdictions increases the generalizability of the chronic pain/chronic disease case ascertainment and health care utilization quantification methods presented in this study.[200,281]

4.5 Conclusions

The present study provides, for the first time in NL, estimates of comorbid condition prevalence and publicly funded health care utilization of people identified as having chronic pain from health administrative data. There was a modest to strong association, approximately 2-4 times the odds, between having chronic pain and having one or more chronic comorbid conditions. Being identified as having chronic pain was modestly associated with having more annual physician visits (nearly 8 family physician visits and 7 specialist visits) and a higher likelihood of expensive diagnostic imaging scans (17%) and hospital admissions (23%), up to twice that of people not identified as having chronic pain when controlling for measured confounders. However, about 84% of physician and 88% of hospital care of Chronic Pain Group members was for conditions not related to pain; a further indication of the complexities to address when managing a chronic pain condition. Deeper examination of the patient-level, practitioner-level, and

system-level factors driving higher health care utilization by NL residents may foster more effective personalized care of individuals with chronic conditions, including pain.

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4.7 Co-authorship Statement

Author Contributions: All authors read and approved the submitted version of Chapter 4. All authors agreed to be personally responsible for their own contribution and ensure that questions related to the accuracy or integrity of any part of the work, even ones in which the author was not personally involved, are appropriately investigated, resolved, and the resolution documented in the literature. Heather E. Foley drafted the work and substantively revised it, and made substantial contributions towards the study design, data acquisition, analysis, and interpretation. Dr. John C. Knight substantively revised the work, and made substantial contributions towards study design, data

acquisition, analysis, and interpretation. Dr. Michelle Ploughman substantively revised the work, and made substantial contributions towards study conception and design and data acquisition and interpretation. Dr. Shabnam Asghari substantively revised the work, and made substantial contributions towards study design, and data acquisition, analysis, and interpretation. Dr. Rick Audas substantively revised the work, and made substantial contributions to the study design, and data acquisition, analysis, and interpretation.

Chapter 5 Summary

5.1 Thesis Overview

Epidemiologic and health care utilization estimates associated with chronic pain in Canada were reported from national/regional survey data and/or provincial administrative data.[18,23,35,43,45,46,49,54-57,169,178,222] However, such estimates varied widely, utilized inconsistent chronic pain case definitions and data collection/linkage methods, and often excluded smaller jurisdictions such as Newfoundland and Labrador (NL).[45,46,47,49,54,57,178] To fill this knowledge gap, this study aimed to apply standardized methodology to compile detailed estimates on the chronic pain condition in the NL context, which can be used to inform health service provision policy for people with chronic pain. Most published estimates on the disease burden of chronic pain globally and in Canada utilized cross-sectional and/or longitudinal surveys as a data source to identify cases of chronic pain and estimate disease epidemiology and costs.[26,39,57,169] The Canadian Community Health Survey and the National Population Health Survey administered by Statistics Canada regularly collect data that is used to estimate the prevalence and quality of life impact of chronic pain in Canada, but the sample drawn from NL was too small to stratify estimates and provide meaningful statistics.[187,214] Using survey methodology with a longitudinal cohort study design to obtain incidence and prevalence estimates of chronic pain in NL was considered cost prohibitive with respect to funding, time, and human resources.[65]

This study sought to achieve its aim by using health administrative data as its data source, which contains regularly collected demographic and health care information on

nearly all NL residents eligible for the Medical Care Plan (MCP). Current guidelines recommend using an algorithm validated for the target NL jurisdiction to ascertain chronic pain cases from health administrative data and obtain disease-specific information.[66] While there are reports of health administrative data algorithms being developed and validated for specific chronic pain conditions, there are none for chronic pain as a single chronic disease to the best of knowledge.[70] Three steps were utilized in this thesis to compile statistics on chronic pain in NL using health administrative data as a data source.

The first step (Chapter 2) was to determine whether NL health administrative data would provide valid information on cases of chronic pain. The study did this by: (1) deriving a case definition that could identify cases of chronic pain as a single chronic disease from NL health administrative data; and (2) validating the case definition against an audit of the primary health electronic medical record data of a NL patient cohort. The second step (Chapter 3) was to utilize the most performant chronic pain algorithm from step one to ascertain cases of chronic pain from residents attending encounters with fee-for-service physicians for pain-related conditions in NL and describe incidence and prevalence of chronic pain. The most performant algorithm was defined as: 1) a single encounter date with an anesthesiologist recording a chronic pain-related provincial MCP procedure billing code (Chapter 7, Section 7.4, Appendix 4) in the MCP Claims File, OR 2) five or more encounter dates with any physician recording any pain-related diagnostic code (Chapter 7, Section 7.3, Appendix 3) in a five-year period with more than 183 days separating at least two pain-related encounter dates in the MCP Claims File. The study determined: (1) annual prevalence of chronic pain (as defined by the most performant

chronic pain algorithm) in NL from 2006/07 to 2009/10 fiscal years; (2) annual incidence rates of chronic pain (as defined by the most performant chronic pain algorithm) in NL from 2006/07 to 2009/10 fiscal years; and (3) demographic and geographic distribution of chronic pain (as defined by the most performant chronic pain algorithm) in NL stratified by sex, age group, health authority region of residence, and rural/urban residential location. The third step (Chapter 4) was to determine the association of chronic pain (as defined by the most performant algorithm) with other comorbid conditions and publicly funded health care utilization in NL. The study did this by: (1) characterizing and comparing comorbid condition prevalence in NL provincial cohort members identified as having chronic pain (as defined by the most performant chronic pain algorithm) to NL provincial cohort members not identified as having chronic pain; and (2) characterizing and comparing the 2009/10 fiscal year health care utilization of NL provincial cohort members identified as having chronic pain (as defined by the most performant chronic pain algorithm) to NL provincial cohort members not identified as having chronic pain.

5.2 Summary of Findings

The following sections summarize and discuss the key findings of each thesis chapter.

5.2.1 Chapter 2 Key Findings

Chapter 2 aimed to determine if Canadian health administrative data would provide valid information on cases of chronic pain as a discrete chronic disease. The aim was achieved via algorithm derivation using administrative data of known chronic pain cases,

and validation against an electronic medical records data audit of a primary health care patient population. There were three key findings. First, the most performant algorithm was chosen based on its utility for chronic pain case ascertainment from NL health administrative data. The Chronic Pain Algorithm was defined as: (1) a single encounter date with an anesthesiologist recording a chronic pain-related provincial MCP procedure billing code in the MCP Fee-for-Service Physicians Claims File; OR (2) five or more encounter dates with any physician recording any pain-related diagnostic code in a five-year period with more than 183 days separating at least two pain-related encounter dates in the MCP Fee-for-Service Physicians Claims File. Second, the Chronic Pain Algorithm identified a high number of false positive and false negative cases impacting its performance on validation tests for selection accuracy, especially positive predictive value, likelihood ratio positive and negative, and area under the Receiving Operator Characteristic curve. It was thus indicated that caution be exercised in assigning an individual a diagnosis of having/not having chronic pain based on Chronic Pain Algorithm selection status, which precluded Algorithm utilization for assessment of causation, adverse events, and intervention effectiveness. Since disease measurement was based on physician encounters, lower performance on selection accuracy measures, especially positive predictive value, does not necessarily indicate uneven distribution of chronic pain cases across geographic and demographic strata. The Chronic Pain Algorithm has significant value in assessing the basic characteristics of chronic pain distribution provincially and regionally in NL, and making comparisons of captured health administrative data variables across groups in NL. As a result, the third key finding was that a credible reflection of geographic and demographic variation in chronic pain

distribution among NL residents could be obtained by ascertaining cases from MCP Fee-for-Service Physicians Claims Data using the Chronic Pain Algorithm. This was evidenced by the Chronic Pain Algorithm identifying 37.6% of a NL provincial cohort that was comparable to the 36% Atlantic Canada chronic pain prevalence previously reported by a national survey, even though apparent bias toward case over-ascertainment occurred in the Reference Standard Cohort. When interpreting NL strata-specific estimates for age and health authority region of residence obtained by the Chronic Pain Algorithm, an important caveat to consider is the demographic skew of the Reference Standard Cohort towards older age groups and the Eastern Regional Health Authority residential locations compared to the NL general population (as demonstrated in Fig. 2.2.). This potentially exposed the Chronic Pain Algorithm to differential misclassification bias (which was quantified in age group strata but may also have impacted Regional Health Authority strata) during validation and suggests caution be exercised in interpreting Algorithm-obtained age and regional health authority strata-specific estimates, particularly in children/young adults and older persons..

There were three main conclusions elicited from Chapter 2. First, the discord among clinicians and researchers regarding diagnostic criteria for chronic pain in the absence of an objective diagnostic test made, and continues to make, for an uncertain reference standard to confirm chronic pain presence. This discord is also evident in surveys (as demonstrated by the presence of multiple definitions and methods used to measure chronic pain presence)[37,39,42,43,46,51,62,64,221] and medical records (as demonstrated by audits exposing low adherence to documenting use of standardized criteria when diagnosing certain chronic pain conditions).[232] Given that low agreement between health

administrative data and medical record or survey data was previously demonstrated for pain-related conditions,[197,209,208,232,236] low Kappa agreement between the Chronic Pain Algorithm and the Reference Standard as applied to the CPCSSN data was not unexpected. However, a low Kappa agreement does not necessarily indicate uneven distribution of chronic pain cases across geographic and demographic strata nor preclude the utilization of the Chronic Pain Algorithm in assessing this distribution in NL. Second, the limitations in the scope and structure of the NL health administrative data may have contributed to the limitations in the Chronic Pain Algorithm utility due to non-capture of other sources of care sought by people with chronic pain (i.e. visits to emergency rooms, pharmacies, non-fee-for-service physicians, and allied health practitioners).[18] Third, despite its limitations, the Chronic Pain Algorithm could be considered an efficient means to begin answering questions posed by policy makers in Canada and NL regarding disease distribution and health care utilization of people with chronic pain. When comparing this study's findings to the literature, the third conclusion is supported by: 1) the Chronic Pain Algorithm validation performance on measures of sensitivity and specificity was comparable to that reported for other health administrative data algorithms for specific chronic pain conditions such as neck/back disorders, arthritis, fibromyalgia, and painful neuropathy[206,208,248] (although it did not perform as well on validation tests as administrative data algorithms for diseases with an objective diagnostic gold standard such as diabetes,[212,213] multiple sclerosis,[67] and rheumatoid arthritis[205]), 2) disagreement between medical record/survey data and administrative data (including validation of case definitions for chronic pain-related conditions) was previously documented,[197,209] and 3) the Chronic Pain Algorithm identified 37.6% of a NL provincial cohort, which was within

the range previously reported for various Canadian regions (6.5-44%) that included the 36% chronic pain prevalence reported for Atlantic Canada.[37,53-56]

5.2.2 Chapter 3 Key Findings

Chapter 3 aimed to describe incidence and prevalence of chronic pain as defined by the Chronic Pain Algorithm in NL. The Chronic Pain Algorithm was applied to the fee-for-service physicians claims data of a provincial cohort to identify cases and estimate annual chronic pain prevalence and incidence rate for the 2006/07 to 2009/10 fiscal years. Demographic variation in chronic pain incidence rate and prevalence (as defined by the Chronic Pain Algorithm) according to sex and age group was estimated for the 2006/07 to 2009/10 fiscal years, and geographic variation in chronic pain prevalence (as defined by the Chronic Pain Algorithm) according to health authority region of residence and rural/urban residential location was estimated for the 2009/10 fiscal year.

There were four key findings. First, annual incidence rates of chronic pain as defined by the Chronic Pain Algorithm were relatively stable but the prevalence steadily increased over the four fiscal years. The 2009/10 age-standardized prevalence was estimated at 37,469 (95% confidence interval (CI): 37,347-37,591) per 100,000 population and incidence rate was estimated at 4,585 (95% CI: 4,510-4,661) per 100,000 person-years at risk. Second, prevalence and incidence rates were higher for females than males in all four fiscal years for all age groups (except the 0-14 age group). The 2009/10 age-standardized chronic pain prevalence per 100,000 population was estimated at 43,278 (95% CI: 43,108-43,448) for females versus 31,418 (95% CI: 31,248-31,588) for males, and incidence rate per 100,000 person-years at risk was estimated at 5,491 (95% CI:

5,370-5,612) for females versus 3,846 (95% CI: 3,751-3,942) for males. Third, chronic pain prevalence and incidence rates in NL increased as age increased, peaking in those 80 years and older (for whom the 2009/10 prevalence was estimated at 63,274 (95% CI: 62,565-63,984) per 100,000 population and incidence rate was estimated at 7,921 (95% CI: 7,291-8,550) per 100,000 person-years at risk). Fourth, the 2009/10 chronic pain prevalence was highest in the Eastern Regional Health Authority and urban locations. The 2009/10 age- and sex-standardized prevalence per 100,000 population was estimated at 42,371 (95% CI: 42,213-42,529) for the Eastern Regional Health Authority versus 34,861 (95% CI: 34,581-35,142) for the Central Regional Health Authority, 33,827 (95% CI: 33,524-34,131) for the Western Regional Health Authority, and 10,224 (95% CI: 9,906-10,541) for the Labrador-Grenfell Regional Health Authority. The 2009/10 crude prevalence per 100,000 population was estimated at 42,281 (95% CI: 42,097-42,464) for urban locations versus 35,953 (95% CI: 35,756-36,136) for rural locations.

There were three main conclusions from Chapter 3. First, nearly four out of ten NL residents in 2009/10 were identified as having chronic pain as defined by the Chronic Pain Algorithm making chronic pain more prevalent than other chronic diseases. The Canadian Chronic Disease Surveillance System uses similar methodology to that used in this study (applying validated algorithms to provincial/territorial fee-for-service claims files and provincial discharge abstract data) and reported that 3 out of 10 people in NL had hypertension, over 8 out of 100 people in NL had ischemic heart disease, and just over 8 out of 100 people in NL had diabetes in the 2009/10 fiscal year.[265] Second, the chronic pain incidence/prevalence and their demographic/geographic variations estimated in Chapter 3 compared with that reported in Canada and globally, and furthered the

argument that this methodology was an efficient means to obtain population-based estimates on chronic pain distribution in NL. The second conclusion was supported by: 1) the 38% annual prevalence estimated in this study being within the 2-54% annual prevalence reported globally[38-41] and 6.5-44% prevalence reported in Canada,[37,43-49,53-56] 2) the 4% annual incidence estimated in this study being within the 1.8-11.1% chronic pain annual incidence reported globally and in Canada,[52,57,62,63] 3) the higher annual incidence and prevalence estimated in females versus males in this study coinciding with the higher chronic pain annual incidence and prevalence in females versus males reported globally and in Canada,[42,45-48,52,57-59,62-64,184] and 4) the increasing annual incidence and prevalence with increased age estimated in this study coinciding with the increasing chronic pain annual incidence and prevalence with increased age reported globally and in Canada.[39,45,57-59,61,190] However, with respect to geographic variation, this study estimated higher annual prevalence in urban areas, which coincided with the higher urban chronic pain annual prevalence reported globally[62] but differed from the rural/urban variation reported in Canada (either no difference[57] in rural/urban or higher rural[56] chronic pain prevalence). Third, there was possible underestimation of chronic pain rates in NL residents under 34 years (due to the differential age-related misclassification bias of the Chronic Pain Algorithm discussed in Chapter 2 where algorithm sensitivity was 0.250-0.576 for these age groups) and in residents of rural regions and the Labrador-Grenfell Health Authority region (due to non-capture of encounters with physicians remunerated through salary and alternate payment plans), which is an important consideration when examining service access for these subpopulations.

5.2.3 Chapter 4 Key Findings

Chapter 4 aimed to determine the strength of association of chronic pain (as defined by the Chronic Pain Algorithm) with the presence of other comorbid chronic conditions and the utilization of publicly funded health services. The Chronic Pain Algorithm was applied to the fee-for-service physician claims data of a NL population cohort to create population-based Chronic Pain and No Chronic Pain comparator groups. The prevalence of 16 comorbid conditions as defined by the Canadian Chronic Disease Surveillance System case definitions was determined for both comparator groups; their strength of association with the presence of chronic pain was estimated. The utilization of fee-for-service physician services and hospital-based services was quantified in both comparator groups; their strength of association with the presence of chronic pain was estimated.

There were three key findings. First, after controlling for potential confounding variables, there was a modest association between the presence of chronic pain (as defined by the Chronic Pain Algorithm) and the utilization of fee-for-service physician services (adjusted relative risk ratio of 1.63 (95% CI: 1.62-1.65)) and hospital services (adjusted relative risk ratio of 1.50 (95% CI: 1.47-1.52)). Second, after controlling for potential confounding variables, there was a modest to strong association between the presence of chronic pain (as defined by the Chronic Pain Algorithm) and the presence of chronic comorbid conditions (as defined by the Canadian Chronic Disease Surveillance System case definitions) (odds ratio ranging from 1.40 (95% CI: 1.36-1.43) to 4.27 (95% CI: 3.55-5.14)). The association was also strong between the presence of chronic pain and the presence of multi-morbidity (odds ratio of 4.25 (95% CI: 4.16-4.34) to have three or

more comorbid conditions). Third, additional data analysis exposed the clinically unexpected finding that physician visits and hospital admissions for pain-related conditions formed a small percentage of the total measured utilization, even for the Chronic Pain Group (where 15.6% of the physician claims and 12.1% of the hospital admissions were for pain-related conditions according to documented diagnoses).

There were two main conclusions taken from Chapter 4. First, the strong association between the presence of chronic pain (as defined by the Chronic Pain Algorithm) and multi-morbidity combined with the high percentage of health services used for non-pain-related versus pain-related conditions, even in the Chronic Pain Group, supports the implementation of concurrent management of pain with chronic disease. Previous studies described higher comorbidity index scores,[175,274,275] higher chronic comorbid disease prevalence,[168,276,277] and higher multi-morbidity odds[178] in people with chronic pain, and similarly recommended an increased focus on effective pain management to improve clinical outcomes and mitigate the negative effects on quality of life.[111,168,171,279] Second, the narrow scope of available NL health administrative data limited quantification of health care utilization to fee-for-service physician services and hospital-delivered services. To illustrate, other studies reported that people with chronic pain had excessively higher rates of emergency department visits, medication use, and allied/complementary health practitioner encounters in addition to higher rates of physician encounters and hospital admissions.[26,41,169,172,180,182,290] The exclusion of emergency department, pharmaceutical, salaried physician, allied health, and complementary health services data represents a significant underestimation of direct health care utilization by people with chronic pain in NL.

5.3 General Discussion of Findings

The findings of this thesis provide previously undetermined epidemiologic and health care utilization information related to chronic pain in NL, which can inform health service changes currently being considered at a policy and clinical level. This thesis also adds to the scarce body of knowledge around utilizing health administrative data to extract information about chronic pain.

5.3.1 Utilizing Newly Extracted Data to Inform Change in Chronic Pain Care in Newfoundland and Labrador

The Department of Health and Community Services struck the Provincial Pain Management Advisory Council in 2019 to review best practices in chronic pain management, identify available current services in the four regional health authorities, and recommend/implement strategies for coordinated services to improve care.[35] This thesis provides valuable data associated with chronic pain regarding the demographic and geographic variation in disease distribution, the strength of association with other prevalent chronic comorbid conditions, and the pattern of publicly funded health service use in NL. It is important to note that the information presented in this thesis was based on data from encounters/admissions up to and including March 31, 2010. While some positive changes in recent years have occurred in health promotion and wellness initiatives,[304] mental health service access,[304] and anesthesiologist-delivered intervention pain treatment access (personal communication), there remains three main foci for change that can benefit from this data, namely prevention, service access, and clinical care of chronic pain.

Given the heavy cost of chronic pain for individuals, families, communities, the economy, and the health care system, prevention emerges as a key mitigation strategy. The estimates provided in this thesis highlight several subpopulations on which to focus for chronic pain prevention strategies. However, the chronic pain incidence and prevalence in youth/young adults aged 15-24 years reported in Chapter 3 stood out as an important observation in the context of prevention. There was a significant increase in chronic pain incidence and prevalence between children aged 0-14 years and youth/young adults aged 15-24 years, particularly in females, in all four observed fiscal years. High national and provincial rates of obesity,[305] sedentary lifestyles,[306] mood and anxiety disorders,[307] child poverty,[308] and children in foster care[309] are important biopsychosocial factors that contribute to chronic pain development and maintenance. Adverse childhood events, such as abuse, assault, family/parental distress, and major injury/illness, are also considered risk factors for chronic pain development in childhood and adulthood.[310,311] Public health, mental health, and child welfare initiatives can address these "upstream" biopsychosocial influences, and include increased physical and mental health education programming, injury prevention, community-level access to physical activity participation, timely access to effective mental health care, and family/child income and welfare support.[32] Children and youth with chronic pain are more likely to develop mental health and chronic pain disorders as adults[312-314] making this subpopulation an important focus for prevention initiatives.

One of the main objectives for the Provincial Pain Management Advisory Council is to improve access for pain/chronic pain management services.[35] Demographic and geographic variation in chronic pain disease distribution observed in Chapter 3 can

inform recommendations regarding expansion of pain management services in NL, particularly in light of increasing NL chronic pain prevalence over time. Although the Eastern Health region was observed to have the highest chronic pain prevalence, one out of three people were identified as having chronic pain in the Western and Central Health regions respectively. At present, the only interdisciplinary chronic pain management program is located in the Eastern Health region (St. John's) presenting a significant geographic barrier to appropriate gold-standard pain service access for residents located in the Central, Western, and Labrador-Grenfell Health regions.[34] There is no dedicated pediatric pain service in NL (unpublished data) making for grossly inadequate access to effective pain management for the 6% of children aged 14 years and under and 22% of youth/young adults aged 15-24 years identified as having chronic pain in this study. Finally, NL residents in the 65 and older age groups were estimated to have the highest incidence and prevalence of chronic pain (8% and 63% respectively). There is no dedicated pain service for older persons in NL (unpublished data) often leaving the family doctor (to whom about one in five NL residents have reduced access)[315] overwhelmed as the sole provider of pain management in addition to chronic disease management services. There are clear gaps in timely, effective pain treatment services for identified NL geographic and demographic subpopulations.

Effective clinical management of pain/chronic pain is also important in preventing and mitigating the devastating long-term sequelae of chronic pain. The strength of association observed in Chapter 4 between chronic pain and both comorbid chronic conditions and publicly funded health care utilization provide important insights into the characteristics of NL residents in pain and the practice patterns of the NL fee-for-service

physicians treating them. NL has among the highest rates of chronic disease in Canada.[189,316] The negative impact of pain-related interference on activity levels and mental health suggests effective pain management is an important component of effective chronic disease management.[109,113,296,297] However, a very low proportion of physician and hospital services were recorded for pain-related conditions in the Chronic Pain Group. There are multiple plausible explanations for this finding, including frequent medical follow-up to monitor treatment effectiveness of multiple comorbid conditions, more advanced care required for deteriorating comorbid conditions, and only one allowable diagnostic code per claim where a non-pain-related code was entered even though a pain-related condition may have been assessed/treated during the encounter.[208] There was also the potential that concurrent pain management was not prioritized in the course of chronic disease management during physician/hospital encounters in NL. Inclusion of effective pain management as a recommendation in chronic disease clinical practice guidelines may engender positive clinical practice change, reduce patient suffering, and reduce subsequent reliance on acute and specialized health services.

5.3.2 Recommendations for Short-term Clinical Practice Change

The data presented in this thesis can inform short-term changes to clinical practice in NL in addition to the broad view long-term changes already presented. Chapter 3 provided evidence that chronic pain (as defined by the Chronic Pain Algorithm indicating frequent use of fee-for-service physician services for pain-related conditions) was highly prevalent in 2009/10 (particularly in female and in increasingly older residents), and that the prevalence was increasing annually. Chapter 4 provided evidence of modest to strong

association between chronic pain and other chronic diseases, and of modest association between chronic pain and health service use (particularly for non-pain-related conditions). The association between chronic pain and health service use was strongest for specialist assessments, hospital admissions, and specialized imaging tests (the more expensive publicly funded services).

There are four recommended changes to clinical practice in the short-term to help reduce the impact of chronic pain on NL residents and the health care system. First, more consistent adherence to clinical practice guidelines for managing painful conditions is recommended (these provide evidence-informed recommendations for pain medication prescriptions, diagnostic imaging requisitions, medical/surgical specialist referrals, and allied health/complementary medicine referrals).[29,35] Particularly pertinent guidelines include the Canadian Guidelines for Opioids for Non-cancer Pain[29] (NL had the highest opioid defined daily dose per 1,000 residents in 2019[165] with cited barriers to guideline implementation including resistance by patients and financial barriers to/low availability of non-pharmacological pain treatment)[317] and Referral Guidelines for diagnostic imaging[318] (physicians practicing in the Eastern Health Region had a high level of ordered computed tomography imaging exams for low back pain in 2016[319] with cited barriers to guideline implementation including patient expectations and level of physician experience with respect to low back pain treatment).[320] Second, increased participation in professional development opportunities that increase competency in pain/chronic pain care is recommended.[35] Such professional development training could include the opioid prescribing course offered by the Atlantic Mentorship Network Pain and Addiction group[321] or Cognitive Behavioral Therapy training similar to that previously offered by

the Office of Professional and Educational Development, Faculty of Medicine, Memorial University.[322] Third, increased utilization of eConsultation[323] services by primary care providers is recommended. This is a relatively new service offered to physicians and lack of awareness may be a barrier to maximizing its uptake. The service is also currently undergoing changes to its access platform and is not taking new users at the present time. Once new users are again accepted onto its access platform, the Government of NL and the NL Medical Association should undertake a media campaign to promote its availability and benefits. Finally, increased utilization of virtual care platforms[35] by NL pain specialists is recommended. NL health professional associations (such as the NL Medical Association, NL Physiotherapy Association, and Association of Psychology NL), Memorial University (through the Faculty of Medicine, Faculty of Nursing, School of Pharmacy, School of Social Work, Faculty of Humanities and Social Science (Psychology), and School of Human Kinetics and Recreation), and the Department of Health and Community Services of the Government of NL can facilitate implementation of these recommendations by increasing professional education opportunities, increasing interprofessional collaboration opportunities, expanding eConsultation opportunities to front-line primary health, allied health, and complementary health care professionals, and expanding remote patient access to medical pain specialists and interdisciplinary pain management teams via virtual care.

5.3.3 Newfoundland and Labrador Health Administrative Data as a Data Source on Chronic Pain

The main objective of this thesis was to obtain important information on chronic pain using health administrative data to inform health policy and clinical practice with the underlying goal to reduce the overall negative impact of chronic pain on NL residents. Health administrative data was considered a population-based, continuously collected, convenient, easily accessible, and economical data source compared to other data sources, such as survey data[66,67]; its use in the NL context was not without its challenges. First, each administrative dataset utilized in this study (MCP Fee-for-Service Physician Claims File, Provincial Discharge Abstract Data, Canadian Primary Care Sentinel Surveillance Network-Newfoundland and Labrador data, Newfoundland and Labrador Prescription Drug Plan data, and Eastern Regional Health Authority data) had a different data custodian despite most (exceptions include the Newfoundland and Labrador Prescription Drug Plan data and the Eastern Regional Health Authority data) being maintained at the Newfoundland and Labrador Centre for Health Information. Permission to use each data source was required from each data custodian (the Department of Health and Community Services of the Newfoundland and Labrador Government, the Newfoundland and Labrador Centre for Health Information, the Atlantic Practice Based Research Network of the Canadian Primary Care Sentinel Surveillance Network, and the Eastern Regional Health Authority) following ethics approval by the Health Research Ethics Board of the Health Research Ethics Authority. Second, once approval to use the requested data sources was granted from the data custodians, approval from the Newfoundland and

Labrador Centre for Health Information was required to use their resources to build the requested datasets and to ensure security protocols were in place to protect the security of the released datasets. The datasets were not built and released until all approvals were obtained and the process took three years (2012-2015) in total. The data was five years old and considered outdated before it was received for analysis. A recent publication provides valuable strategies to more efficiently navigate this process,[324] but the process is still complex and prolonged. While health administrative data has advantages over other methods of health data collection in some respects, it involves navigating complex privacy-confidentiality issues and complicated data linkage and management that precludes its ability to provide timely information for disease surveillance and health policy considerations in NL at this time.

The unavailability of data for this study regarding visits to pharmacies (medication data), physicians remunerated through alternate payment plans, allied health professionals, emergency rooms, and WorkplaceNL-remunerated health professionals was an important limitation of NL health administrative data in the context of extracting information on chronic pain. Data is now available (since 2015 that is beyond this study's data period) on all prescriptions filled in NL pharmacies through the Pharmacy Network (maintained at the Newfoundland and Labrador Centre for Health Information),[324] but NL health administrative datasets are still deficient on other health service data. Other provincial jurisdictions are not as reliant as NL on medical services provided by physicians remunerated by salary and/or alternate payment plans, and they collect and maintain data from salaried physicians through "shadow-bill claims".[270] Several other Canadian jurisdictions also collect and maintain standardized information on emergency

room and publicly funded ambulatory allied health care visits through the National Ambulatory Care Reporting System.[325] The NL regional health authorities maintain information on emergency room visits, which is not submitted to the National Ambulatory Care Reporting System, is not standardized, and has reduced data quality for the purposes of research (particularly the medical diagnosis data) (personal communication). WorkplaceNL maintains administrative data on all costs associated with the management of each workplace injury claim, including those incurred through physician visits, diagnostic imaging exams, and allied health professional visits, but these are used for internal evaluation of expenses/liabilities.[326] Other provincial and global jurisdictions maintain information via centralized data repositories on welfare, employment, and disability status, which are important variables to consider in the context of chronic pain.[41,327] Access to such data could possibly enable development of an improved chronic pain algorithm with respect to selection accuracy, and construction of a more complete portrait of chronic pain in society from a social determinants of health perspective.

Considering the limitations to the NL health administrative data comprehensiveness and the procedural barriers to its timely access, four main recommendations are provided to maximize the potential of this valuable data resource. First, to streamline the request process for secondary use of administrative data, it is recommended all NL health administrative datasets be maintained under a single organization (the Newfoundland and Labrador Centre for Health Information) that is authorized to grant all permissions for NL health data access thus creating a single data request entry point. Second, to enhance timeliness of extraction of meaningful information from administrative data, it is

recommended a process be developed for fast-tracked updating of previously approved/constructed datasets by the Newfoundland and Labrador Centre for Health Information. Third, to broaden the scope of available health data, it is recommended the four NL regional health authorities regularly contribute data collected from emergency room and publicly funded ambulatory allied health care visits to the National Ambulatory Care Reporting System. It is also recommended a process be developed to track services provided by physicians remunerated through salary or alternate payment plans, such as through "shadow billing" or province-wide electronic medical record entries. And finally, it is recommended the Government of Newfoundland and Labrador consider expanding data assets held at the Newfoundland and Labrador Centre for Health Information to include information on social determinants of health, such as that collected by the Departments of Education, Justice and Public Safety, and Advanced Education, Skills, and Labour.

5.3.4 Recommendations for Future Research

As discussed in Chapter 2, the focus of future research in extracting information on chronic pain from health administrative data lies in further algorithm development and validation. This thesis describes the first known attempt to use standardized methodology to derive an algorithm that ascertains cases of chronic pain as a discrete chronic condition from health administrative data. While the Chronic Pain Algorithm performed moderately well on validation tests for ascertainment, its performance on selection accuracy precluded its use for case selection to assess causation, treatment effectiveness, and adverse events. Similar to clinical diagnostic tests, a single validation study in one

jurisdiction is not sufficient to judge the validity and reliability of a health administrative data algorithm.[70] Future research is recommended to: 1) modify and validate the Chronic Pain Algorithm by utilizing other appropriate administrative datasets, such as the NL Pharmacy Network data, 2) modify and validate the Chronic Pain Algorithm that incorporates flexible algorithms based on age- and/or condition-specific health service use/codes to reduce strata-specific misclassification bias, 3) utilize a validation cohort that more closely resembles the target population with respect to demographics to reduce strata-specific misclassification bias, 4) compare the Chronic Pain Algorithm case selection utility to that of the Canadian Community Health Survey (NL data), 5) explore the potential of creating a reference standard for chronic pain from the raw electronic medical record data generated and maintained in the Med Access electronic medical records solution now being implemented in primary care province-wide, and 6) modify and validate the Chronic Pain Algorithm in other Canadian jurisdictions utilizing available provincial-level health administrative data sources. Creating a chronic pain algorithm with strong performance on validation tests for ascertainment and selection accuracy that is generalizable across jurisdictions can unlock the considerable potential of Canadian health administrative data as a valuable and efficient source of information. A chronic pain algorithm with a high degree of selection accuracy can facilitate research into the epidemiology, health care utilization, treatment effectiveness/harms, causation (assessing the presence of chronic pain as either an exposure or outcome), and long-term health outcomes associated with chronic pain.

5.4 Concluding Remarks

In the context of research, this thesis was the first, to the best of our knowledge, to use a standardized methodology to create, validate, and report an algorithm that identified cases of chronic pain as "a single disease entity",[150] a complex and multi-faceted chronic condition, in health administrative data. The methodology and results described added to a significantly understudied area of chronic pain research as recently iterated in a systematic review.[70] Recommendations to the research community moving forward include the scientific advancement of the methodology described here to increase the validity, reliability, and generalizability of chronic pain case ascertainment from health administrative data. This, in turn, advances the utility of the information obtained and examined by researchers, clinicians, and health policy makers.[66]

In the context of public health and health care delivery, this thesis significantly adds to the body of knowledge regarding chronic pain epidemiology (particularly in the context of NL) and publicly funded health resource utilization. Additional information in the NL context was also provided regarding the strong association between chronic pain and chronic comorbid conditions previously described in other jurisdictions. The recommendation moving forward is to translate this data into tangible positive changes in the prevention and treatment of chronic pain in NL and Canada.

5.5 Co-authorship Statement

Heather E. Foley drafted Chapter 5 and made substantial contributions to its content and revision. Dr. Rick Audas contributed to revision of Chapter 5. Dr. Michelle

Ploughman contributed to revision of Chapter 5. Dr. John C. Knight contributed to revision of Chapter 5. Dr. Shabnam Asghari contributed to revision of Chapter 5.

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Chapter 7 Appendices

7.1 Appendix 1. Anatomical Therapeutic Classification Codes[a] of Opioid Medication Used Almost Exclusively for Pain Treatment

ATC Code	Drug Name
N02AA01	Morphine
N02AA02	Opium
N02AA03	Hydromorphone
N02AA05	Oxycodone
N02AA55	Oxycodone, combinations (Targin®)
N02AA59	Codeine, combinations excluding psycholeptics
N02AA79	Codeine, combinations with psycholeptics
N02AB02	Pethidine (Meperidine in Canada)
N02AB03	Fentanyl
N02AC04	Dextropropoxphene (Discontinued in Canada in 2010)
N02AD01	Pentazocine
N02AE01	Buprenorphine
N02AF01	Butorphanol
N02AF02	Nalbuphine (usually used pre-operation or during labour)
N02AX02	Tramadol
N02AX06	Tapentadol (available in Canada since 2010)
N02AX52	Tramadol, combinations
N01AH01	Fentanyl
N01AH02	Alfentanil

N01AH03	Sufentanil
N01AH06	Remifentanil

Abbreviations: ATC; Anatomical Therapeutic Chemical classification codes, WHO; World Health Organization, DDD; defined daily dose.

[a.] Source: WHO ATC/DDD Index; 2012. WHO Collaborating Centre for Drug Statistics Methodology. http://www.whocc.no/atc_ddd_index/. Published 2012. Accessed October 23, 2013.

7.2 Appendix 2. Pain-related Diagnostic Codes Recorded by Primary Care Providers in Canadian Primary Care Sentinel Surveillance Network[a]-Newfoundland and Labrador Electronic Medical Record Data

Pain Condition Group	ICD-9 codes
Neuropathic pain	53, 53.11, 53.9
	250.6
	256, 256.3, 256.4
	350, 350.1, 350.2
	351, 351.0, 351.8
	352, 352.0, 352.9
	353, 353.0, 353.2, 353.6
	354, 354.0, 354.4,
	355, 355.0, 355.1, 355.3, 355.5, 355.6, 355.9,
	356, 356.2, 356.9,
	357, 357.2, 357.4,
	729, 729.0, 729.1, 729.2, 729.3, 729.31, 729.4, 729.5,
	729.71, 729.81, 729.82, 729.9
Musculoskeletal conditions and arthritis	710, 710.0, 710.1, 710.2, 710.4
	711.9
	712.2, 712.3
	713.3, 713,6

	714, 714.0, 714.1, 714.3, 714.8, 714.9 715, 715.26, 715.3, 715.9, 715.98 716, 716.1, 716.15, 716.4, 716.5, 716.9 717, 717.0, 717.3, 717.4, 717.41, 717.43, 717.5, 717.6, 717.7, 717.8, 717.82 718, 718.01, 718.07, 718.4, 718.6, 718.80 719, 719.0, 719.1, 719.4, 719.41, 719.44, 719.45, 719.46, 719.47, 719.51, 719.52, 719.53, 719.54, 719.55, 719.56, 719.57, 719.61, 719.62, 719.63, 719.67, 719.7, 719.9 725 726, 726.0, 726.1, 726.11, 726.12, 726.19, 726.3, 726.31, 726.32, 726.33, 726.5, 726.6, 726.61, 726.64, 726.65, 726.7, 726.71, 726.72, 726.79, 726.9, 726.91 727, 727.0, 727.03, 727.05, 727.1, 727.3, 727.4, 727.43, 727.51, 727.6, 727.60, 727.61, 727.62, 727.65, 727.68, 727.82, 727.9 728, 728.10, 728.11, 728.2, 728.3, 728.4, 728.5, 728.6, 728.7, 728.71, 728.79, 728.83, 728.84, 728.85, 728.87, 728.9
Back/neck disorders	720, 720.0, 720.2, 720.8, 720.9 721, 721.0, 721.2, 721.3, 721.8

	722, 722.10, 722.4, 722.5, 722.52, 722.6, 722.71, 722.9, 722.91, 722.92, 722.93 723, 723.0, 723.1, 723.5, 723.8 724, 724.0, 724.02, 724.1, 724.2, 724.3, 724.5, 724.6, 724.7, 724.79, 724.8 737, 737.0, 737.1, 737.12, 737.21, 737.3 738, 738.0, 738.1, 738.5, 738.7 739, 739.5 756, 756.1, 756.11, 756.17, 756.52, 756.59, 756.71 805, 805.6, 805.8 806.0, 806.7 839.8 846, 846.0, 846.1 847, 847.0, 847.2, 847.3, 847.4, 847.9 848, 848.0, 848.1, 848.3, 848.4, 848.41, 848.42, 848.9 905.9 959.09
Bone disorders	730.0, 730.1, 730.36, 730.38, 730.39 731, 731.0 732, 732.4, 732.7, 732.9 733, 733.0, 733.02, 733.03, 733.2, 733.4, 733.5, 733.6, 733.82, 733.9, 733.90, 733.92, 733.93

	734
	735, 735.0, 735.2, 735.4, 735.5, 735.8, 735.9
	736.00, 736.1, 736.2, 736.21, 736.4, 736.41, 736.73,
	736.76, 736.79, 736.81
Musculoskeletal trauma	807, 807.0, 807.2
	808
	820
	821.00
	822
	823, 823.02, 823.80, 823.81, 823.82
	824, 824.0, 824.2, 824.4, 824.6
	825, 825.0, 825.23
	826
	827
	829
	831, 831.04
	840, 840.0, 840.4, 840.5, 840.6, 840.9
	841
	842, 842.0, 842.1
	843, 843.0
	844, 844.0, 844.1, 844.2

	845, 845.0, 845.01, 845.03, 845.09, 845.1, 845.11, 845.12, 845.13
Headaches	346, 346.0, 346.1, 346.2, 346.8, 346.9 784, 784.0, 784.1, 784.9, 784.99
Other conditions associated with chronic pain	287.2 307, 307.81 337, 337.2 340 349 388.5 440, 440.21, 443, 443.0, 443.1, 443.89, 443.9 447.6 459.81, 459.9 524.6 558 564, 564.1, 564.2, 564.4, 564.6, 564.8 569.42 577.0, 577.1 592, 592.0, 592.1 596.59

	608.9 617, 617.9 625, 625.0, 625.1, 625.2, 625.3, 625.4, 625.5, 625.6, 625.9 709.2 781, 781.0, 781.1, 781.2, 781.3, 781.94 785.6 786.5, 786.59, 786.8 788.0, 788.1 789, 789.0, 789.06, 789.1, 789.2, 789.3, 789.5, 789.66, 789.9 991.2, 991.3
Central Pain Syndrome, Chronic Pain, or Chronic Pain Syndrome	338.0[b], 338.2[b], 338.4

Abbreviations: ICD-9, *International Classification of Disease – 9th revision.*

[a.] The Canadian Primary Care Sentinel Surveillance Network is a clinical data source comprised of information retrieved directly from the electronic medical records of consenting patients attending participating primary care practices across Canada.

[b] The diagnostic code is not used in the Canadian Primary Care Sentinel Surveillance Network-Newfoundland and Labrador data but is included for completeness.

7.3 Appendix 3. Pain-related Diagnostic Codes Recorded by Physicians in the Medical Care Plan Fee-For-Service Physicians Claims File and/or Provincial Discharge Abstract Data of Newfoundland and Labrador, Canada

Pain Condition Group	ICD-9 Code	Description	ICD-10-CA Code	Description
Neuropathic Pain	053	Herpes Zoster	G50	Disorders of Trigeminal Nerve
	256	Ovarian Dysfunction	G52	Disorders of Other Cranial Nerves
	350	Trigeminal Nerve Disorders	G53	Cranial Nerve Disorder in Diseases Classified Elsewhere
	351	Facial Nerve Disorders	G54	Nerve Root and Plexus Diseases
	352	Disorders of Other Cranial Nerves	G55	Nerve Root and Plexus Compression in Diseases Classified Elsewhere
	353	Nerve Root and Plexus Disorders	G56	Mononeuropathies of Upper Limb
	354	Mononeuritis of Upper Limb and Mononeuritis Multiplex	G57	Mononeuropathies of Lower Limb
	355	Mononeuritis of Lower Limb	G58	Other Mononeuropathies

356	Hereditary and Idiopathic Peripheral Neuropathy	G59	Mononeuropathy in Diseases Classified Elsewhere
357	Inflammatory and Toxic Neuropathy	G60	Hereditary and Idiopathic Neuropathy
729	Other Disorders of Soft Tissue	G61	Inflammatory Polyneuropathy
		G62	Other and Unspecified Polyneuropathies
		G63	Polyneuropathy in Diseases Classified Elsewhere
		G64	Other Diseases of the Peripheral Nervous System
		G82	Paraplegia (Paraparesis) and Quadriplegia (Quadriparesis)
		G97	Intraoperative and Post-procedural Complications and Disorders of Nervous System, Not Elsewhere Classified

			M89	Other Disorders of Bone
			R29	Other Symptoms and Signs Involving the Nervous and Musculoskeletal Systems
Musculoskeletal Conditions and Arthritis	710	Diffuse Diseases of Connective Tissue	M05	Rheumatoid Arthritis with Rheumatoid Factor
	711	Arthropathy Associated with Infections	M06	Other Rheumatoid Arthritis
	712	Crystal Arthropathies	M07	Enteropathic Arthropathies
	713	Arthropathy Associated with Other Disorders Classified Elsewhere	M08	Juvenile Arthritis
	714	Rheumatoid Arthritis and Other Inflammatory Polyarthropathies	M10	Gout
	715	Osteoarthritis and Allied Disorders	M11	Other Crystal Arthropathies

716	Other and Unspecified Arthropathies	M12	Other and Unspecified Arthropathy
717	Internal Derangement of Knee	M13	Other Arthritis
718	Other Derangement of Joint	M14	Arthropathies in Other Diseases Classified Elsewhere
719	Other and Unspecified Disorders of Joint	M15	Polyosteoarthritis
725	Polymyalgia Rheumatica	M16	Osteoarthritis of Hip
726	Peripheral Enthesopathies and Allied Syndromes	M17	Osteoarthritis of Knee
727	Other Disorders of Synovium, Tendon, and Bursa	M18	Osteoarthritis of First Carpometacarpal Joint
728	Disorders of Muscle, Ligament, and Fascia	M19	Other and Unspecified Osteoarthritis
		M23	Disorder of Patella

			M24	Other Specified Joint Derangements
			M25	Other Joint Disorder, Not Classified Elsewhere
			M36	Systemic Disorders of Connective Tissue in Diseases Classified Elsewhere
			M77	Other Enthesopathies
			R26	Abnormalities of Gait and Mobility
Back/neck disorders	720	Ankylosing Spondylitis and Other Inflammatory Spondylopathies	M43	Other Deforming Dorsopathies
	721	Spondylosis and Allied Disorders	M45	Ankylosing Spondylitis
	722	Intervertebral Disc Disorders	M46	Other Inflammatory Spondylopathies
	723	Other Disorders of Cervical Region	M48	Other Spondylopathies
	724	Other and Unspecified Disorders of Back	M49	Spondylopathies in Diseases Classified Elsewhere
	737	Curvature of Spine	M50	Cervical Disc Disorders

738	Other Acquired Deformity	M51	Thoracic, Thoracolumbar, and Lumbosacral Intervertebral Disc Disorders
739	Nonallopathic Lesions, Not Elsewhere Classified	M54	Dorsalgia
756	Other Congenital Musculoskeletal Anomalies	M81	Osteoporosis without Current Pathological Fracture
805	Fracture of Vertebral Column without mention of Spinal Cord Injury	M82	Osteoporosis in Diseases Classified Elsewhere
806	Fracture of Vertebral Column with Spinal Cord Injury		
839	Other, Multiple, and Ill-defined Dislocations		
846	Sprains and strains of Sacroiliac Region		

	847	Sprains and Strains of Other Unspecified Parts of Back
	848	Other and Ill-defined Sprains and Strains
	905	Late Effects of Musculoskeletal and Connective Tissue Injuries
Bone Disorders	730	Osteomyelitis, Periostitis, and Other Infections Involving Bone
	731	Osteitis Deformans and Osteopathies Associated with Other Disorders Classified Elsewhere
	732	Osteochondropathies
	733	Other Disorders of Bone and Cartilage
	734	Flatfoot

	735	Acquired Deformities of Toe		
	736	Other Acquired Deformities of Limbs		
Musculoskeletal Trauma	808	Fracture of Pelvis	S12	Fracture of Cervical Vertebra and Other Parts of Neck
	830	Dislocation of Jaw	S22	Fracture of Rib(s), Sternum, and Thoracic Spine
	831	Dislocation of Shoulder	S32	Fracture of the Lumbar Spine and Pelvis
	832	Dislocation of Elbow	S42	Fracture of the Shoulder and Upper Arm
	840	Sprains and Strains of Shoulder and Upper Arm	S43	Dislocation and Sprain of Joints and Ligaments of Shoulder Girdle
	841	Sprains and Strains of Elbow and Forearm	S53	Dislocation and Sprain of Joints and Ligaments of Elbow

	842	Sprains and Strains of Wrist and Hand	T02	Fractures Involving Several Regions of the Body
	843	Sprains and Strains of Hip and Thigh	T08	Fractures of the Spine, Level Not Specified
	844	Sprains and Strains of Knee and Leg	T91	Sequelae of Injuries of Neck and Body
	845	Sprains and Strains of Ankle and Foot		
Headaches	346	Migraine	G43	Migraine
	784	Symptoms Involving Head and Neck	G44	Other Headache Syndromes
			R51	Headache

Other conditions associated with chronic pain	307	Special Symptoms or Syndromes, Not Elsewhere Classified	F45	Somatoform Disorders
	564	Functional Digestive Disorders, Not Elsewhere Classified	G96	Other Disorders of Central Nervous System
	625	Pain and Other Symptoms Associated with Female Genital Organs	L89	Pressure Ulcer
	781	Symptoms Involving Nervous and Musculoskeletal Systems	L97	Non-Pressure Chronic Ulcer of Lower Limb, Not Elsewhere Classified
	789	Other Symptoms Involving Abdomen and Pelvis	L98	Other Disorders of Skin and Subcutaneous Tissue, Not Elsewhere Classified
	907	Late Effects of Injuries to the Nervous System	M22	Internal Derangement of Knee

908	Late Effects of Other and Unspecified Injuries	M47	Spondylosis
		M53	Other and Unspecified Dorsopathies, Not Elsewhere Classified
		M65	Synovitis and Tenosynovitis
		M70	Soft Tissue Disorders Related to Use, Overuse, and Pressure
		M75	Shoulder Lesions
		M79	Other Enthesopathies
		M80	Other and Unspecified Soft Tissue Disorders, Not Elsewhere Classified
		M99	Biomechanical Lesions, Not Elsewhere Classified
		R07	Pain in Throat and Chest
		R10	Abdominal and Pelvic Pain

	R52	Pain, Unspecified
	S13	Dislocation and Sprain of Joints and Ligaments at Neck Level
	T85	Complications of Other Internal Prosthetic Devices, Implants, and Grafts
	T88	Other Complications of Surgical and Medical Care, Not Elsewhere Classified
	T92	Sequelae of Injuries of Upper Limb
	T93	Sequelae of Injuries of Lower Limb
	T94	Sequelae of Injuries Involving Multiple and Unspecified Body Region

Abbreviations: ICD-9*, International Classification of Disease – 9th Revision*; ICD-10-CA, *International Classification of Disease – 10th Revision (Canadian).*

Notes: All diagnostic codes are organized by pain condition. All diagnostic codes are displayed in the three-digit *International Classification of Disease – 9th Revision* and the *International Classification of Disease – 10th Revision (Canadian)* format with

the accompanying description. See Section 7.5, Appendix 5 for further description of code formats used in the Newfoundland and Labrador health administrative datasets.

7.4 Appendix 4. Newfoundland and Labrador, Canada, Provincial Medical Care Plan Chronic Pain Clinic Procedure Billing Codes

Fee Code	Procedure
400020	Pain Clinic Consultation
419020	Pain Clinic Reassessment
578000	Epidural Steroid Injection
578020	Intercostal Nerve Block(s)
578040	Paravertebral Nerve Block of Thoracic or Lumbar Roots
578060	Peripheral Nerve Block for Chronic Pain
578080	Cranial Nerve/Branch Block for Chronic Pain
578100	Stellate Ganglion Block
578120	Intravenous Sympathetic Block by Injection and Infusion of Bretylium, Guanetidine, and Reserpine
578140	Intravenous Injection and Infusion with Lidocaine for the treatment of Chronic Pain

Medical Care Plan, Department of Health and Community Services. Medical Payment Schedule - 2009. http://www.health.gov.nl.ca/health/mcp/providers/full_mcp_payment_schedule_2009.pdf. Published 2011. Accessed January 10, 2017.

7.5 Appendix 5. Health Administrative Databases Providing Study Data from Newfoundland and Labrador, Canada

Database	Data Period	Diagnostic Codes Utilized	Number of Diagnostic Codes per Entry	Variables Obtained for study datasets
MCP Physician Fee-for-Service Claims File	1999-2010	3-digit ICD-9	1	• MCP number (de-identified prior to data provision to research team) • Service date • Diagnostic code • Diagnostic description • Procedure code • Physician specialty code
NL Provincial Discharge Abstract Database	1999-2010	Up to 5-digit ICD-9 up to March 31, 2001	Up to 16	• MCP number (de-identified prior to data provision to research team) • Care episode identifier • Admission date

		Up to 6-digit ICD-10-CA April 1, 2001 onwards		• Discharge date • Diagnostic code(s) • Diagnostic description(s) • Diagnostic type • Provider service code • Admission type
MCP Beneficiary File	1999- 2010	Not applicable	Not applicable	• MCP number (de-identified prior to data provision to research team) • Age as of September 1, 2012 • Sex • Rural/urban location of residence based on population cut-off of 4000 in 2009/10 fiscal year • Regional health authority location of residence in 2009/10 fiscal year

	• MCP eligibility status for each fiscal year from 2003/2004 to 2009/2010

Abbreviations: MCP, Medical Care Plan; ICD-9, *International Classification of Disease – 9th Revision*; ICD-10-CA, *International Classification of Disease – 10th Revision (Canadian)*; NL, Newfoundland and Labrador.

7.6 Appendix 6. Summary of Canadian Chronic Disease Surveillance System Coding Algorithm Case Definitions for Comorbid Conditions

Health Condition	Hospital Diagnosis Codes (ICD-9 up to and including March 31, 2001; ICD-10-CA from April 1, 2001 onwards)	Physician fee-for-service Diagnosis Codes (ICD-9)	Case Definition	Age	Start year for reporting
Mental health conditions	290-319 up to and including March 31, 2001 F00-F99 from April 1, 2001 onward	290-319	One or more hospitalizations or one or more physician claims within one year	1+	2000-01

Hypertension, pregnancy-induced hypertension excluded	401; 402; 403; 404; 405 up to and including March 31, 2001 I10, I11, I12, I13, I15 from April 1, 2001 onward	401; 402; 403; 404; 405	One or more hospitalizations or two or more physician claims within two years Special exclusion: Pregnancy-induced hypertension in women age 20-54: 120 days preceding or 180 days after hospital records containing any of the gestational diagnostic codes. • ICD-9: 641-676, V27 • ICD-10 and ICD-10-CA: O1, O21-95, O98, O99, Z37	20+	2000-01
Mood and anxiety disorders	296; 300; 311 up to and including March 31, 2001	296; 300; 311	One or more hospitalizations or one or more physician claims within one year	1+	2000-01

	F30-F42, F44-F48, F68 from April 1, 2001 onward				
Diabetes, type unspecified, gestational diabetes excluded	250 up to and including March 31, 2001 E10, E11, E12, E13, E14 from April 1, 2001 onward	250	One or more hospitalizations or two or more physician claims within two years Special exclusion: Evidence from women aged 10-54 is removed 120 days preceding or 180 days after hospital records containing any of the pregnancy-related and obstetrical codes: • ICD-9: 641-676, V27 • ICD-10 and ICD-10-CA: O1, O21-95, O98, O99, Z37	1+	2000-01

Ischemic heart disease (IHD)	410; 411; 412; 413; 414 up to and including March 31, 2001 I20, I21, I22, I23, I24, I25 from April 1, 2001 onward	410; 411; 412; 413; 414	One or more hospitalizations or procedure code or two or more physician claims within one year	20+	2000-01
Chronic obstructive pulmonary disease (COPD)	491; 492; 496 up to and including March 31, 2001 J41, J42, J43, J44 from April 1, 2001 onward	491; 492; 496	One or more hospitalizations or one or more physician claims ever Special exclusions: ICD-9 Code 490, and ICD-10 Code J40	35+	2000-01

Asthma	493 up to and including March 31, 2001 J45, J46 from April 1, 2001 onward	493	One or more hospitalizations ever or two or more physician claims within two years	1+	2000-01
Cancer	C00-80, C97	N/A	One or more hospitalizations		2001-02
Heart failure	428 up to and including March 31, 2001 I50 from April 1, 2001 onward	428	One or more hospitalizations or two or more physician claims within one year	40+	2000-01

Acute myocardial infarction	410 up to and including March 31, 2001 I21; I22 from April 1, 2001 onward	N/A	One or more hospital inpatient admission	20+	2000-01
Stroke	G45.x (exclude G45.4), H34.0, H34.1, I60.x, I61.x, I63.x (exclude I63.6), I64	430, 431, 434, 435, 436	One or more hospitalization or two or more physician claims within one year	20+	2003-04

Hip fracture	820 up to and including March 31, 2001 S72.0; S72.1; S72.2 from April 1, 2001 onward	N/A	One or more hospitalizations (6 month episode period)	40+	2000-01
Dementia, including Alzheimer's disease	G30, F00, F01, F02, F03	290, 331	One or more hospitalizations; or three or more physician claims within two years, with at least 30 days between each claim	65+	2002-03

Epilepsy	G40	345	• For individuals aged 1-19 years: Three or more physician claims, with at least 30 days between each claim, within two years. • For individuals aged 20 years and over: One or more hospitalizations; or three or more physician claims, with at least 30 days between each claim, within two years.	1+	2005-06
Parkinsonism	N/A	332	Two or more physician claims, with at least 30 days between the first and the second claim within one year	40+	2004-05
Multiple sclerosis	G35	340	One or more hospitalizations or five or more physician claims within two years	20+	2003-04

Abbreviations: ICD-9*, International Classification of Disease – 9th Revision*; ICD-10-CA, *International Classification of Disease – 10th Revision (Canadian)*

Source: Public Health Agency of Canada. Public Health Infobase: Canadian Chronic Disease Surveillance System (CCDSS). Government of Canada. https://health-infobase.canada.ca/ccdss/data-tool/. Published 2018. Accessed February 27, 2019.

Source: Xie L, Semenciw R, Mery L. Cancer incidence in Canada: trends and projections (1983-2032). *Health Promot Chronic Dis Prev Can.* 2015;35 Suppl 1:2-186. https://www.canada.ca/en/public-health/services/reports-publications/health-promotion-chronic-disease-prevention-canada-research-policy-practice/vol-35-no-1-2015/supplement.html. Accessed April 12, 2019.

7.7 Appendix 7. Provincial Medical Care Plan Procedure Billing Codes Used to Describe Diagnostic Imaging Claims in Newfoundland and Labrador, Canada

Procedure Code	Procedure Description
General	
Radiograph	
701000	Skull-Routine
701010	Sella turcica
701100	Facial bones
701110	Nose
701120	Mandible
701130	Temporomandibular joints
701200	sinuses
701210	Mastoids - acute
701320	Teeth - full set
701400	Eye - for foreign body
701410	Eye - for localization (stereo-optics)
701420	Optic Foramina
701500	Salivary gland region
701600	Neck for soft tissues
701900	General radiograph
702000	Cervical spine
702100	Thoracic spine

702200	Lumbar or lumbosacral spine
702250	Sacrum and/or coccyx
702300	Pelvis - single view
702350	Pelvis and hips
702400	Sacroiliac joints
702450	Spine - scoliosis series
702500	Ribs - unilateral
702510	Ribs - bilateral, extra
702600	Sternum
702700	Special additional view of any spine and pelvis item
703000	Clavicle
703010	Sternoclavicular joint
703030	Acromioclavicular joints - bilateral (with or without weighted distraction)
703100	Shoulder
703200	Scapula
703300	Humerus
703310	Elbow
703320	Ulna and radius
703330	Wrist
703340	Wrist and Hand
703350	Hand

703360	Finger
703370	Thumb, including metacarpals
703380	Scaphoid
703500	Hip
703510	Hip pinning, interpretation only
703520	Femur
703530	Orthoroentgenogram
703600	Knee
703640	Tibia and fibula
703660	Ankle
703680	Calcaneus
703700	Foot
703800	Toe
703900	Special additional view of any item in the section headed extremities
703950	Post reduction check
704300	Skeletal survey for bone age - single film
704310	Skeletal survey for bone age - 2 or more films or views
704400	Other survey - basic for rheumatoid survey
704500	Other survey - basic for metabolic survey
704600	Other survey - basic for metastatic survey
704650	Other survey - plus per film or view for either of the above

705010	Chest - single film
705020	Chest - 2 views
705030	Chest - 3 or more views
705200	Mammography - unilateral
705220	Mammography - bilateral
705250	Screening mammography program
706000	Abdomen - Survey film
706010	Abdomen - additional film studies (acute abdomen)
706100	Esophagus
706200	Stomach and duodenum
706210	Stomach and duodenum with small intestinal series
706250	Small bowel only
706260	Upper GI - double contrast
706300	Colon - barium enema
706310	Colon - with air study
706450	T-tube cholangiogram
706500	Operative cholangiogram, interpretation only
707000	GU tract - Survey film
707050	Retrograde pyelogram
707100	Intravenous pyelogram
707140	Intravenous pyelogram - with nephrotomogram
707300	Urethrocystogram

707350	Stress urethrocystogram
707380	Voiding urethrocystogram
707450	Nephrostogram
708240	Obstetrics and Gynecology - Hysterosalpingogram
Computed Tomography Scan	
738000	Head - without IV contrast
738010	Head - with IV contrast
738020	Head - with and without IV contrast
738050	Complex head - without IV contrast
738060	Complex head - with IV contrast
738070	Complex head - with and without IV contrast
738100	Neck - with IV contrast
738110	Neck - without IV contrast
738120	Neck - with and without IV contrast
738150	Thorax - without IV contrast
738160	Thorax with IV contrast
738170	Thorax with and without IV contrast
738200	Abdomen - without IV contrast
738210	Abdomen - with IV contrast
738230	Abdomen with and without IV contrast

738250	Extremities - without IV contrast
738260	Extremities - with IV contrast
738270	Extremities - with and without IV contrast
738300	Spine without IV contrast
738310	Spine with IV contrast
738320	Spine with and without IV contrast
738350	Pelvis without IV contrast
738360	Pelvis with IV contrast
738370	Pelvis with and without IV contrast
Magnetic	
Resonance	
Imaging Scan	
738500	Head - multislice SE
738510	Head - multislice IR
738520	Head - repeat
738530	Head with gating
738550	Neck - multislice SE
738560	Neck - multislice IR
738570	Neck - repeat
738600	Thorax - multislice SE
738610	Thorax - multislice IR
738620	Thorax - repeat

738630	Thorax - when gating is performed
738650	Abdomen - multislice SE
738660	Abdomen - multislice IR
738670	Abdomen - repeat
738680	Abdomen - when gating is performed
738700	Pelvis - multislice SE
738710	Pelvis - multislice IR
738720	Pelvis - repeat
738750	Extremity - multislice SE
738760	Extremity - multislice IR
738770	Extremity - repeat
738800	Spine - 1 segment - multislice SE
738810	Spine 1 segment - multislice IR
738820	Spine 1 segment - repeat
738860	Spine 2 segments - multislice SE
738870	Spine 2 segments - multislice IR
738880	Spine - 2 segments - repeat
738910	Complex spine - multislice SE
738920	Complex spine - multislice IR
738930	Complex spine - repeat
745200	Diagnostic biopsy by any radiography technique

Source: Medical Care Plan, Department of Health and Community Services. Medical Payment Schedule - 2009. http://www.health.gov.nl.ca/health/mcp/providers/full_mcp_payment_schedule_2009.pdf. Published 2011. Accessed January 10, 2017.

7.8 Appendix 8. Most Recent Approval from the Health Research Ethics Board of Newfoundland and Labrador

Heather Foley

From: administrator@hrea.ca
Sent: February-03-20 9:08 AM
To: Heather Foley
Cc: Audas Richard(Supervisor); administrator@hrea.ca
Subject: HREB - Approval of Ethics Renewal

Researcher Portal File #: 20181270

Dear Mrs. Heather Foley:

This e-mail serves as notification that your ethics renewal for study HREB # 2017.273 – Portrait of Chronic Pain in Newfoundland and Labrador: (Incidence, Prevalence and Health Care Utilization) – has been **approved**. Please log in to the Researcher Portal to view the approved event.

Ethics approval for this project has been granted for a period of twelve months effective from January 31, 2020 to January 31, 2021.

Please note, it is the responsibility of the Principal Investigator (PI) to ensure that the Ethics Renewal form is submitted prior to the renewal date each year. Though the Research Ethics Office makes every effort to remind the PI of this responsibility, the PI may not receive a reminder. The Ethics Renewal form can be found on the Researcher Portal as an "Event".

The ethics renewal will be reported to the Health Research Ethics Board at their meeting dated February 13, 2020.

Thank you,

Research Ethics Office

(e) info@hrea.ca
(t) 709-777-6974
(f) 709-777-8776
(w) www.hrea.ca
Office Hours: 8:30 a.m. – 4:30 p.m. (NL TIME) Monday-Friday