Chronic Low Back Pain: Exploring Trends and Potential Predictors

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Abstract

Context: Hundreds of thousands of Quebec residents suffer from chronic pain, for which treatment is far from optimal. Chronic pain is recognized as a major health problem, not only because of its frequency, but also the devastating effects it has on physical, emotional, and social aspects of life. Despite low back pain being the second most common reason to visit a primary care physician, management remains challenging. Additionally, chronic low back pain (CLBP) has been found to be the most common reason for patients to be referred to tertiary pain centers. Recently, there has been an increasing acceptance that bio-psycho-social factors play a crucial role the clinical course of CLBP, yet limited research concerning CLBP has been completed beyond one year. ***Objectives:*** The purpose of this study was to identify subgroups of CLBP patients treated in tertiary care, as defined by their changes in pain and disability over time, and to explore possible characteristics associated with these changes. Specific objectives were: 1) to establish whether there are distinct subgroups of patients with CLBP with different characteristics associated with change in pain and disability at 6, 12, and 24 months following an initial visit in a tertiary pain clinic; and 2) to identify potential social, psychological, biological, and environmental factors that may predict their responses in pain intensity and disability in accordance with the Revised Wilson and Cleary Model for Health-Related Quality of Life. ***Design:*** Observational prospective design to follow a cohort of patients who were enrolled in the web-based Quebec Pain Registry. ***Setting:*** The Quebec Pain Registry, a research database comprised of close to 5000 chronic pain patients from tertiary pain centers associated with Université de Montréal, Université de Sherbrooke, and McGill University Health Centre. ***Participants:*** Adults diagnosed with

CLBP who are registered in the Quebec Pain Registry. Eligible participants included all patients who 1) have been diagnosed with lumber without radicular pain, LBP (diagnostic code 3.1), lumbar & radicular pain, LRP (diagnostic code 3.2), or diffuse lumbar pain, DLP (diagnostic code 3.4), 2) who provided written consent for their data to be used for research purposes, and 3) have completed their initial visit to the pain clinic by May 31, 2011. ***Intervention:*** The data required for this project had previously been collected and entered in the Quebec Pain Registry. Basic descriptive results were produced using SAS® software 9.2. This analysis described the characteristics of the 917 patients included in the study at baseline. Additional data were explored to examine patterns of changes over two years for certain characteristics. A generalized estimating equations model (GEE) was used to analyze data at 6, 12, and 24 months after the initial visit. ***Results:*** 299 (32.6%) patients were diagnosed LBP, 522 (56.9%) with LRP, and 96 (10.4%) with DLP. In general, all patients were relatively comparable in terms of their characteristics with the exception of DLP, where proportions were noticeably different. Patients diagnosed with DLP had a higher pain duration median (6.0 years) and the most frequently current employment status was permanent disability (both in regards to proportions). The most common ethnicity was Caucasian among all diagnoses. Income was similarly distributed among all groups and secondary school was the highest level of education completed for all. The top three medical conditions reported other than CLBP were rheumatoid arthritis/osteoarthritis, hypertension, and depressive disorders. DLP patients reported “accident at work” as the most common circumstance surrounding their onset of pain. DLP also had noticeably different mean scores for average pain, worst pain, depression, catastrophizing, disability, mental and physical summary scores on the

health-related quality of life questionnaire at baseline, 6, 12, and 24 months (in regards to proportions). Patients with higher worst pain scores, longer pain duration, and lower physical summary scores at the initial visit were significantly less likely to show improvements in pain intensity and disability at six and 12 months. ***Conclusions:*** Although modifying the analysis prohibited conclusions for a two-year follow to be made, characteristics, such as worst pain, pain duration, and lower physical summary scores at both six and 12 months were discovered, thus providing insight into the clinical evolution of CLBP from baseline to 12 months by determining what characteristics predict worse pain and disability outcomes. While it is apparent from this study that DLP patients have noticeably different characteristics compared to other pain CLBP diagnoses, it is recommended that DLP patients be explored in more depth over a longer period of time. The overall findings of this project indicate there is still much needed research in the area of CLBP.

Résumé

Contexte: Des centaines de milliers de résidents du Québec souffrent de douleurs chroniques. Pour eux, un traitement est loin d'être optimale. La douleur chronique est reconnue comme un problème de santé majeur, non seulement en raison de sa fréquence, mais aussi les effets dévastateurs qu'elle a sur les aspects physiques, émotionnels et sociaux de la vie. En dépit de la douleur au bas du dos étant la deuxième cause la plus fréquente de consulter un médecin de soins primaires, la gestion reste difficile. En outre, chronique des douleurs au bas du dos (lombalgie) a été trouvé d'être la raison la plus commune pour les patients d'être adressés à des centres de la douleur tertiaires. Récemment, il y a eu une acceptation croissante que les facteurs bio- psychosociale (biologiques, psychologiques et sociaux) jouent un rôle crucial de l'évolution clinique de la lombalgie chronique , mais peu de recherches concernant la lombalgie chronique ont étés achevé plus d'un an . **Objectif:** L'objectif de cet étude est d'identifier les groupes de patients à faible maux de dos chroniques dans les soins tertiaires, telles que définies par leur changement dans la douleur et le handicap au fil du temps, et d'explorer les caractéristiques possibles associés à ces changements Les objectifs spécifiques sont : 1) d'établir s'il existe des groupes distincts de patients atteints de lombalgie chronique avec des caractéristiques de réponse à 6, 12 et 24 mois après la visite initiale, et 2) pour identifier le potentiel social, psychologique, biologique et environnemental caractéristiques, conformément à la modèle révisée Wilson et Cleary pour la qualité liée à la santé de la vie. **Conception:** analyse prospective d'une cohorte historique. **Cadre:** Le Registre québécois de la douleur, une base de données de recherche unique composée de près de 5000 patients souffrant de douleurs chroniques de centres de la douleur tertiaires

associés à l'Université de Montréal, Université de Sherbrooke, Centre universitaire de santé McGill et l'Université Laval. **Participants:** adultes diagnostiqués avec la douleur chronique au bas du dos qui sont inscrits dans le registre de la douleur Québec. Les participants admissibles inclus tous les patients qui ont été diagnostiqués avec le bois sans douleur radiculaire , LBP (code de diagnostic 3.1), lombaire et douleur radiculaire , LRP (code de diagnostic 3.2) , ou une douleur lombaire diffuse , DLP (code de diagnostic 3.4) et ont terminé leur formation initiale visite à la clinique de la douleur avant le 31 mai 2011. **Intervention:** Les données nécessaires à ce projet avaient déjà été recueillies et consignées sur le registre de la douleur Québec. Résultats descriptives de base ont été produites en utilisant SAS ® 9.2 logiciel. L'analyse descriptive a décrit les 917 patients inclus dans l'échantillon de l'étude au départ, générant des scores moyens. Des données supplémentaires ont été explorées pour observer des modèles sur deux ans pour certaines caractéristiques. Un modèle des équations d'estimation généralisées (GEE) a été utilisé pour analyser des données corrélées à six, 12 et 24 mois. **Résultats:** 299 (32.6%) patients ont été diagnostiqués LBP, 522 (56.9%) avec LRP, et 96 (10.4%) avec DLP. En général, tous les diagnostics étaient comparables à l'exception de DLP. Les patients diagnostiqués avec DLP avaient une durée médiane de la douleur plus élevé (6,0) et l'invalidité permanente le plus fréquemment rapporté pour le statut actuel de l'emploi. L' ethnie la plus fréquente était de race blanche parmi tous les diagnostics . Le revenu a été distribué similaire dans tous les groupes, et à l'école secondaire était le plus haut niveau de scolarité atteint pour tous. Les trois conditions médicales rapportées étaient la polyarthrite rhumatoïde / arthrose, l'hypertension et les troubles dépressifs. DLP patients ont signalé

« accident du travail » comme circonstance la plus courante qui entoure leur apparition de la douleur. DLP a également indiqué sensiblement différents scores moyens pour la douleur moyenne, pire douleur, la dépression, catastrophisme, le handicap, le score résumé mental, et le score résumé physique au départ, 6, 12 et 24 mois. Les patients ayant les plus mauvais scores de la douleur, la durée de la douleur plus élevé, et des scores plus bas sommaires physiques étaient significativement moins susceptibles de montrer des améliorations dans la douleur et le handicap à six et 12 mois. **Conclusions:** Bien que la modification des conclusions interdites d'analyse pour un suivi de deux ans à faire, des caractéristiques importantes telles que la pire douleur, la durée de la douleur, et les scores sommaires physiques inférieurs aux deux six et 12 mois ont été découverts, offrant ainsi un aperçu de l'évolution clinique de lombalgie chronique de référence à 12 mois par la détermination de ce caractéristiques prédisent pire douleur et les résultats d'invalidité. S'il ressort de cette étude que les patients DLP ont sensiblement différentes caractéristiques et schémas de réponse par rapport à d'autres diagnostics de la douleur, il est recommandé que les patients DLP soient examinées plus en profondeur sur une longue période de temps. Les résultats globaux de ce projet indiquent qu'il y a encore beaucoup de recherches nécessaires dans le domaine de la lombalgie chronique.

Introduction

Background

Overview of the Health Problem: Chronic Low Back Pain

Back pain is one of the most prevalent and costly musculoskeletal health problems in today's industrial societies [1]. The World Health Organization indicates that back pain is the most common cause of disability among persons under the age of 45 and second only to arthritis in persons between the ages of 45 and 65 [2] [3]. More specifically, low back pain (LBP) is one of the most common forms of back pain and is associated with disability, economic costs, and social burdens [4, 5]. Additionally, low back pain is the most common cause of morbidity and accompanying functional limitations [6]. Unfortunately, the management and prognosis of low back pain is uncertain, often resulting in a chronic health condition [4, 5].

Low back pain is defined as pain in the spine or muscles of the lower back [3] and is deemed chronic after three months of initial onset [7, 8] [4] and functional disability has been impaired [9].With a recurrence rate close to 85%, recovery after the 12-week time point is uncertain [9]. At any given time, 12%-33% of the adult population is suffering from low back pain. Estimates for a one-year prevalence are between 22% and 65%, with a lifetime prevalence ranging from 11% to 84% [4]. In Canada alone, the incidence of chronic LBP is 45 per 1000 persons [2].

While back pain is the second most common reason to visit a family physician [10], 85% of primary care patients diagnosed with low back pain have pain that is labeled nonspecific [10]. This is primarily due to the complexity of the bone, muscular

ligamentous, and neural elements of the back along with minimal or zero structural or inflammatory changes visible in the spine or joints [11]. Up to 40% of patients who consult a primary care professional do not completely recover within three months and approximately 5% to 10% of these patients will develop lifelong chronic low back pain (CLBP) [12]. Unfortunately, CLBP has been linked to extensive reductions in physical function and general well-being [13] [7]. This complex, multifactorial health condition is contingent upon several factors from a variety of aspects including somatic, psychological, and environmental [14].There has been an increasing acceptance that psychological factors are heavily linked to the transition from acute to chronic pain, acting as strong predictors of a chronic evolution [15]. Researchers agree that psychological factors may contribute as much as clinical factors [16] and that psychological factors may have a larger impact on disability and quality of life compared to biomedical factors [15].

CLBP is therefore a devastating problem within the realm of public health due to the tremendous medical and social costs [14]. The socioeconomic burden of CLBP is comparable to heart disease, depression, and diabetes in terms of work absence and disability [17]. In the United States, the costs associated with general back pain are more than 25 billion dollars annually, with a large portion of this amount attributed to care seeking and disability [18]. Less than half of persons disabled as a result of CLBP for more than six months will return to work; after two years, the number is almost zero [19]. Back pain directly costs the American healthcare system $12.2 billion annually, not far behind heart disease and motor vehicle crashes [20].

Epidemiology and Natural History

While CLBP has been found to be the most common reason for patients to be referred to tertiary pain centers, little is known about the natural history of CLBP. The classical medical model only addresses somatic factors, thus failing to address the numerous psychological, social, and environmental variables associated with low back pain and the transition to chronicity [14]. While previous studies have explored back pain through the bio-psycho-social model, Wilson and Cleary first developed a more detailed model in 1995, known as the Conceptual Model of Quality of Life. This model promotes the selection of appropriate measurement variables while identifying potential links between these variables and the complex construct of quality of life [21].

A common clinical challenge among clinicians is early identification of subgroups of patients at risk for developing CLBP. Individually targeted treatment responses are urgently needed, therefore; factors that drive change in pain in individuals must be explored [12] [1].Unfortunately, studies focused on low back pain composed of large sample populations tend to lose data due to poor follow up measures [4]. Moreover, studies that explore CLBP and disability beyond one year of follow up are rare, [22] yet urgently needed to adequately assess the wide range of characteristics associated with CLBP [22]. Long term research that focuses on the wide array of characteristics modifying risk along with the resilience or susceptibility of back pain is needed [22] .This can be achieved by exploring trajectories of change. Trajectories explain the course of an outcome over time [23] and while pain has been explored using trajectories, very few studies have explored CLBP specifically [22] . Trajectories are poorly understood in terms of the natural history of low back pain and the characteristics that affect the change in

pain [22]. Currently, there is no existing research that has explored trajectories of change in CLBP beyond one year of follow up.

Study Objectives

The purpose of this study was to identify subgroups of CLBP patients treated in tertiary care, as defined by their changes in pain and disability over time, and to explore possible characteristics associated with these changes. The specific objectives of this study were: 1) to establish whether there are distinct subgroups of patients with CLBP with different characteristics associated with change in pain and disability at 6, 12, and 24 months following an initial visit in a tertiary pain clinic; and 2) to identify potential social, psychological, biological, and environmental factors that may predict their responses in pain intensity and disability in accordance with the Revised Wilson and Cleary Model for Health-Related Quality of Life.

Research Questions

Specifically, the research questions addressed in this study are:

1. What are the pain and disability characteristics of CLBP patients treated in tertiary care centers over a two-year period?
2. What are the bio-psycho-social factors that predict changes in pain and disability among CBLP patients over a two-year period?

Review of Related Literature

This section reviews the literature concerned with CLBP. The purpose of this section is to explore our knowledge of the interlaced dimensions of CLBP, including the characteristics that are proposed to contribute to changes in pain and disability over time. For organizational purposes, the literature is presented under the following topics: (1) Search Strategy, (2) Modeling Chronic Low Back Pain, (3) Predictors of Chronic Low Back Pain, (4) Evidence for Interventions and Treatment, (5) Advanced Measures of Chronic Low Back, and (6) Knowledge Gaps and Synthesis. This section will provide further evidence for the rationale of the research study.

Search Strategy

In order to retrieve relevant scientific articles, the MEDLINE and EMBASE databases were used via OVID Online. To retrieve relevant articles, the following search terms were incorporated into the literature search:

"Back pain (complications, diagnosis, diet therapy, drug therapy, epidemiology, etiology, prevention and control, psychology, rehabilitation, surgery, therapy)
"Low back pain"
"Chronic low back pain"
"Chronic"
"Trajectories"
"Trajectories and pain"
"Biopsychosocial approach"
"Biopsychosocial"

Inclusion/ Exclusion Criteria

The literature search was limited to English publications published after 1998 found within the MEDLINE or Embase databases via Ovid Online. Geographic limitations were not applied to the search as a way to broaden the results.

Modeling Chronic Low Back Pain

This section describes existing models used to explain the interaction of characteristics concerned with chronic health conditions, as applied to CLBP.

The Bio-Psychosocial Model

Due to the complex nature of CLBP, the traditional biomedical model does not address the critical characteristics associated with this health condition. Within recent years, there has been increasing support for the bio-psycho-social model of chronic pain, a model emphasizing the relationships between biological, psychological, and social factors. This model, introduced by George L. Engel in 1977 [24], enables health care professionals to explore interacting mechanisms at the cellular, tissue, organismic, interpersonal, and environmental levels [24]. Furthermore, the bio-psycho-social model incorporates patients' unique biological, psychological, and social factors that affect their pain including medical comorbidities, illness beliefs, coping strategies, emotional reactions, fear and depression, employment, and economic concerns [25]. Evidence supporting the bio-psycho-social approach has increased within the last 30 years however; the biomedical model is still the prevailing model of medicine today. Despite this, health professionals are often faced with medically unexplained symptoms that require a different approach,

where the psychological well-being of patients (i.e. depression and anxiety) are looked at [24]. Engel [24] argued that psychological well-being played a protective role in the balance between health and chronic conditions and believed that exploring other aspects of patient's lives was an important part of patient care [24]. Today, however, the majority of healthcare spending is focused on the biomedical model; a large number of deaths and disability is attributed to preventable behavior and exposures such as smoking and obesity [24]. It has been suggested that spinal pain and disability can only be understood and managed in accordance to the bio-psycho-social model [26]. While this model addresses the various factors associated with CLBP, a more recent model developed by Wilson and Cleary encompasses a wider array of biological, psychological, and social factors with emphasis on how different variables interact.

The Wilson and Cleary Model of Health-Related Quality of Life (HRQoL)

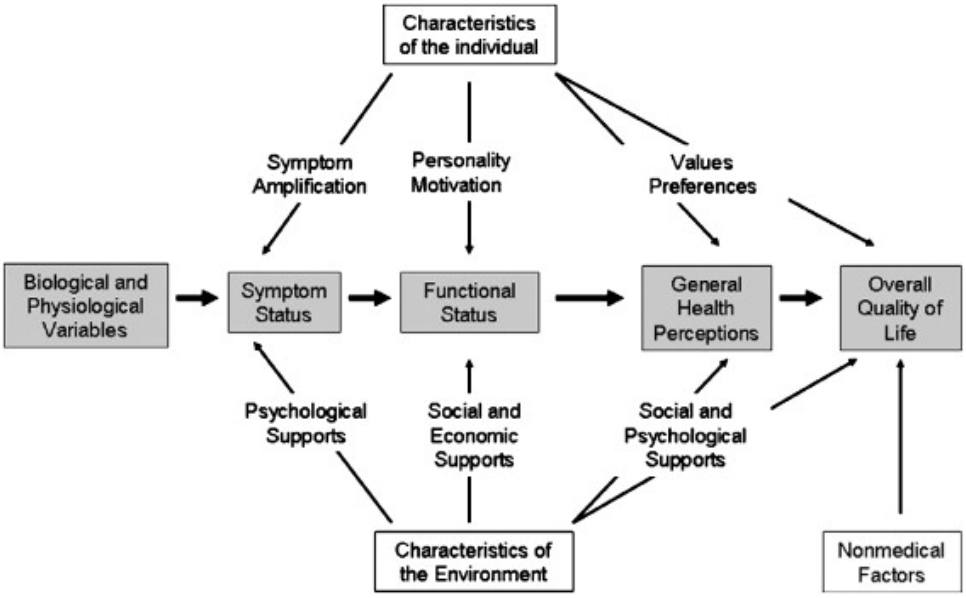
Similar to the bio-psycho-social model developed by Engel [24], Wilson and Cleary (1995) developed a model in 1995 for patient outcomes known as The Wilson and Cleary Health-Related Quality of Life Conceptual Model. These authors believed that progress in the area of research related to quality of life was hindered due to lack of conceptual models that specify how different types of patient outcome measures correlate [27]. Their model focused on a continuum of biological, social, and psychological complexities [27], further emphasizing the concept of quality of life through various economic, political, cultural, and spiritual factors that are typically not considered by the healthcare system and are believed to play a role in the health of individuals[27]. Ultimately, Wilson and Cleary (1995) developed a model that integrates two very different paradigms of health: one held by clinicians and one held by social scientists. The five levels in the model

include: biological and physiological variables, symptom status, functioning, general health perceptions, and overall quality of life [27]. *Biological and physiological* factors involve the function of cells, organs, and organ systems and include factors such as diagnoses, laboratory values, measures of physiological function, and physical examination findings[27]. The *symptoms* level focuses on the individual as a whole and can include physical, psychological, and emotional symptoms. Wilson and Cleary (1995) define a symptom as " a patient's perception of an abnormal physical, emotional, or cognitive state" [27]. *Functioning* refers to "the ability of the individual to perform particular defined tasks" [27]. Four commonly measured domains of functioning are physical, social, role, and psychological function. Wilson and Cleary (1995) stress that several aspects of an individual's life have the potential to improve functioning in these domains. Furthermore, Wilson and Cleary (1995) believe that symptoms and functioning are heavily correlated and can predict function levels. *General health perceptions* are affected by numerous factors. Biological and physiological factors, functional status, and social factors have all been found to affect health perceptions. Strong predictors of general health perceptions are somatization and hypochondriasis [27] two factors found to be associated with CLBP. Finally, *overall quality of life* is complex in itself. Numerous constructs and theories relating to well-being have been developed and tested over the years, primarily focusing on satisfaction. This level of the model is more sensitive to change, as individual responses often change due to changes in other levels of the model [27].

It is evident there is room for overlap in the model. For example, depression could be classified two different ways, symptom, or psychological functioning. Nonetheless,

regardless where variables are classified, they can have causal relationships with other variables at any level of the model. The Wilson and Cleary Model of Health-Related Quality of Life imcludes variables from all aspects of patient's life that contribute to health conditions, such as CLBP. Figure 2.1 illustrates the model developed by Wilson and Cleary (1995).

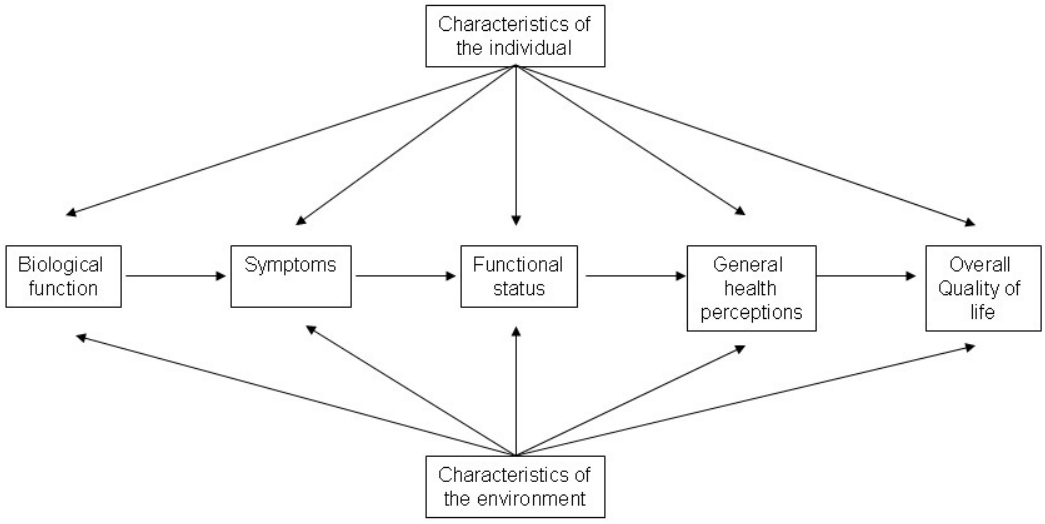
Figure 2.1- Wilson and Cleary Model of Health-Related Quality of Life (HRQoL)



Revised Wilson and Cleary Model for Health-Related Quality of Life

More recently, Carol Estwing Ferrans and colleagues (2005) revised Wilson and Cleary's model. Although the revisions were very minimal, the purpose of these revisions was to further facilitate the use of this conceptual model of health-related quality of life in healthcare by incorporating relevant literature from more recent years [28]. The revised model can be found in Figure 2.2.

Figure 2.2 Revised Wilson and Cleary Model for Health-Related Quality of Life (HRQoL)



Three major revisions of the original model were made. First, Ferrans and colleagues (2005) added arrows to illustrate that biological function is influenced by characteristics of both the individual and the environment. Second, the authors included nonmedical factors as an influence of overall quality of life. The revised model indicates that nonmedical factors are organized as characteristics of the individual or environment and thus, the box for nonmedical factors is not included in the revised model. Finally, the original model included arrows accompanied by examples [28]. Ferrans and colleagues (2005) believed these examples limited the characterization of relationships and therefore eliminated specific examples. Likewise, the revised model focuses on the five types of measures of patient outcomes found in the middle of both models. Additionally, biological and physiological variables were renamed to biological function, and symptom status to symptoms [28]. Although the revised model has only minor changes, this study will incorporate the revised model by Ferrans and colleagues (2005). Incorporating the

revised Wilson and Cleary model improves the approach to examining the potential characteristics that contribute to the change in pain and disability relating to CLBP over time because it will enable several characteristics to be explored through a more complex analysis as compared to the bio-psycho-social model. This model provided the basis for the selection of the characteristics included in this study. The characteristics relating to the revised Wilson and Cleary Model for Health-Related Quality of Life that were analyzed in the present study are summarized in Table 2.1.

Table 2.1- Levels of the Revised Wilson and Cleary Model for Health-Related Quality of Life with Quebec Pain Registry variables

Revised Wilson and Cleary Model for Health-Related Quality of Life	**Quebec Pain Registry Characteristics**
Characteristics of the Individual	Demographics • Date of Birth • Sex • Ethnic Group • Education Level • Current Work Status • Family Income Medical History • Current and Past Medical History (Number of co-morbidities) Pain Coping • Tendency to Catastrophize
Symptoms	Pain History • Pain Duration • Circumstances Surrounding Onset of Pain Pain Characteristics • Frequency • Intensity Psychological Well-Being and Quality of Life • Depression
Functional Status	• Pain Interference on Daily Activities
Health Related Quality of Life	• Health-Related Quality of Life

Predictors of Chronic Low Back Pain

A common concern that was explored in the reviewed literature was the close association between predictors, contributors, variables, and prognostic factors relating to CLBP. While there is some consensus among researchers and healthcare professionals, there is a vast array of literature that report contradictory findings relating to the characteristics relating to CLBP. For the purpose of this thesis, the potential characteristics relating to CLBP in accordance to the Revised Wilson and Cleary Model for Health-Related Quality of Life and the data that are available in the Quebec Pain Registry were explored.

Characteristics of the Individual

Among the studies that have focused on the characteristics associated with CLBP, the majority of studies concluded that demographic characteristics are associated with this unfavorable health condition. While several studies have demonstrated consensus regarding specific demographic characteristics, other studies suggest alternate findings. The most debatable individual characteristic relating to CLBP is sex. There appears to be no consensus among researchers as to whether or not sex predicts outcomes associated with CLBP. Nyiendo and colleagues [29] reported that sex was not a predictor of pain and disability at six and 12 months [29]. Similarly, a systematic review of low back pain characteristics had the same conclusions [10]. Williams and colleagues (2010) suggested that low back pain incidence was higher among males [30]. Soucy and colleagues (2006) completed a study that focused on work-related factors contributing to chronic disability in low back pain and found that women were twice as likely to return to work, concluding that gender was a strong predictor of disability [31]. A systematic review of MEDLINE and EMBASE completed by Chou and Shekelle (2010) found that

demographic characteristics including age, sex, and education level failed to predict worse outcomes after three months [10]. Interestingly, Costa and colleagues (2009) reported that delayed recovery was significantly related with lower levels of education. Participants who did not receive an education beyond secondary school were 26% less likely to recover from pain any time after initial onset [32]. Krismer and Tulder (2007) reported a low education level as a risk factor for CLBP however; they found that age was only associated with a single episode of low back pain [33]. Nyiendo and colleagues (2001) completed a prospective observational study and concluded that income was an important predictor of pain and disability for patients with CLBP however, previous studies have reported contradictory findings [29]. While some researchers strongly believe demands in the workplace contribute to chronic low back pain, existing literature indicates there is room for debate in this area. A systematic review by Chou and Shekelle (2010) found that both higher physical work demands and dissatisfaction at work did not predict worse outcomes at three months, but did at 12 months [10].

Pain catastrophizing has also been shown to be associated with increased pain intensity and functional disability in pain patients [34]. Catastrophizing, defined as a set of negative emotional and cognitive processes, is highly associated with the bio-psycho-social approach to pain management [35]. Catastrophizing is often found alongside depression and the fear-avoidance model, which suggests that catastrophic interpretations of pain lead to avoidance and therefore to higher levels of disability and depression [12]. Leeuw and colleagues (2007) reviewed scientific evidence focusing on the characteristics associated with the fear-avoidance model and concluded that fear and anxiety are associated with increased avoidance behaviors and high levels of catastrophic thoughts

[34]. Moreover, they also state that personal vulnerabilities such as fundamental fears and neuroticism may influence individual responses to pain. The authors conclude there are several unexplored issues in this realm of pain research and are left with questions such as, when to target pain related fear and when is pain related fear adaptive and dysfunctional. Similarly, Melloh and colleagues (2007) determined that fear avoidance beliefs were found to be a strong predictor of functional limitation in CLBP patients [34]. Finally, Chou and Shekelle (2010) reviewed 20 studies that explored characteristics associated with disabling low back pain and found similar conclusions. The authors state that patients with maladaptive coping behaviors, including fear avoidance and catastrophizing were more likely to have worse outcomes at three, six, and 12 months [10].

Symptoms

Pain History

Using the Revised Wilson and Cleary Model for Health-Related Quality of Life and the data available in the Quebec Pain Registry, symptoms consist of pain history, more specifically pain duration and circumstances surrounding the onset of pain. Melloh and colleagues (2009) reviewed 13 studies and determined that pain duration served as one of the strongest predictors of pain intensity [1]. Furthermore, research conducted by Costa and colleagues (2009) explored red flag signs, such as insidious onset and major trauma however, statistically significant results were not found [32].

Pain Characteristics

Individual pain characteristics such as pain frequency and pain intensity are recognizably related higher levels of disability. Costa and colleagues (2009) followed a cohort of CLBP patients for one year and determined there was a strong association between pain intensity and delayed recovery[32]. The authors labeled pain intensity at chronic presentation as a "red flag" symptom and found the results to be significantly associated with delayed recovery as a result of disability (32% less likely to recover)[32].

Depression

Depression is often explored as a predictor for low back pain. Arguably, depression is the most debatable characteristic associated with low back pain as researchers are still trying to determine if depression predicts low back pain or low back contributes to depression. Nyiendo and colleagues (2001) explored predictors for long-term pain and disability outcomes in patients with CLBP and found that chronic depression was an important predictor of both pain and disability [29]. Similarly, a systematic review completed by Chou and Shekelle (2010) reviewed seven studies that explored psychiatric comorbidities, including depression for predicting chronic disabling low back pain and concluded that psychiatric comorbidities can increase the likelihood of predicting disabling CLBP [10]. Pincus and colleagues (2002) also determined that depressive mood is a significant predictor of unfavorable outcomes [16]. Contrary to these findings, a study by Currie and Wang (2005) from the University of Calgary examined the relationship between chronic back pain and depression using depression as both a risk factor and consequence of chronic back pain. The authors concluded that major depression increases

the risk of developing chronic pain however; the causal mechanism linking both back pain and depression is unknown [36]. Higher pain severity was associated with a higher prevalence of major depression. These findings suggest that the link between depression and chronic back pain is not fully understood and more longitudinal epidemiological studies are needed to further understand how these conditions influence one another.

Functional Status

Pain Interference on Daily Activities

A common focus throughout the reviewed literature was the negative effects CLBP has on a patient's functional status, specifically their everyday activities. Arguably, some researchers have explored functional status looking at disability as both a contributing characteristic or as an outcome. Similar to this study, a primary outcome for a study completed by Costa and colleagues (2009) was disability; 42% of the 406 participants in the study reported no disability at baseline. Only 1% (3 participants) reported extreme disability at baseline. Similar numbers were found at both the nine and 12 month follow up[32]. Despite these findings, several of the variables included in their study were found to be significantly associated with disability as an outcome measure. In Melloh and colleagues (2009) systematic review of prognostic factors for chronicity in patients with low back pain, it was determined that a higher level of disability was a predictor for a longer duration of sick leave [1].

Evidence for Interventions, Management, and Treatment

Although the potential market for management and treatment related to CLBP is vast, discrepancies among healthcare professionals concerning interventions and treatment options are common, resulting in failed treatment attempts and economic and emotional

costs [37]. While treatment goals vary, the majority of interventions focus on similar outcome measures such as symptoms, primarily pain as well as activity/ participation, primarily disability. Although pharmacological interventions have been proven effective, highly successful treatments for chronic low back pain have been found to be multidisciplinary programs that include both exercise programs and behavioral therapy [33].

Lifestyle Interventions

While there are several lifestyle factors that contribute to the clinical evolution of CLBP, researchers have yet to determine a single factor that plays a primary role. A review of selected guidelines, systematic reviews, and clinical studies all focused on lifestyle interventions determined that fitness programs and education programs serve as beneficial lifestyle interventions [33]. Fitness programs with a focus on exercises for flexibility, aerobics, muscular strength, and endurance, performed daily for 30 minutes provide strong evidence for reducing pain and disability [33]. Successful education programs were focused on minimizing individual fear relating to their CLBP. Effective programs addressed worries while simultaneously addressing measures to enhance physical activity and an ergonomic living [33].

Pharmacological Interventions

Scientific evidence states that various drug therapies can control pain and reduce muscle tension, two principal characteristics of CLBP [33]. There is no evidence to support that this type of intervention can prevent CLBP. Selected guidelines, systematic reviews, and clinical trials have determined that the following pharmacological interventions can

reduce symptoms and improve physical functioning: simple (non-opioid) analgesics, anti-inflammatory analgesics, antidepressants, muscle relaxants, and epidural injection of steroids [33]. Despite these findings, interventions that target more than the pharmacological aspect alone are recommended to address the complex nature of CLPB.

Rehabilitative Interventions

Rehabilitative interventions are primarily aimed at improving functioning while focusing on the individual as a whole. The list of rehabilitative interventions that have supporting scientific evidence is complex and specific [33]. Table 2.2 summarizes the various rehabilitation interventions that have been proven to be effective when addressing CLBP [33].

Table 2.2- Rehabilitation Interventions Targeted at CLBP

Rehabilitation Interventions
Angular joint mobilization
Joint play techniques
Traction
Rest
Functional immobilization
Strengthening exercises
Flexibility techniques
Biofeedback
Relaxation techniques
Acupuncture
Aerobic fitness and endurance
Therapeutic cold
Hydrotherapy
Massage
Transcutaneous Electrical Nerve Stimulation (TENS)
Behavioral treatment
Multidisciplinary treatment programs

While a detailed description of each intervention is not possible in this thesis, rehabilitative interventions are performed by a variety of healthcare professionals and are

documented in the Quebec Pain Registry under "current pain treatments other than pharmacological treatment and current interventions" performed at the Pain Clinic.

Advanced Analyses of the Clinical Evolution of Chronic Low Back Pain

Recently, there has been an increase in the exploration and application of trajectory-based models [23] to describe the course of an outcome over time [23]. Most commonly, trajectory-based models have been applied to study the developmental course of various disorders, primarily depression [23]. The trajectory may depend on variables such as sex, social background, time-varying covariates, and personal characteristics of individuals [38].When exploring trajectories of changes, also known as developmental trajectories, repeated measures of given outcomes are collected over time with the purpose of describing how individuals grow or change over a pre-determined interval of time [38]. A trajectory approach is able to better describe the recurrent and fluctuating nature of many painful conditions, including CLBP [22]. Although prospective studies of back pain have been completed, the most common type explored how variables collected at one time point lead to an outcome at a second time point [22]. Studies exploring several potential characteristics relating to CLBP that are longer than one year and include repeated measurements beyond one year are extremely rare [22]. Regrettably, CLBP is a long lasting health condition, thus studies covering a single year only provide some insight into the complexity of CLBP, consequently missing information that may play an important role in understanding CLBP in the long term. Trajectories describe patterns of single characteristics as well as describe changes, transitions, and marked changes of direction, otherwise known as "turning points" [22]. While trajectory-based models are a novel approach to studying CLBP, this study will provide a base for further developing

this approach. With this in mind, it is important to introduce trajectories as an advanced measure of CLBP as this study has been designed and developed with this approach in mind. Unfortunately, due to time limitations and difficulty with the statistical material, it was not possible to incorporate a trajectory-based approach to exploring CLBP. Although this study does not incorporate an in depth exploration of trajectories, the data analysis included in the present thesis will incorporate similar analyses relating to change in pain and disability over time.

Knowledge Gaps and Synthesis

The reviewed literature indicates that CLBP has been the focus of previous research. Consensus regarding the characteristics that contribute to change in pain and disability over time has not been reached. While not all the reviewed literature had the same focus, methodologies, or study populations, a similar concept was evident throughout all the studies reviewed. Researchers agree the clinical course of CLBP is poorly understood. For the most part, authors of the studies reviewed agreed that optimal management of chronic low back pain is not available. There is general agreement that interventions targeting individuals must be developed and implemented but few concrete suggestions are made. This suggests that interventions that are tailored to the specific characteristics of individual cases should be developed through interdisciplinary collaboration among healthcare professionals.

There was general consensus on the subject of the numerous factors that contribute to CLBP. While there are several theories exploring the factors associated with CLBP, the majority of the reviewed literature indicates the wide acceptance that biological, psychological, and social factors all play significant roles in CLBP. A majority of studies

have examined low back pain using very specific populations, for example pain brought on by work related injuries [22]. Larger studies that include diverse populations of participants are needed. Authors commonly mentioned the need for studies lasting longer than one year. Several authors also discuss the need for studies that included several measurement tools, large sample populations, and repeated measurements. As stated by Dunn (2006), the majority of back pain studies are designed to collect baseline data and predict outcomes at later time points. What is needed are studies designed to characterize the course of characteristics relating to CLBP over time [39].

A need for further research exploring CLBP is apparent. Future studies should take into consideration that a variety of characteristics contribute to low back pain and each individual course is different. In order to successfully determine characteristics that relate to change in pain and disability over time, characteristics from various areas of life must be explored, along with new approaches to exploring this health condition, and studies that include multiple follow up visits. As previously mentioned, the specific objectives of this study were: 1) to establish whether there are distinct subgroups of patients with CLBP with different characteristics associated with change in pain and disability at 6, 12, and 24 months following initial visit in a tertiary pain clinic; and 2) to identify potential social, psychological, biological, and environmental factors that may predict their responses in pain intensity and disability in accordance with the Revised Wilson and Cleary Model for Health-Related Quality of Life.

Methods

Study Design

Given that little is known about the clinical evolution of CLBP, an observational prospective design was used to follow a cohort of patients who suffered from this type of health condition and were enrolled in the web-based Quebec Pain Registry

Data Sources

Quebec Pain Registry

The Quebec Pain Registry (QPR) is a unique clinical, administrative and research database comprised of anonymized data collected prospectively from a large cohort of patients with chronic pain conditions treated in tertiary pain clinics [40-42]. Originally initiated in 2008 by the Quebec Pain Research Network, the purpose of creating the QPR was to create a province-wide clinical pain research infrastructure. In turn, this would enable researchers in both academia and industry to complete large epidemiological, observational, and clinical studies to answer research questions associated with chronic pain conditions.

The QPR is a web-based database that uses identical clinical descriptors, uniform outcomes, and common validated and standardized measurement tools used [40-42]. The participating tertiary care clinics include the 1) Pain Clinic of the Centre hospitalier de l'Université de Montreal (CHUM), 2) Pain Clinic of the Centre hospitalier de l'Université de Sherbrooke (CHUS), 3) Alan Edwards Pain Management Unit of the McGill University Health Centre (MUHC), and 4) the Pain Clinics of the Centre hospitalier universitaire de Québec and of the Hôtel-Dieu de Lévis, which are both

affiliated with Université Laval. As these last two clinics joined the Quebec Pain Registry at the later stages in July 2012, they were not included in the present study.

When the patients are assigned their first appointment at the pain clinic, they are informed that they are required to complete questionnaires prior to their visits and at specified follow-up time points. This information is used for clinical purposes to monitor the evolution of their condition and for administrative purposes to establish annual statistics for the clinic. If the patient accepts that their anonymized data will also be used for research purposes, the patient provides written consent. This procedure and the consent form have been duly approved by the Research Ethics Boards affiliated with each participating site. More than 90% of the patients enrolled in the QPR accepted to sign the consent form[41].

In addition to baseline data that were collected prior to the patient's first visit at the clinic, follow up evaluations were performed at pre-specified time points. Up to March 2012, follow-up evaluations were scheduled at 6 months for all patients, and at 12 and 24 months for those who continued to be treated at the pain clinic. When a patient was discharged from the clinic, follow up was terminated at the next time point. Due to economic considerations, follow-up data collection at 12 and 24 months was however discontinued for all patients from April 2012 onward.

Baseline and follow-up data were collected with 1) a self-administered questionnaire (Patient Questionnaire) sent and returned by mail, 2) a structured interview protocol, administered by the registry nurse on the phone or at the clinic (Nurse Questionnaire), and 3) a review of the patient medical charts performed by the registry nurse. Collected data include a variety of demographic and clinical variables that are measured with well-

validated questionnaires/scales[41]. Variables of interest include pain characteristics (e.g., duration, frequency, intensity, psychological well-being (e.g., depression), health-related quality of life, medical history and consumption habits, past and current pharmacological and non-pharmacological pain treatments, patient expectations and satisfaction of treatment, patient global impression of change, and several socio-demographics (see Appendix 1). Pain diagnosis was established at the initial visit to the pain clinic by a medical pain specialist using a comprehensive list of diagnostic codes (112 different codes). This list of diagnostic codes was developed by five experienced pain clinicians because the more common ICD-10 system does not provide precise enough diagnostic codes for various chronic pain syndromes. The list of codes was piloted and the final version was put in place in each of the participating sites.

All data entered into the Quebec Pain Registry are anonymized and each patient is assigned a unique identification code. The Patient and Nurse Questionnaires are translated into electronic case report forms and entered into the web-based QPR. The database is fully compliant with good clinical practices and quality assurance standards including the FDA 21 CRF Part 11 regulations.

Study Population

The population of interest for this study was patients suffering from CLBP. They were selected from the QPR database among the patients attending the Pain Clinics of the CHUM, MUHC, and CHUS based on following criteria: 1) adult patients (≥ 18 years old) 2) patients whose primary diagnosis[1] was lumbar without radicular pain -i.e., diagnostic code 3.1 (LBP), lumbar and radicular pain-i.e., diagnostic code 3.2 (LRP), or diffuse pain

[1] Given that some patient may suffer from more than one chronic pain syndrome, only those whose primary diagnosis was CBLP were selected for the present study.

in the lumbar region-i.e., diagnostic code 3.4 (DLP), and 3) patients who provided written consent for their data be used for research purposes. Patients diagnosed with radicular pain only (diagnostic code 3.3) were excluded along with those whose pain was brought on by malignancy.

Available Study Population

To access data in the QPR, a data request form was completed outlining the patient selection criteria and the specific details pertaining to the variables that were needed for this study. Data were extracted by the QPR statistician and transferred using an Excel format. At the time of data extraction, the QPR had a total of 4936 patients of which 1008 had a primary diagnosis of LBP, LRP, or DLP at the first visit at the pain clinics. Initial visit and follow up dates ranged from October 31st, 2008 to April 21, 2013 in the database. Eligible patients who had their first visit at one of the three pain clinics after May 31st 2011 (N=201) were excluded from the data analysis because follow-up data was not available over a 24-month period. The number of patients with available data at each follow up time [2] (6, 12, and 24 months) varied as shown in Figure 3.1. Some of the patients were discharged from the pain clinic while others were lost to follow-up, could not be reached, or refused. Furthermore, some patients may have completed the Patient Questionnaire and not the Nurse Questionnaire or the other way around, while others completed both. Finally, as of April 1st 2012, the 12- and 24-month evaluations were discontinued in all patients due to budget restrictions as previously mentioned. Table 3.1

[2] In principle, the 6-month follow-up evaluation was carried out in all patients who completed the questionnaires at the initial visits whether they were discharged from the pain clinic or not. The 12- and 24-month follow-up evaluations were carried out only if the patients continued to be treated at the pain clinic.

outlines the number of patients with complete and incomplete data and the most common reasons why the questionnaires were not completed at each of the follow up times.

Figure 3.1- Study Population Selection Process and flow diagram

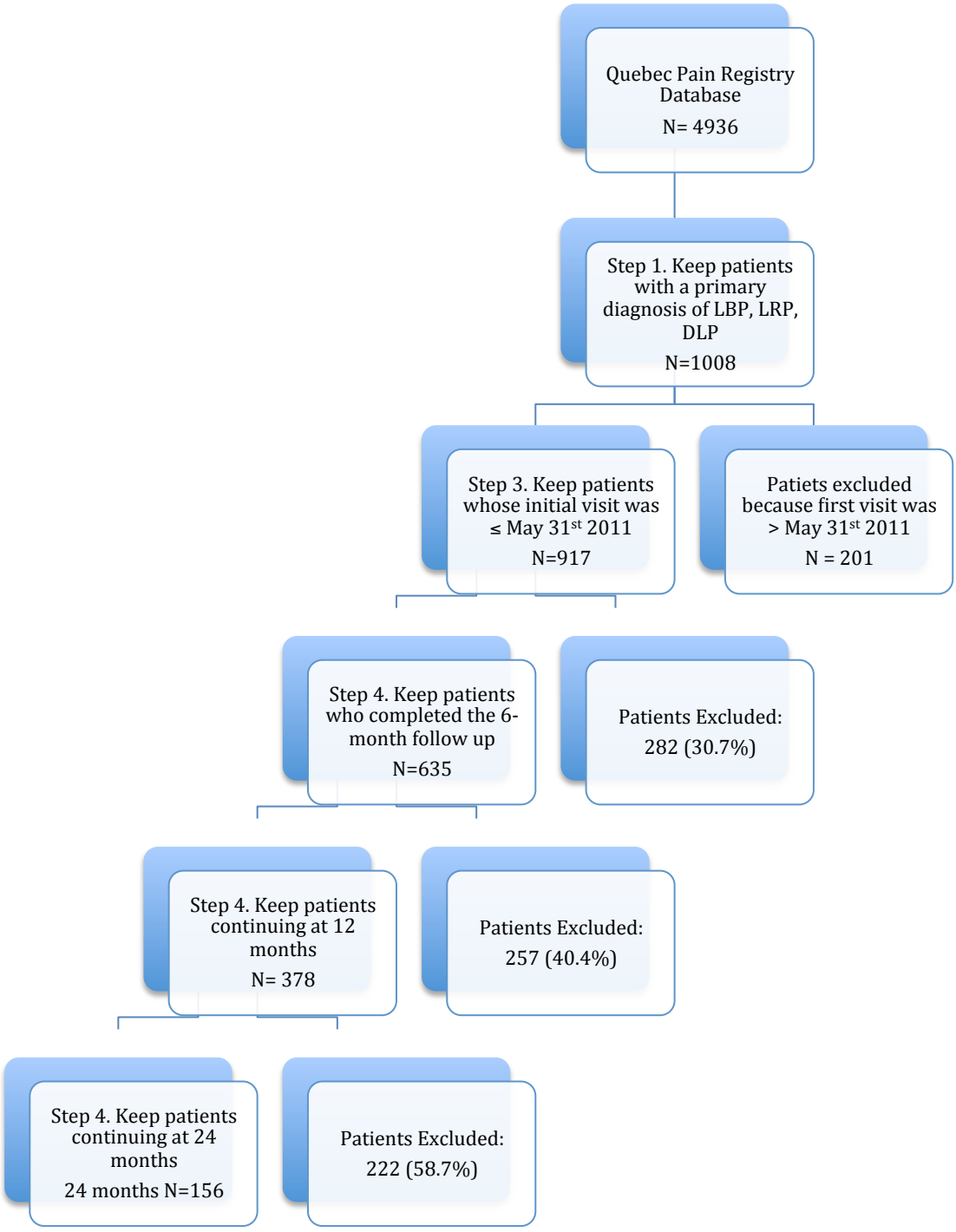


Table 3.1- Number and % of patients who completed or not the Nurse Questionnaire and/or the Patient Questionnaire and the most common reason why the questionnaires were not completed at each follow up times

	N (%)			
	Baseline	**6 Months**	**12 Months**	**24 Months**
Nurse Questionnaire				
Completed	915 (99.7%)	836 (91.1%)	510 (74.7%)	209 (48.4%)
Not Completed	2 (0.2%)	81 (8.8%)	172 (25.2%)	222 (51.5%)
Patient Questionnaire				
Completed	905 (98.6%)	641 (69.9%)	378 (55.4%)	157 (36.6%)
Not Completed	12 (1.3%)	276 (30.1%)	304 (44.5%)	272 (63.4%)
Lost to Follow up	N/A	35 (3.8%)	29 (14.2%)	8 (1.8%)
Most common reasons why the Nurse Questionnaire and/or the Patient Questionnaire were not completed at follow up times				
	Baseline	**6 months**	**12 Months**	**24 Months**
Nurse Questionnaire	N/A	Refused	-End of following -File ended, new procedure April 2012 -Refused	-File ended, new procedure April 2012 -Not seen in more than 1 year -Could not be reached
Patient Questionnaire	N/A	-Delay too long -Not returned by patient -Patient never received questionnaire	-Delay too long -End of following -File ended, new procedure April 2012	-File ended, new procedure April 2012 -Not seen in more than 1 year -Refused

Variables and Measurement Tools

Variables

Variables and measurement tools included in the Quebec Pain Registry were chosen according to the recommendations of the IMPACT WiGroup (Initiative on Methods, Measurement, and Pain Assessment in Clinical Trials) [43] [44], the existing patient databases used in clinics from Quebec and across Canada, and the expertise of collaborators' experiences in pain assessment and management. Additionally, the selection of measurement tools used in the registry was assessed for psychometric qualities (i.e. validity, reliability, and sensitivity) along with the availability of French and English versions.

Demographic data were collected through standardized questions contained in the Patient Questionnaires. Baseline demographic data includes date of birth, sex, ethnicity, family income, education level, and employment status, Additional data collected at baseline, 6 months, 12 months, and 24 months include the following:

- Average pain intensity in the past 7 days
- Worst pain intensity in the past 7 days
- Pain frequency (number of days during the past month)
- Pain interference (disability) on various aspects of daily living
- Depression levels
- Tendency to catastrophize in face of pain
- Health related quality of life (mental and physical summary scores)

Medical history, circumstances surrounding onset of pain, pain duration, and pain frequency were collected through nurse-administered questionnaires. The remaining data were collected through self-reported patient questionnaires. The following measurement scales were used to collect data over a two-year period relating to the important characteristics of CLBP and the outcomes measured in this study.

Measurement Tools

Depression

Beck Depression Inventory Version-1. Depression was measured using the Beck Depression Inventory-Version 1 (BDI-1). The BDI-1 is a 21 question self-reported questionnaire developed in 1961 and used to measure the severity of depression [45, 46]. Beck stressed the cognitive dimensions of depression therefore; the content of the BDI explores the patients' attitude toward themselves[46]. All questions cover the major symptoms and qualities of depression as observed in psychiatric patients, 15 cover emotions, 4 cover behavioral changes, and 6 cover somatic symptoms [45, 46]. Items are scored on a 0-3 point scale, with a maximum possible score of 63. Typically, a global score between 0 and 10 indicates "normal ups and down" and a score over 40 indicates severe depression. While Beck cautions against adherence to cut-off points, typical categories for the BDI-1 for non-psychiatric patients are as follows [46]:

- Less than 10= minimal or no depression
- 10-18= mild to moderate depression
- 19-29= moderate to severe depression
- 30 and more= severe depression

Health-Related Quality of Life

SF12-v2. Health related quality of life was measured using the SF12-v2 measurement scale. This instrument includes 12 questions chosen from the SF-36, a longer version and the most widely used survey for measuring health status and health outcomes. The SF-12-V2 contains eight subscales; physical functioning, role physical, bodily pain, general health, vitality, social functioning, role emotional, and mental health[47]. Two summary measures can be derived from these subscales, one summarizing the physical items, and one summarizing the mental items[48]. All eight subscales of the SF12-v2 included in the

Quebec Pain Registry were standardized using norm-based scoring with a mean of 50 and a standard deviation of 10. The means and standard deviations used to standardize the items are derived from the 1998 general U.S. population[48].

Tendency to Catastrophize in the face of pain

Pain Catastrophizing Scale. Pain coping was measured using the Pain Catastrophizing Scale (PCS), an instrument developed in 1995 by Dr. Michael Sullivan (Scientific Director of the McGill University Centre for Research on Pain and Disability). The PCS is a 13-item questionnaire with scores ranging from 0 to 52 [49]. It is often administered to chronic pain patients to evaluate individual negative beliefs and thoughts regarding their pain [50]. The PCS has excellent psychometric properties [49] [51] and is one of the most widely used instrument in pain research to measure pain catastrophizing, The PCS has three sections, one that explores how patients ruminate their pain, one focusing on magnification of pain, and one centering on how patients feel helpless in managing their pain [49, 52]. Although some studies dichotomize patients as catastrophizers and non-catastrophizers, the majority of research treats catastrophizing as a continuous, normally distributed variable. Dr. Sullivan recommends classifying patients with a score of 20 or less as "likely to go back to work", thus minimal catastrophizing behavior and patients with a score of 20 or higher patients would have "greater difficulty with returning back to work", indicating catastrophizing thinking [52]. This study will follow the cut-off points set forth by Dr. Sullivan.

Outcomes: Pain and Disability

Average Pain

Data pertaining to average pain intensity were self-reported using a numerical rating scale (NRS) from 0 to 10. Patients were asked to answer the following question *"Please select on the next scales, the one number that best describes: your pain ON THE AVERAGE OR AT ITS USUAL LEVEL in the past 7 days"*. Zero indicated no pain and 10 indicated the worst possible pain. Average pain intensity was classified in 4 categories:

- 0= No pain
- 1-3= mild pain
- 4-6= moderate pain
- 7-10= severe pain

While there has been debate within the realm of chronic pain research as to the optimal cut off points for mild, moderate, and severe pain, the classifications chosen for this study have been found to be the most commonly accepted for clinical and administrative use[53].

Disability

Interference Items of the Brief Pain Inventory. Pain-related interference on daily functioning was measured using the modified version of the Brief Pain Inventory (BPI) [54]. In its original version, the BPI used a 0-10 scale (0 = does not interfere, 10 = interferes completely) to measure pain interference in 7 domains: general activity, mood, walking ability, normal work, relations with other people, sleep, and enjoyment of life [55]. The BPI is well-validated questionnaire [55] that has been widely used in both cancer and noncancerous pain conditions [50] and which has been recommended as a core outcome measure for pain-related studies [44]. Tyler et al (2002) validated a modified version of the BPI in which three additional relevant interference items were added to the

7 contained in the BPI (i.e., self-care, recreational activities, and social activities) [54] . The version of the BPI developed by Tyler and colleagues (2002) is used in the Quebec Pain Registry and scored by taking the sum of the 10 items (minimum = 0, maximum = 100). Similar to the strategy used with the numerical rating scale for average pain intensity, this study used the following categories to classify overall pain related interference:

- 0= no interference
- 10-30= mild interference
- 40-60= moderate interference
- 70-100= severe interference

Statistical Analysis

Primary Research Question: General Descriptive Statistics

Basic descriptive results were produced using SAS® software 9.2. The purpose of this descriptive analysis was to describe the study sample at baseline at 6 months, 12 months, and 24 months stratified by diagnostic code in order to observe patterns over two years for certain characteristics. The SAS® software commands that were executed included *"PROC GENMOD"*, *"PROC UNIVARIATE"*, and *"PROC SGPLOT"*. These commands produced counts, means, standard deviations, medians, and histograms to determine normality. Data were restricted where necessary to include only certain diagnoses (i.e. DLP only).

Secondary Research Question: Bio-Psychosocial Characteristics of Pain and Disability

This set of analyses explored the bio-psychosocial characteristics associated with changes in pain intensity and disability (pain-related interference) in CLBP patients over a two-year period, using a generalized estimating equations model (GEE). A GEE model, also

known as a generated multivariate analysis is a method of analyzing correlated, binary data [56]. This model is particularly useful when analyzing data from longitudinal studies where participants are measured at different time points [56]. There were 917 patients at baseline that met the inclusion criteria for this study, however, after including only those who completed baseline and 24 month follow up, the number of patients dropped to 156. Missing scores were accounted for by filling in the missing score with the patient's score from their previous visit. Table 3.2 illustrates the missing observations for each characteristic at all four visits at the clinic.

Table 3.2- Missing Values for Patients who Completed Baseline and 24 Months

	Missing Data			
Characteristics	**Baseline**	**6 Months**	**12 Months**	**24 Months**
Average Pain	N/A	19	17	N/A
Disability	N/A	19	17	N/A
Worst Pain	N/A	19	17	N/A
Pain Frequency	N/A	3	6	3
Depression	N/A	19	17	N/A
Catastrophizing	N/A	19	17	N/A
Mental Summary Score	N/A	19	19	N/A
Physical Summary Score	N/A	19	18	N/A

For each of the primary outcomes, average pain and disability and individual scores at baseline (labeled as visit one) were subtracted from 24 months (labeled as visit 4) to generate a difference score for each outcome. The difference score was then divided by the baseline score to generate a percent change from baseline. In accordance with the reviewed literature, a improvement from baseline of 30% or greater in average pain and disability indicates meaningful clinical change [50]. A percent change from baseline score of ≥30% was coded as "1". If the percent change from baseline was <30%, the new

outcome variables was coded as "0". Creating new binary variables enabled a GEE model to be used, as the model can only be used with binary responses.

Generalized Estimating Equations Model

The GEE model was performed using the SAS procedure *"PROC GENMOD"*. The *GENMOD* procedure in SAS enables a GEE analysis to be performed by specifying a *REPEATED* statement in which clustering information pertaining to the patient's specific identification number (CODEID) was provided along with a working correlation matrix [56]. GEE parameter estimates and empirical standard errors based on the specified working correlation structure were generated in the model. The *DESCENING* option used in the mode statement indicated that modeling the probability of a good outcome (outcome=1) instead of a poor outcome (outcome=0) was used. The *REPEATED* statement used was *SUBJECT=CODEID* (patient ID), this identified CODEID as the clustering variable. The *CORRW* statement used generates an estimated working correlation matrix [57].

Results

Primary Research Question: Descriptive Results

Of the 917 patients, 299 (32.6%) were diagnosed with lumbar without radicular pain (LBP), 522 (56.9%) with lumbar & radicular pain (LRP), and 96 (10.4%) were diagnosed with diffuse pain in lumbar region (DLP) at baseline visit. Demographic characteristics of the study population stratified by diagnosis are presented in Table 4.1.

In general, demographic data were comparable across all diagnostic groups with the exception of DLP, where differences were observed in magnitudes of proportions. While inferential statistics were not used to explore demographic data, conclusions were drawn referring to differences in proportions. There were slightly more females than males across all groups except DLP where males and females were more equally represented (49.4% and 50.5% respectively). Patients diagnosed with DLP had a higher median pain duration (6.0y), whereas the median for LBP and LRP was 4.0y (referring to proportions). The most common ethnicity was Caucasian among all diagnoses (92.2%-96.9%). Income was fairly evenly distributed among all groups although a number of patients (10.4%- 13.8%) preferred not to disclose their family income. There is an apparent difference between DLP and other diagnosis with DLP having a higher proportion of people in the <$20,000 bracket and fewer in the $35,000-$64,999 bracket compared to patients with other diagnostic codes (Fig 4.1). University was the highest level of education completed by all groups however; the education level attained by the largest proportion of respondents was secondary school (figure 4.2). Permanent disability status was more frequent among the proportion of DLP patients (figure 4.3). The most common current employment status for all other diagnoses was “retired”, while the least

frequently reported categories were volunteer, student, and laid off (patients were allowed to choose more than one current employment status). The top three medical conditions reported at baseline for all diagnoses included rheumatoid arthritis/osteoarthritis, hypertension and depressive disorders. The circumstances surrounding the onset of pain are shown in figure 4.4 and were similar for LBP and LRP, with the most common circumstance being "no precise event". DLP patients however reported "accident at work" as the most common circumstance surrounding their onset of pain.

Figures 4.5-4.11 show the mean scores at baseline, 6, 12, and 24 months for measures of average pain, disability, worst pain, pain frequency, depression, catastrophizing, mental summary score, and physical summary score. It is noticeable that subjects with diagnostic code DLP display a different profile of responses in all domains (with the exception of pain frequency) in regards to proportions compared to other diagnostic codes. DLP patients exhibited higher scores at baseline, 6, 12, and 24 months in regards to average pain and worst pain. Disability and depression were higher among these patients at baseline, 6, and 24 months, while catastrophizing was found to be higher at baseline 6, and 12 months. Patients diagnosed with DLP presented with the lower health related quality of life scores (mental and physical summary) at all four time points compared with other diagnoses.

Table 4.1-Baseline characteristics of the study population stratified by diagnosis.

Characteristics	**Lumbar without radicular pain (LBP)** (N=299) 32.6%	**Lumbar & radicular pain (LRP)** (N=522) 56.9%	**Diffuse pain in lumbar region (DLP)** (N=96) 10.4%	**All Low Back Pain** (N=917)
Age (mean)	55.8 (15.2)	57.1 (16.2)	55.0 (16.0)	56.5 (15.9)
Sex				
Female	166 (55.7%)	273 (54.2%)	48 (50.6%)	487 (53.8%)
Male	132 (44.3%)	230 (45.8%)	47 (49.4%)	419 (46.2%)
Pain Duration (years)	7.5 (9.4)	6.9 (8.3)	9.6 (9.7)	7.4 (8.9)
Mean, (SD)	4.0	4.0	6.0	4.0
Median	296	519	95	910
Ethnicity				
Caucasian	275 (92.2%)	477 (93%)	92 (96.9%)	844 (93.2%)
Black	10 (3.4%)	21 (4%)	1 (1%)	32 (3.5%)
Native American	5 (1.7%)	4 (0.8%)	1 (1%)	10 (1.1%)
Hispanic	3 (1%)	5 (1%)	0 (0%)	8(0.9%)
Asian	4 (1.3%)	5 (1%)	1 (1%)	10 (1.1%)
Other	1 (0.3%)	1 (0.2%)	0 (0%)	2 (0.2%)
Family Income				
Less than $20 000	78 (26.1%)	127 (24.8%)	35 (36.8%)	240 (26.5%)
$20 000- 34 999	63(21.1%)	89 (17.3%)	20 (21%)	172 (19%)
$35 000- 64 999	74 (24.8%)	139(27%)	15 (15.8%)	228 (25.1%)
$65 000 and more	52 (17.4%)	87 (17%)	12 (12.6%)	151 (16.7%)
Do not wish to answer	31 (10.4%)	71 (13.8%)	13 (13.7%)	115 (12.7%)
Employment Status				
Retired	89 (27.2%)	145 (25%)	23 (22.1%)	257(25.5%)
Full Time	53 (16.2%)	107 (18.5%)	9 (8.7%)	169 (16.7%)
Permanent Disability	49 (15%)	73 (12.6%)	28 (26.9%)	150 (14.9%)
Temporary Disability	40 (12.2%)	86 (14.8%)	12 (11.5%)	138 (13.7%)
Homemaker	34 (10.3%)	49 (8.5%)	10 (9.6%)	93 (9.2%)
Part Time	26 (8%)	47 (8.1%)	6 (5.8%)	79 (7.8%)
Unemployed	23 (7%)	42 (7.3%)	9 (8.7%)	74 (7.3%)
Volunteer	6 (1.8%)	10 (1.7%)	3 (2.9%)	19 (1.9%)
Student	5 (1.5%)	6 (1%)	2 (1.9%)	13 (1.3%)
Laid Off	2 (0.6%)	9 (1.6%)	2 (1.9%)	13 (1.3%)
Other	0 (0%)	4 (0.7%)	0 (0%)	4 (0.4%)

Medical History				
Rheumatoid Arthritis/ Osteoarthritis	175 (14%)	282 (13.9%)	55 (13.7%)	512 13.7(%)
Hypertension	121 (9.7%)	190 (9.3%)	39 (9.7%)	350 (9.4%)
Depressive Disorders	104 (8.3%)	174 (8.6%)	37 (9.2%)	315 (8.4%)
Anxiety Disorders	100 (8%)	166 (8.1%)	35 (8.7%)	301 (8%)
Dyslipidemia	100 8(%)	180 (8.9%)	31 (7.7%)	311 (8.3%)
Chronic headache/migraine	96 (7.7%)	175 (8.6%)	21 (5.2%)	292 (7.8%)
Chronic Snoring	86 (6.9%)	160 (7.9%)	33 8.2(%)	279 (7.4%)
Restless Leg Syndrome	56 (4.4%)	101 (5%)	20 (5%)	177 (4.7%)
Bruxism	62 (4.9%)	95 (4.7%)	22 (5.5%)	179 (4.8%)
Diabetes	49 (3.9%)	71 (3.5%)	11 (2.7%)	131 (3.5%)
• Type 1	• 6	• 7	• 2	• 15
• Type 2	• 42	• 64	• 9	• 115
Asthma	55 (4.3%)	78 (3.8%)	13 (3.2%)	146 (3.9%)
Hypothyroidism	41 (3.2%)	82 (4%)	14 (3.5%)	137 (3.7%)
Dysmenorrhea	40 (3.1%)	67 (3.3%)	14 (3.5%)	121 (3.2%)
IBS	41 (3.2%)	52 (3.6%)	11 (2.7%)	104 (2.8%)
Angina/ heart attack	40 (3.1%)	6 (0.3%)	13 (3.2%)	113 (3%)
Fibromyalgia	22 (1.8%)	41 (2%)	11 (2.7%)	74 (2%)
Interstitial Cystitis	20 (1.6%)	42 (2.1%)	9 (2.2%)	71 (2%)
COPD	18 (1.4%)	24 (1.1%)	3 (0.7%)	45 (1.2%)
CVA	13 (1%)	28 (1.4%)	4 (1%)	45 (1.2%)
Heart Failure	14 (1.1%)	19 (0.9%)	5 (1.2%)	38 (1%)
Circumstances Surrounding Onset of Pain				
No precise event	89 (26%)	182 (31.7%)	21 (18.6%)	292 (28.4%)
Other illness	53 (15.4%)	109 (19%)	17 (15%)	179 (17.4%)
Accident at work	50 (14.6%)	105 (18.3%)	24 (21.2%)	179 (17.4%)
Following surgery	23 (6.7%)	42 (7.3%)	11 (9.7%)	76 (7.4%)
Motor vehicle accident	29 (8.5%)	27 (4.7%)	13 (11.5%)	69 (6.7%)
Accident at home	31 (9%)	34 (5.9%)	4 (3.5%)	69 (6.7%)
Other	16 (4.7%)	19 (3.3%)	6 (5.3%)	41 (4%)
Repetitive movement / trauma	17 (5%)	23 (4%)	8 (7%)	48 (4.7%)
Accident in a public place	17 (5%)	17 (3%)	3 (2.7%)	37 (3.6%)
Sport accident	12 (3.5%)	11 (1.9%)	2 (1.8%)	25 (2.4%)
Stressful event	3 (0.9%)	5 (0.9%)	1 (0.9%)	9 (0.9%)
Cancer	2 (0.6%)	0 (0%)	3 (2.7%)	5 (0.5%)

Table 4.2- Additional Characteristics of the study population stratified by diagnosis

Characteristics	**LBP** (N=299)	**LRP** (N=522)	**DLP** (N=96)	**All Low Back** Pain (N=917)
Average Pain				
None	2 (0.7%)	0	0	2 (0.22%)
Mild	14 (4.7%)	31 (6%)	3 (3.2%)	48 (5.23%)
Moderate	102 (34.1%)	166 (32.4%)	31 (32.6%)	299 (32.61%)
Severe	179 (59.9%)	316 (61.6%)	61 (64.2%)	556 (60.63%)
Disability				
No Interference	6 (2%)	17 (3.3%)	1 (1%)	24 (2.6%)
Mild Interference	60 (20%)	75 (14.4%)	10 (10.4%)	145 (15.8%)
Moderate Interference	129 (43.1%)	250 (47.9%)	50 (50%)	429 (46.8%)
Severe Interference	104 (34.8%)	180 (34.5%)	35 (36.5%)	319 (34.8%)
Depression				
Minimal/no depression	66 (22%)	9 (18.2%)	17 (17.7%)	178 (19.4%)
Mild to moderate depression	107 (35.8%)	214 (41%)	32 (33.3%)	353 (38.5%)
Moderate to severe depression	88 (29.4%)	151 (28.9%)	32 (33.3%)	271 (29.6)
Severe depression	37 (12.4%)	62 (11.9%)	15 (15.6%)	114 (12.4%)
Catastrophizing				
Likely to go back to work	69 23.1%	125 (24%)	17 (17.7%)	211
Greater difficulty with returning back to work	230 (76.9%	397 (76%)	79 (82.3%)	706
Health-Related Quality of Life				
Physical summary score	296 (99%)	517 (99%)	96 (100%)	909
Physical summary score	3 (1%)	5 (1%)	0	8
Mental summary score	234 (78.3%)	410 (78.5%)	80 (83.3%)	724
Mental summary score	65 (21.7%)	112 (21.5%)	16 (16.7%)	193

Figure 4.1- Family Income by diagnosis

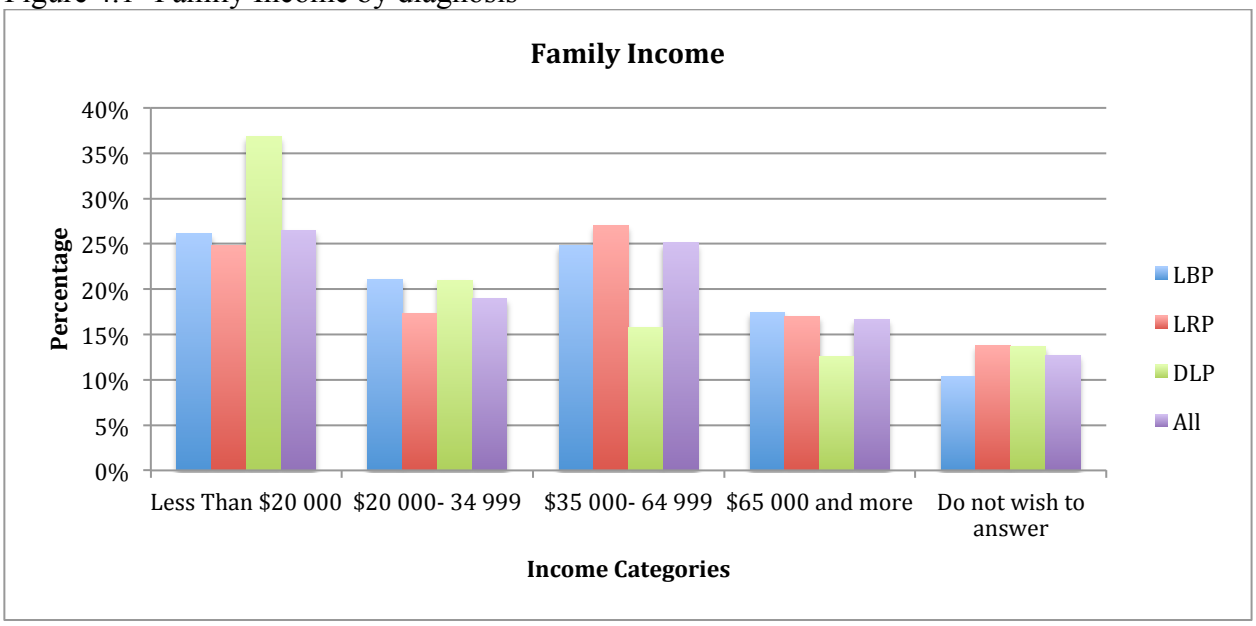


Figure 4.1- Most commonly reported family income categories by patients at baseline stratified by diagnosis. Percentages presented in the chart were calculated based on diagnosis.

Figure 4.2- Highest level of education completed by diagnosis

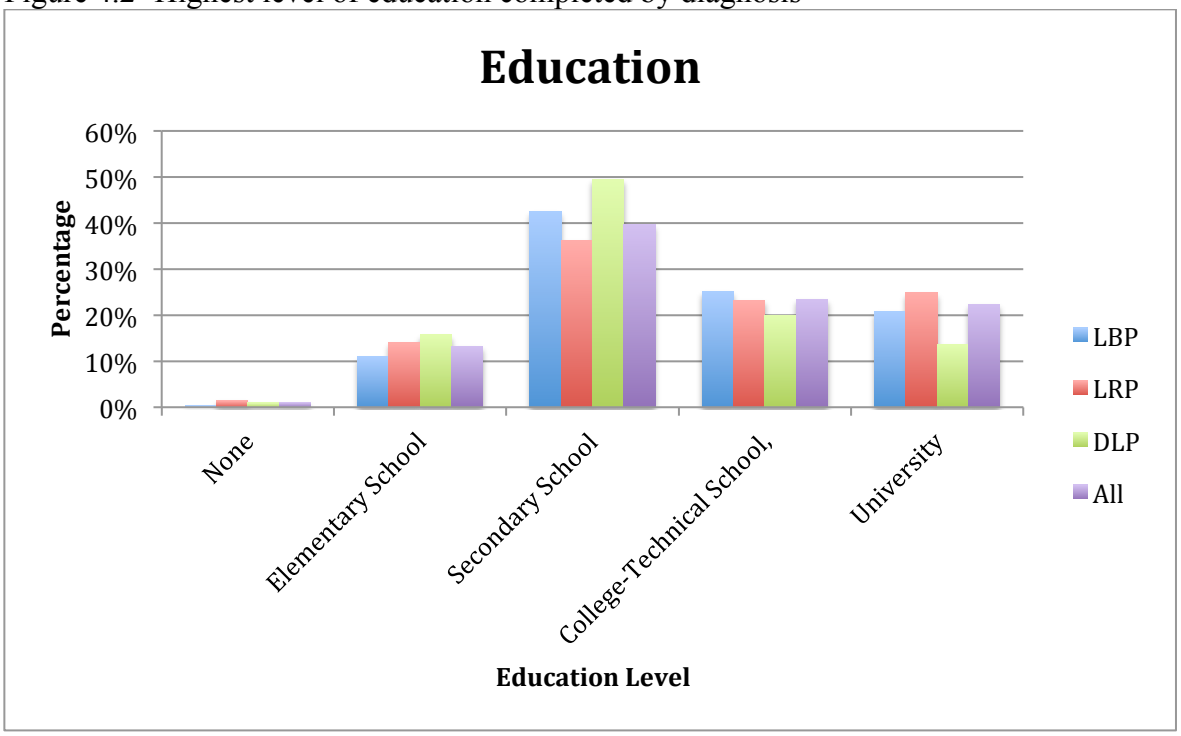


Figure 4.2- Highest level of education completed reported by patients at baseline stratified by diagnosis. Percentages presented in the chart were calculated based on diagnosis

Figure 4.3- Current employment Status by diagnosis

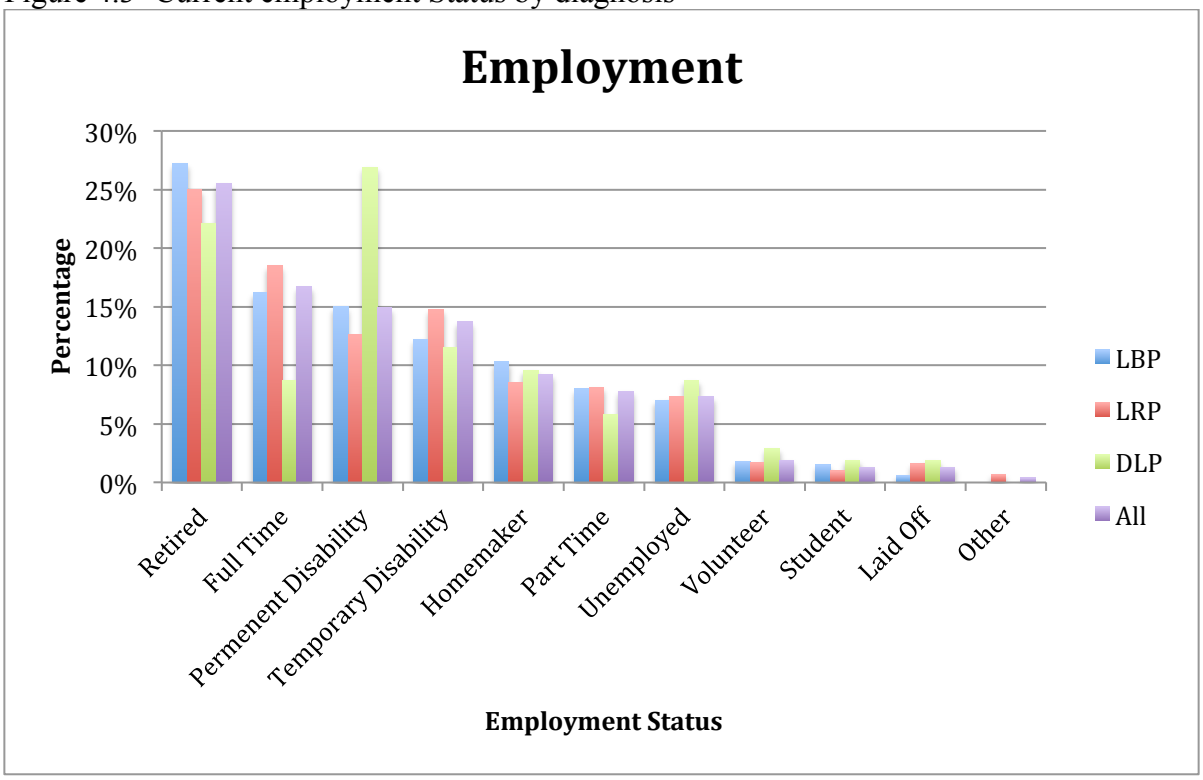


Figure 4.3- Most commonly reported current employment status by patients at baseline stratified by diagnosis. Percentages presented in the chart were calculated based on diagnosis.

Figure 4.4- Circumstances Surrounding Onset of Pain

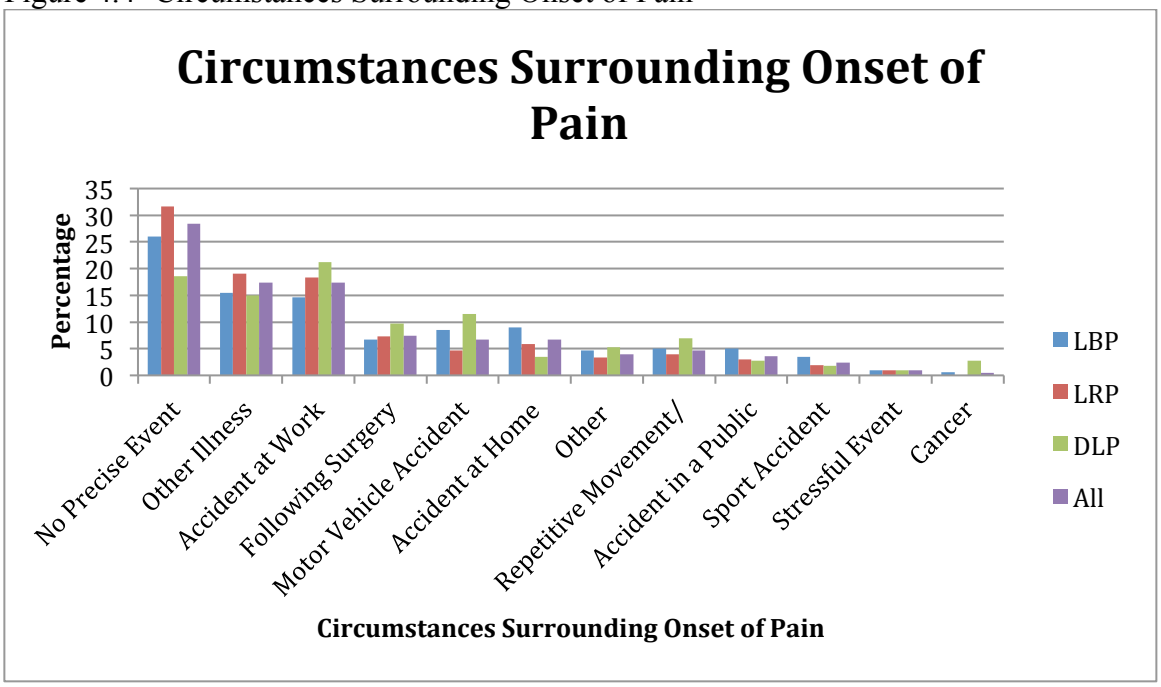


Figure 4.4- Most commonly reported circumstances surrounding onset of pain by patients at baseline stratified by diagnosis. Percentages presented in the chart were calculated based on diagnosis.

Figure 4.5-Average pain past 7 days

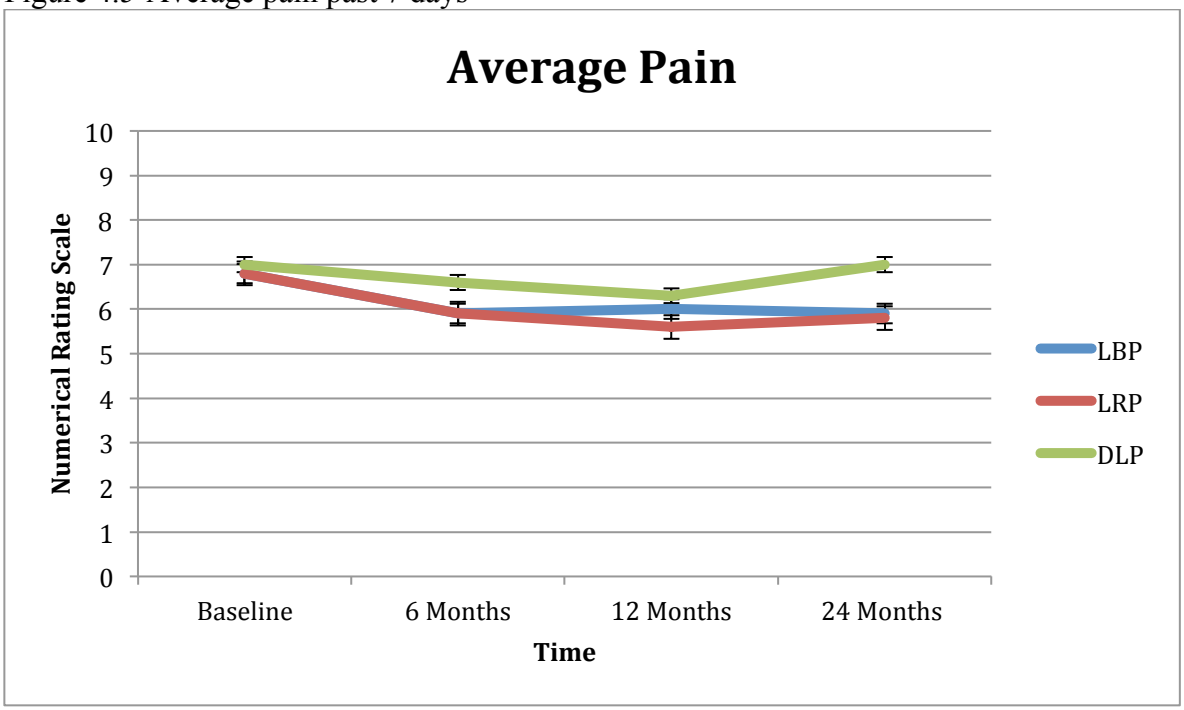


Figure 4.5- Average pain in the past 7 days (mean) reported by patients at baseline, 6 months, 12 months, and 24 months, stratified by diagnosis. The numerical rating scale presented in the chart is the same scale presented in the patient questionnaires. Standard errors are included.

Figure 4.6- BPI score

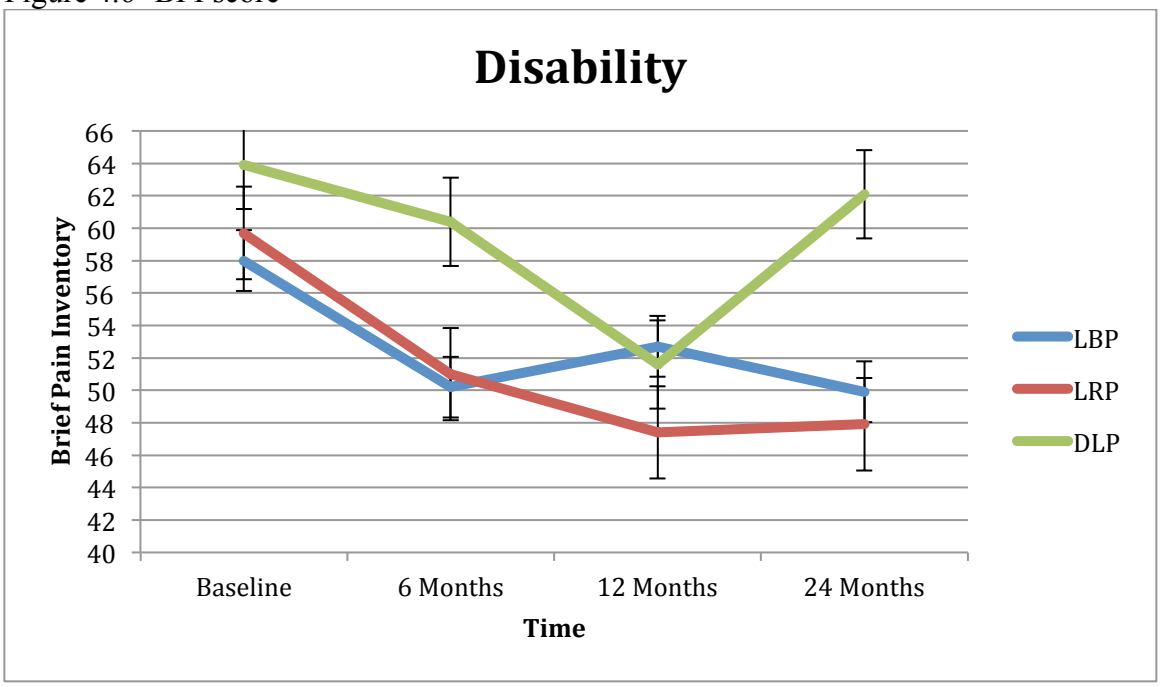


Figure 4.6- Brief Pain Inventory score (mean) at baseline, 6 months, 12 months, and 24 months stratified by diagnosis. Standard errors are included.

Figure 4.7- Worst pain in the past 7 days

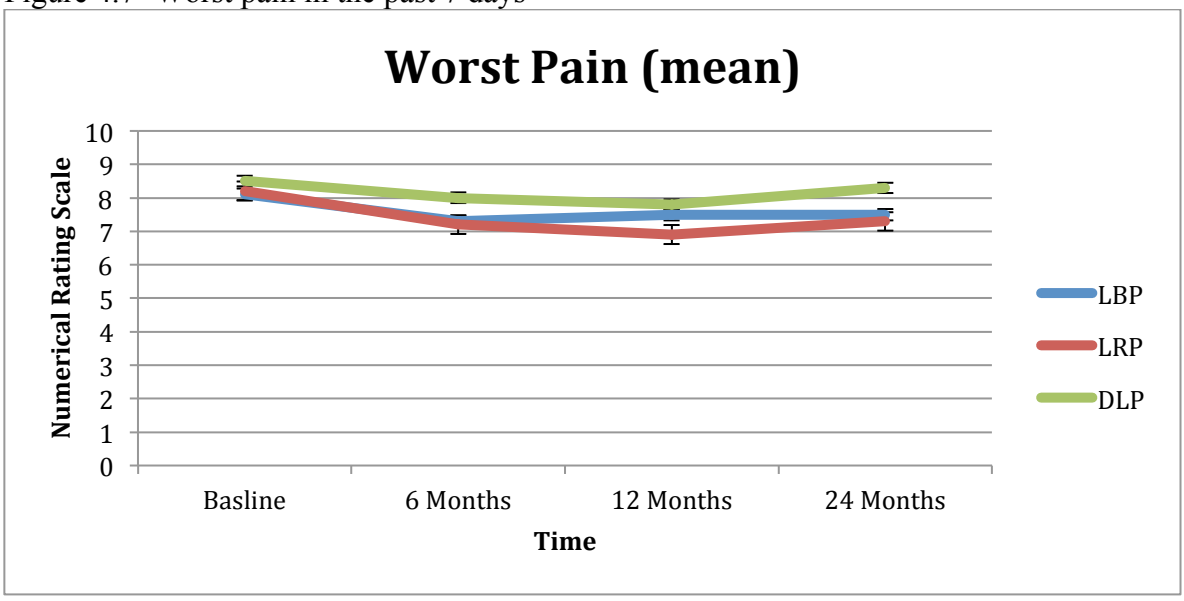


Figure 4.7- Worst pain in the past 7 days (mean) reported by patients at baseline, 6 months, 12 months, and 24 months, stratified by diagnosis. The numerical rating scale presented in the chart is the same scale presented in the patient questionnaires. Standard errors are included.

Figure 4.8- Global BDI-1 Score

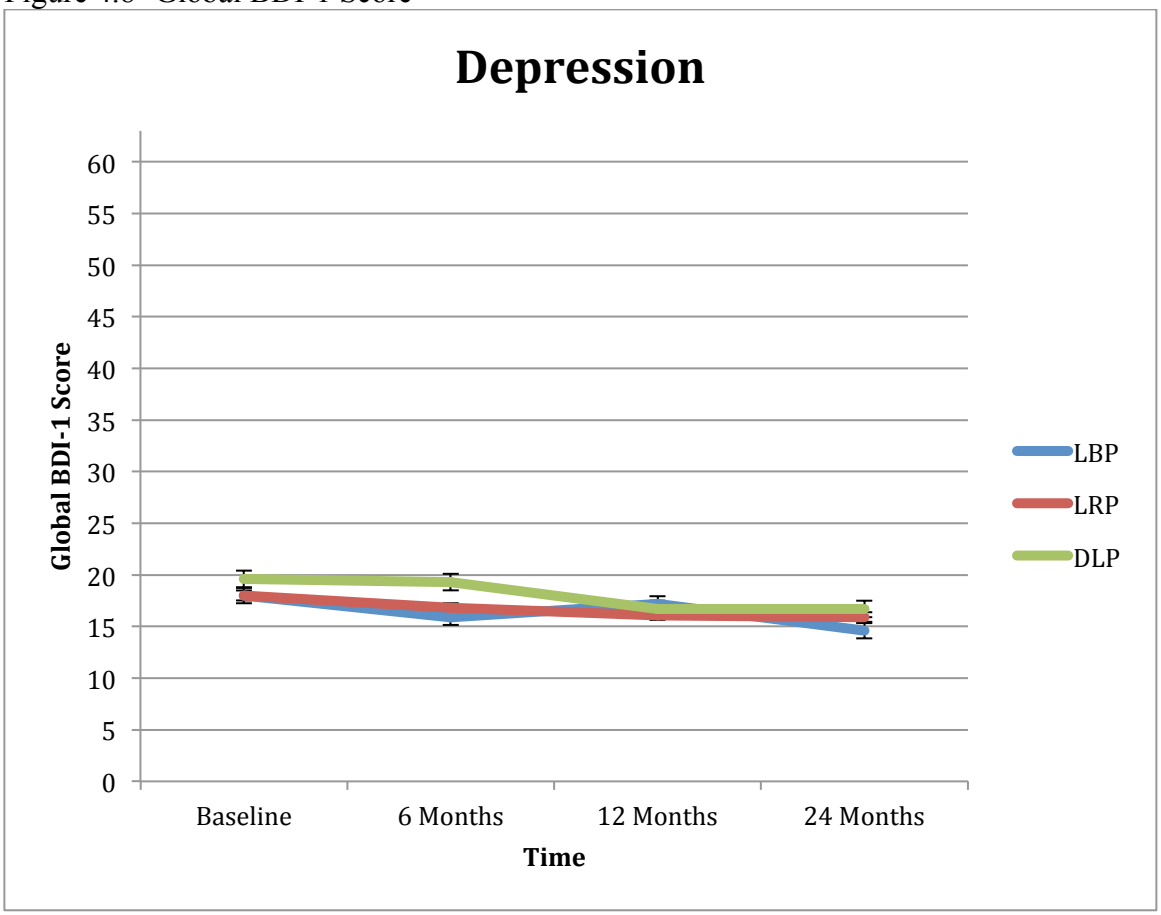


Figure 4.8- Global BDI-1 (mean) score calculated at baseline, 6 months, 12 months, and 24 months, stratified by diagnosis. The global BDI-1 has a maximum possible score of 63. Standard errors are included.

Figure 4.9- PCS global score

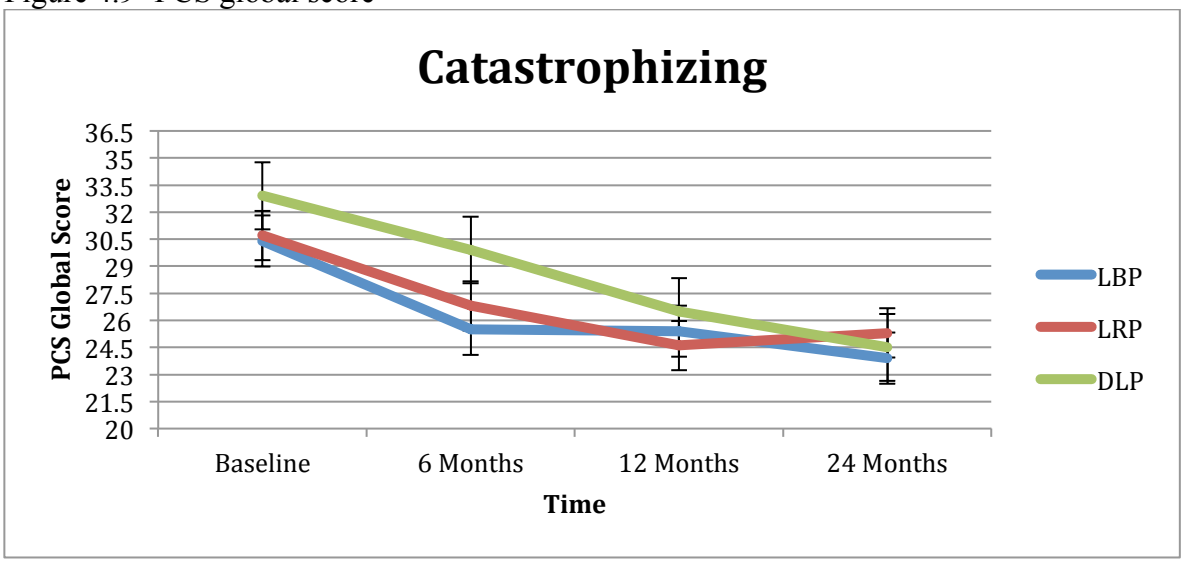


Figure 4.9- Pain Catastrophizing Scale global score (mean) reported by patients at baseline, 6 months, 12 months, and 24 months, stratified by diagnosis. Standard errors are included.

Figure 4.10- Health related quality of life (mental summary score)

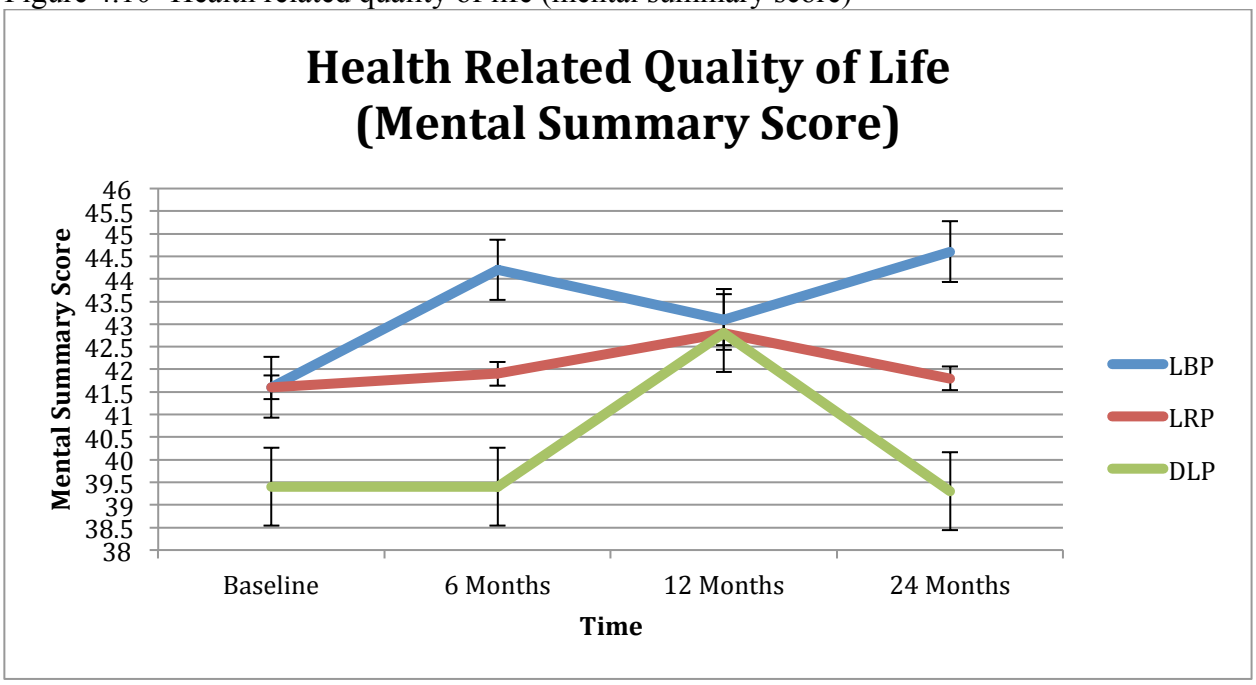


Figure 4.10- Health related quality of life (mental summary score) calculated at baseline, 6 months, 12 months, and 24 months, stratified by diagnosis. Standard errors included.

Figure 4.11- Health related quality of life (physical summary score)

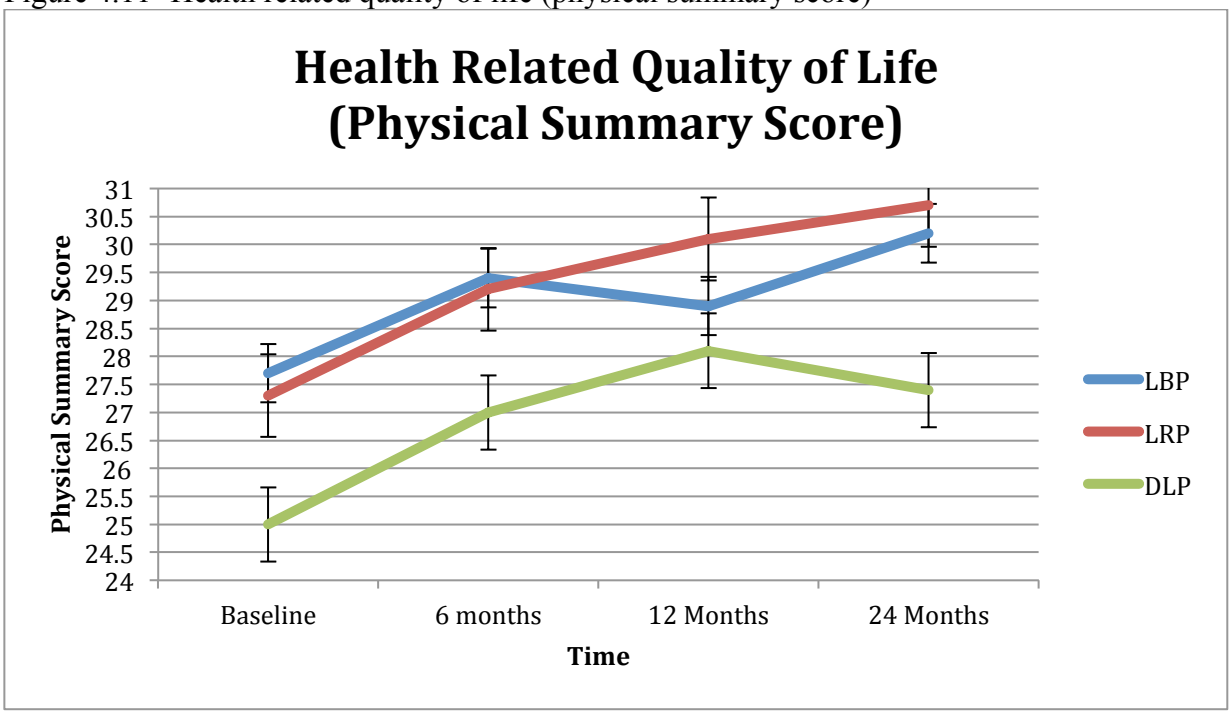


Figure 4.11- Health related quality of life (physical summary score) calculated at baseline, 6 months, 12 months, and 24 months, stratified by diagnosis. Standard errors included.

Secondary Research Question

Initially, it was intended to explore the improvement in average pain and disability (change ≥30%) from baseline (visit one) to 24 months (visit four). However, after including all patients who completed both baseline and the 24-month follow up visit, there were only 156 patients. Due to the low follow-up rate at two years, modified analyses were performed. Improvement in average pain and disability were explored with a change of ≥20% not only at 24 months, but also at 12 and 6 months. The following section outlines the results generated using adjusted multivariate models when exploring the bio-psychosocial characteristics associated with change in pain and disability.

Average Pain

A generalized estimating equation model was used to explore the factors associated with an improvement of ≥30% in average pain from baseline to 24 months. Unfortunately, due to the small number of patients and the number of variables explored, there was not enough power to generate significant results. After exploring the baseline characteristics of the study population that were generated from the primary research question, it appeared that patients diagnosed with DLP have noticeably different baseline characteristics and responses over time. To determine if diagnosis contributed to change in average pain, diagnosis was added as a binary parameter in the adjusted multivariate model. LBP and LRP were combined, while DLP remained as is (if diagnosis LBP LRP then=1, else diagnosis=0). Baseline characteristics were similar for LBP and LRP; therefore creating one variable for both ensured DLP could be analyzed alone. Similar to the first adjusted multivariate model, the number of patients was too small to yield any power. After determining that a change of ≥30% in average pain from baseline to 24

months did not generate any significant results, a modified analysis was performed. It was important to exhaust all possible analyses using patients who had completed baseline and the 24-month follow up to ensure a thorough two-year follow period was explored therefore, a ≥30% change in average pain was reduced to ≥20% change. Table 4.3 illustrates the results generated from the adjusted multivariate model when change in average pain was reduced to ≥20%.

Characteristics that appear to be associated with a poor outcome (≤20% pain reduction at 24 months) include sex (-0.2483), higher reported worst pain (-0.5219), and a lower physical summary score (-0.0076). While several of the characteristics produced odds ratios greater than one, thus indicating an increased risk, only worst pain produced a 95% confidence interval that is statistically significant (0.41-0.85).

Similarly, a change of ≥30% in average pain at 12 months did not yield any statistically significant results except for worst pain (95% CI=0.50-0.75). Table 4.4 illustrates the GEE model results for change of ≥30% in average pain at 12 months. Patients who had worse pain, longer duration, and a lower physical summary score were significantly less likely to have an improvement in pain after 12 months. A final analysis of characteristics associated with average pain included a GEE model that explored a change of ≥30% at 6 months. Details are provided in table 4.4. Both pain duration and worst pain were found to be statistically significant with 95% confidence intervals of 0.93-0.99 and 0.48 to 0.68 respectively.

Table 4.3- GEE Analysis 24 Months, Average Pain (≥20% change)

Parameter	Estimate	Standard Error	Z Pr	Z	OR (95% CI)
Intercept	-0.8454	3.9759	-0.21	0.8316	0.43 (0.001-1040.1)
Age	-0.0019	0.0228	-0.08	0.9335	1.00 (0.95-1.04)
Sex	-0.2483	0.5161	-0.48	0.6304	0.78 (0.28-2.15)
Depression	0.0585	0.0428	1.37	0.1719	1.06 (0.98-1.15)
Catastrophizing	0.0016	0.0240	0.07	0.9459	1.001 (0.96-1.05)
Pain Duration	0.0306	0.0287	1.07	0.2856	1.03 (0.98-1.09)
Pain Frequency	0.0386	0.0676	0.57	0.5684	1.04 (0.91-1.19)
Worst Pain	**-0.5219**	**0.1858**	**-2.81**	**0.0050**	**0.59 (0.41-0.85)**
Physical Summary	-0.0076	0.0321	-0.24	0.8127	0.99 (0.93-1.06)
Mental Summary	0.0283	0.0324	0.87	0.3823	1.03 (0.97-1.10)

Table 4.3- Generalized estimating equations analysis. Change of ≥20% in average pain from baseline to 24 months.

Table 4.4-GEE Analysis 12 Months, Average Pain (≥30% change)

Parameter	Estimate	Standard Error	Z Pr	Z	OR (95% CI)
Intercept	-0.3033	2.9114	-0.10	0.9170	0.74 (0.002-222.1)
Age	-0.0012	0.0146	-0.08	0.9345	1.00 (0.97-1.03)
Sex	0.1196	0.3622	0.33	0.7413	1.13 (0.55-2.29)
Depression	0.0274	0.0264	1.04	0.2997	1.03 (0.98-1.08)
Catastrophizing	0.0018	0.0186	0.10	0.9212	1.001 (0.97-1.04)
Pain Duration	-0.0147	0.0175	-0.84	0.4009	0.99 (0.95-1.02)
Pain Frequency	0.0445	0.0651	0.68	0.4938	1.05 (0.92-1.19)
Worst Pain	**-0.4913**	**0.1050**	**-4.68**	**<.0001**	**0.61 (0.50-0.75)**
Physical Summary	-0.0323	0.0285	-1.14	0.2563	0.97 (0.92-1.02)
Mental Summary	0.0229	0.0211	1.09	0.2774	1.02 (0.98-1.07)

Table 4.4- Generalized estimating equations analysis. Change of ≥30% in average pain from baseline to 12 months.

Table 4.5-GEE Analysis 6 months, Average Pain (≥30% change)

Parameter	Estimate	Standard Error	Z Pr	Z	OR (95% CI)
Intercept	-2.0600	2.3446	-0.88	0.3796	0.13 (0.001-12.62)
Age	-0.0000	0.0113	-0.00	0.9994	1.00 (0.98-1.02)
Sex	-0.2773	0.2941	-0.94	0.3458	0.76 (0.43-1.35)
Depression	0.0181	0.0228	0.79	0.4285	1.02 (0.97-1.07)
Catastrophizing	-0.0033	0.0154	-0.21	0.8324	1.00 (0.97-1.07)
Pain Duration	**-0.0403**	**0.0169**	**-2.38**	**0.0172**	**0.96 (0.93-0.99)**
Pain Frequency	0.1088	0.0511	2.13	0.0333	1.11 (1.01-1.23)
Worst Pain	**-0.5557**	**0.0869**	**-6.39**	**<.0001**	**0.57 (0.48-0.68)**
Physical Summary	0.0144	0.0208	0.69	0.4887	1.01 (0.97-1.06)
Mental Summary	0.0252	0.0197	1.28	0.2019	1.03 (0.99-1.07)

Table 4.5- Generalized estimating equations analysis. Change of ≥30% in average pain from baseline to 6 months.

Disability

Similar to the GEE models for average pain, many of the GEE models for change in disability did not have enough power to generate statistically significant results. Setting the outcome as either a change of ≥30% in disability from baseline to 24 months, or a change of ≥30% including diagnosis as a parameter from baseline to 24 months, or a change of ≥20% from baseline to 24 months did not produce any significant results. Despite this, both models that included a ≥30% change in disability at both 12 and 6 months yielded similar significant results. Tables 4.6 and 4.7 illustrate the results for ≥30% change in disability at 12 and 6 months. Similar to change in average pain, patients who had worse pain were significantly less likely to have an improvement in disability after 12 and 6 months.

Table 4.6-GEE Analysis 12 Months, Disability (≥30% change)

Parameter	Estimate	Standard Error	Z Pr	Z	OR (95% CI)
Intercept	-3.9875	2.2566	-1.77	0.0772	0.02 (0.001-1.55)
Age	0.0049	0.0132	0.37	0.7100	1.01 (0.98-1.03)
Sex	0.3324	0.3359	0.99	0.3223	1.39 (0.72-2.69)
Depression	0.0338	0.0297	1.14	0.2536	1.03 (0.98-1.10)
Catastrophizing	-0.0048	0.0197	-0.24	0.8084	1.00 (0.96-1.03)
Pain Duration	-0.0053	0.0181	-0.29	0.7709	0.99 (0.965-1.03)
Pain Frequency	-0.0006	0.0388	-0.02	0.9867	1.00 (0.93-1.08)
Worst Pain	**-0.2946**	**0.0841**	**-3.51**	**0.0005**	**0.75 (0.63-0.88)**
Physical Summary	0.0620	0.0215	2.88	0.0039	1.06 (1.02-1.11)
Mental Summary	0.0321	0.0227	1.41	0.1571	1.03 (0.99-1.08)

Table 4.6- Generalized estimating equations analysis. Change of ≥30% in disability from baseline to 12 months.

Table 4.7-GEE Analysis 6 months, Disability (≥30% change)

Parameter	Estimate	Standard Error	Z Pr	Z	OR (95% CI)
Intercept	-3.4695	1.8432	-1.88	0.0598	0.31 (0.008-1.15)
Age	0.0193	0.0089	2.16	0.0308	1.02 (1.001-1.037)
Sex	-0.0010	0.2486	-0.00	0.9969	0.99 (0.61-1.63)
Depression	0.0133	0.0196	0.68	0.4969	1.01 (0.97-1.05)
Catastrophizing	-0.0077	0.0127	-0.61	0.5432	0.99 (0.97-1.02)
Pain Duration	-0.0094	0.0146	-0.64	0.5213	0.99 (0.96-1.02)
Pain Frequency	0.0097	0.0384	0.25	0.8010	1.009 (0.94-1.09)
Worst Pain	**-0.2384**	**0.0649**	**-3.67**	**0.0002**	**0.80 (0.69-0.89)**
Physical Summary	0.0279	0.0167	1.67	0.0942	1.03 (0.99-1.06)
Mental Summary	0.0310	0.0151	2.06	0.0392	1.03 (1.001-1.06)

Table 4.7- Generalized estimating equations analysis. Change of ≥30% in disability from baseline to 6 months.

Discussion

Summary of Main Findings and Comparison with Existing Research

This study explored the characteristics and outcomes of patients seen in tertiary pain centers who were diagnosed with CLBP over a two-year period. To our knowledge this is the longest follow up that has been conducted with this population. Our principle findings were that the primary outcomes of pain and disability improved at six months, but little change was noted after this time. More specifically, we found that patients diagnosed with diffuse lumbar pain (DLP) had a different profile of baseline and response characteristics as oppose to the other diagnoses of radicular (LRP) or non-radicular pain (LBP). Our study was also unique in that we used data from the Québec Pain Registry, a specialized registry containing in depth data relating to chronic pain conditions. From a total eligible sample of 1228 patients, we found 917 who had been diagnosed with one of three low back pain diagnoses (LBP, LRP, or DLP). Fifty-seven percent of the 917 patients explored at baseline were diagnosed with LRP, while only ten percent were diagnosed with DLP however; these patients displayed noticeably different characteristics compared to patients diagnosed with LBP and LRP. For the most part, LBP and LRP were similar in baseline and response characteristics. Specifically, we found that patients with worst pain, longer pain duration, and lower physical summary scores were less likely to have improvement in pain and disability after six and 12 months.

Previous research has determined that pain radiating below the knee has been found to predict greater pain and disability after six months [29], and research conducted by Chou

and Shekelle found that radiculopathy increased the odds of worse outcomes at six months and one year. [10] Our findings did not yield any significant results relating to specific diagnoses. The proportion of males and females were similar in all of our LBP subgroups and gender was not found to be significantly associated with change in average pain and disability. Dunn and colleagues enrolled a larger proportion of women in their study, which was attributed to higher response rate among this gender [39] however, Nyiendo and colleagues (2001) and Melloh (2009) concluded that gender did not predict worse outcomes [1, 29]. Despite the large study population at baseline, Caucasians comprised over 90% of ethnicities in each group. While there have been discrepancies among previous studies regarding ethnicity as a contributing factor, there was not enough variation in this study to draw any significant conclusions. The most common employment status in our study was 'retired'. While the mean age for the study population at baseline was 56.5y, it is surprising that retirement was reported as the most common current employment status.

A difference for the circumstances surrounding the onset of pain was also detected for DLP patients. This group reported "accident at work" as the most common circumstance surrounding their onset of pain, while other categories of LBP report "no precise event" most frequently. Koleck and colleagues discovered work related accidents were found to be quite prevalent among chronic patients and served as a risk factor for poor outcomes [14]. Moreover, Melloh determined that occupational factors serve as prognostic influences for CLBP [1]. A status of permanent disability was also found to be more frequent among DLP patients. DLP patients also had higher median pain duration (the number of years they have experienced pain). It is thought that a DLP diagnosis is more

disabling due to the deep tissue pain and longer history of pain associated with this diagnosis therefore, these patients are less likely to work.

Income was similarly distributed among all groups. The most commonly reported category was < $20 000 with the exception of LRP, where $35,000-64,999 was reported as the most common family income. The least common category was >$65 000. Interestingly, a large number of patients (10.4%- 13.8%) preferred not to disclose their family income. Lower income has been found to predict pain and disability levels in CLBP patients [29]. Similar medical conditions were reported from all groups. The top three conditions included rheumatoid arthritis/osteoarthritis, hypertension, and depressive disorders. The majority of reviewed literature did not commonly explore specific medical conditions. However, it is not surprising that rheumatoid arthritis/osteoarthritis are most commonly associated with CLBP, given that both conditions affect the lining of the joints causing painful swelling[58]. More specifically, the most common form of arthritis, osteoarthritis can damage any joint the body, but most commonly affects the protective cartilage on joints in the lower back and gradually worsens over time [59].

While the existing literature concerning CLBP is extensive, the vast majority agrees that psychological factors play a significant role in terms of pain, disability, and recovery outcomes. Not only has depression been found to increase the risk of developing chronic pain [16, 60], but it has also been extensively linked to a greater perceived risk of persistent pain [4, 14]. While depression alone is considered to be a predictor of persistent low back pain[29], depression has also been linked with fear avoidance and high levels of catastrophizing behavior resulting in worse outcomes at six months. Furthermore, Pincus and colleagues discovered that catastrophizing behavior predicted worse outcomes after

six months[16], while Melloh concluded that catastrophizing beliefs was the strongest predictor of functional limitation[1]. Chou and Shekelle discovered that higher levels of functional impairment (disability) at baseline increased the likelihood of poor outcomes at six and 12 months. Costa found that higher disability levels at baseline lead to greater perceived risk of persistent pain, which lead to delayed recovery and higher pain intensity levels. The strongest predictors of pain have been found to be pain intensity, duration, frequency of pain, and coping strategies [1]. Higher pain intensity at baseline predicted worse outcomes at 6 months [10]. While our study did not generate any significant results relating to several factors predicting change in pain and disability, it is likely that a larger sample size would generate statistically significant results consistent with current literature. Our study adds further insight into contributing factors of worse outcomes in both pain and disability relating to worst pain scores, pain duration, and health-related quality of life scores

Strengths and Limitations

The data used for this study were generated from the Québec Pain Registry with a specific focus on CLBP. The Québec Pain Registry is the largest pain registry in the province and this allowed for the evaluation of numerous characteristics that have been collected using a diversity of relevant measures. The database is unique in that it contains high quality data relating to very specific chronic pain disorders. Additionally, a major strength of this study is that data were collected from three specialized pain clinics and patients received a more specified diagnosis from a pain specialist upon admission to the clinic as opposed to a general pain diagnosis given by a primary care physician. The data collected at 12 and 24 months provide additional information to that obtained at six

months. Statistical analyses used to compare the data obtained at the initial visits versus those at six, 12, and 24 months have generated valuable findings that would most likely yield significant results with a larger sample size. As stated by Kopec and colleagues (2004), few prospective studies of low back pain in the general population have been conducted, making this study relatively unique[2]. Additionally, most longitudinal studies that explore back pain look at acute pain only [39]. Modifying the statistical analysis for my second research question enabled data at six and 12 months to be explored, thus providing the opportunity for early identification of significant characteristics associated with adverse outcomes. In turn, these results will provide opportunities for targeted interventions that can decrease the likelihood of developing chronic characteristics associated with low back pain, such as disability to be developed. As stated by Dunn and colleagues, there has been less research involving patients with primarily chronic symptoms. This study provides insight into the course of symptoms and characteristics among severe chronic patients, who ultimately constitute the majority of pain patients seen in primary care[39]. Furthermore, very few studies have attempted to characterize the course of low back pain using repeated measurements of a large sample of patients. While this study does not fully explore the course of low back pain, it does provide an understanding into the course of CLBP and the factors associated with this condition using repeated measures. Finally, this study provides a large sampling frame of well-characterized patients for several types of studies, including phase II/III trials, facilitating patients recruitments and reducing time and costs associated with the initial process of study start-ups.

While the Québec Pain Registry contains information pertaining to chronic pain patients, the data are limited to a selected population of patients seen in tertiary pain centers within the province of Québec. Data have been sampled from prevalent cases of CLBP, which could potentially introduce bias, as patients who are seen in primary care settings may have a different experience with this chronic health condition. The factors that are associated with patients from primary care may not be relevant to those who have been seen by specialists in a tertiary care setting. Prognosis of patients with a long lasting health condition is likely worse compared to patients who have a newly developed case of low back pain. Due to this, data produced from this study may limit the generalizability to other populations across Canada. Furthermore, testing within an extremely heterogeneous sample of individuals in terms of levels of chronicity may serve as an interpretive challenge. The 12-month follow up point may correspond to pain duration of two years for one patient yet 10 years for another patient. Due to this, changes in variables over fixed time points are only interpretable if the sample was homogenous in terms of chronicity in patients. While the database did capture "pain duration" and such variable was explored in this study, conclusions are subject to interpretation and the findings pertaining to the decreased scores for the diffuse lumbar pain group on the Brief Pain Inventory are very difficult, if not impossible to interpret. The patients included in this study have been referred to a pain clinic by a variety of health care professionals for very complex reasons related to CLBP. As such, these health concerns might not be generalizable to patients seen in primary care practice. Data in this study are also limited to patients who were enrolled in the registry from October 2008 up to May 2011 and who signed the consent form therefore, any patients who enrolled in the registry after May 31st

2011 including those from the two other tertiary pain centers in the database are not included. Future studies should include all five tertiary pain centers included in the Québec Pain Registry. Furthermore, although the data in the registry has been collected prospectively, this study is an analysis of an historical cohort; therefore additional data could not be collected and thus, missing data were taken into consideration. It may be beneficial for future studies to collect data from patients prospectively and add to the database during the course of their research. This would allow for missing data to be added and any modifications to questions, etc. to be made. The large number of patients at baseline makes this study unique in terms of size however, the limited number of patients who continued and completed both patient and nurse questionnaires beyond six months acted as a barrier in the statistical analyses of this study, as there were not enough patients to generate statistically significant results. Due to the low retention rate at 24 months, it was a challenge to run a GEE model with the patients who had completed two years of follow up. Due to this, analyses pertaining to the secondary research question, exploring the bio-psychosocial characteristics of change in pain and disability were modified to explore patients who had completed follow up at both one year and six months where we discovered that worst pain, pain duration, and lower physical summary scores prohibit improvement in both pain and disability. Furthermore, data collected via patient questionnaires are self-reported thus, introducing the potential for bias. Patients are more likely to over report when self-reporting symptoms and information related to their own pain however, self-reported data is common in pain research and is the only method to collect pain data since it cannot be measured any other way. Finally, patients for whom data is missing at 12 and 24 months because they were discharged from the

clinic may have either improved significantly, stayed the same and no other treatment could be offered, or refused to go back to the pain clinic.

Although the database contains information of specific diagnoses relation to CLBP, diffuse lumbar pain is complex and requires a more in depth exploration. It is not clear from the information available in the database how and why physicians at the tertiary pain clinics chose to diagnose their patients with diffuse lumber pain. This diagnosis alone is comprised of patients with extremely diverse pain circumstances. The novel finding of this thesis is that patients diagnosed with diffuse lumbar pain show elevated levels of physical and emotional distress compared to those diagnoses with lumber without radicular pain and lumber with radicular pain. After carful consideration and further exploration of the database, it has been determined that making such conclusions regarding this group of patients is not possible without further information relating to the diagnostic category. It is not clear from the description in the database whether this is a diagnosis linked to specific pathophysiological mechanisms or whether it is a diagnosis based only on geographical distribution of complaints by patients. Future research should address this concern by including a guideline for physicians with specific inclusion criteria for diagnosing patients with diffuse lumbar pain. Patients must meet a certain number of these criteria to be accurately diagnosed with this type of specific chronic low back pain. By doing so, there will be a better understanding as to why physicians chose this diagnosis while allowing for a more homogeneous cohort of diffuse lumbar pain patients. It may even be possible to create subcategories within the diffuse lumbar pain category that would serve to better understand this population of patients. For example, pain brought on by a specific circumstance, pain that has lasted more than a certain

amount of years, patients who have tried certain methods to relieve pain i.e. surgery, specific pharmacological interventions. It may also be beneficial to explore diffuse lumbar pain patients only if significant sub categories were created.

A major weakness of this study pertains directly to the statistical analyses used. Initially, structural equation and regression analyses were to be used. Unfortunately, due to time limitations and difficulty with the statistical material, a simpler analysis was developed and executed. Unfortunately, adopting this less complex approach to data analysis meant the original plan to address trajectories of change over a two year period was not completed. Adapting to the new statistical plan may also be why the analysis was not able to adjust for the duration of pain and worked only with fixed time points (assuming all the patients had the same duration of pain).

Conclusions and Clinical Applications

Although modifying the analysis prohibited conclusions for a two-year follow to be made, significant characteristics, such as worst pain, pain duration, and lower physical summary scores at both six and 12 months were discovered, thus providing insight into the clinical evolution of CLBP from baseline to 12 months by determining what characteristics predict worse pain and disability outcomes.

As the prevalence of CLBP continues to rise, this proportion of patients will continue to consume the majority of resources devoted to low back pain, amounting to millions of dollars in terms of healthcare resources, ongoing compensation payments, decreased productivity, and failed treatment costs. This study contributes to the understanding of change in pain and disability over time and the social, psychological, biological, and environmental characteristics in accordance to the Revised Wilson and Cleary Model for

Health-Related Quality of Life. The results of this study yield an important understanding of the characteristics associated with pain and disability at six and 12 months providing insight into different profiles of patients. Results from this study may yield important information related to potential characteristics for measuring pain and disability in patients who suffer from CLBP such as, Essentially, the findings from this study begin to inform the development of education initiatives and clinical practice development programs aimed at primary care physicians that address the relevant findings from this study, such as addressing pain patients early on, attempting to control their worst pain with individually targeted treatments, and addressing their physical summary scores relating to health-related quality of life. As discussed by Koleck and colleagues (2006), early prevention programs should include a multidisciplinary approach and should include psychological interventions on coping strategies[14]. Our findings have valuable implications for interventions geared towards research in chronic low back pain in primary care settings. As the existing literature clearly states, interventions that target factors that are commonly found to predict worse outcomes such as pain and disability are needed. For example, interventions that target fear avoidance behaviors and depression. The next logical step in the area of family medicine would be to identify characteristics in patients with CLBP who are seen in primary care that are hypothesized to predict worse outcomes. For example, if depression were determined to be a significant predictor of average pain and disability, this would indicate that depression should be included in screening tools to successfully address this concern in primary and secondary prevention. Early interventions of characteristics that predict adverse outcomes

provide opportunity for targeted interventions that can decrease the likelihood of developing CLBP.

The overall findings of this project indicate there is still much needed research in the area of CLBP. While it is apparent from this study that DLP patients have noticeably different characteristics and response patterns (in regards to proportions) compared to other pain diagnoses, it is recommended that DLP patients be explored in more depth over a longer period of time. Exploring this specific population of chronic pain patients in more detail would yield further insight into this unique population. A specific recommendation would be to explore the various treatment options, including pharmacological that has been exhausted by this population. In turn, this may provide further evidence into how CLBP is experienced by DLP patients. Although there have been numerous studies that have yielded meaningful results, this health condition is extremely broad therefore, exploring subgroups in detail is still needed and will help determine patterns of change over time that are not necessarily apparent in large sample populations.

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Appendices

Appendix 1

A1.1 Variables and Measurement Tools Included in the Québec Pain Registry. Patient Questionnaire (initial visit)

Variable	Measurement Tool
Pain location	Body diagram
Pain intensity	Numerical rating scale
Pain-related interference on daily functioning	Interference items of the Brief Pain Inventory (PBI)
Impact of pain on sleep	Chronic Pain Sleep Inventory (CPSI)
Pain coping	Pain Catastrophizing Scale (CPS)
Depression	Beck Depression Inventory – Version 1
Anger	Numerical rating scale
Health-related quality of life	SF-12-V2
Patient's expectations with regards to treatment at the pain clinic	Adapted version of the Patient's Global Impression of Change
Patient's expectation re: pain relief	Pain Relief Numerical Scale
Consumption habits re: cigarettes, alcohol, illicit drugs	Questions drawn from the Enquete sociale et de santé- Institut de la statistique du Québec
Demographics: • Date of birth • Sex • Ethnic group • First language • Education level • Current living conditions • Civil status • Current work status • Family income • Principal source of income • Disability benefits • Litigation	

A1.2 Variables and Measurement Tools Included in the Québec Pain Registry. Patient Questionnaire (follow up visit)

Variable	**Measurement Tool**
Pain location	Body diagram
Pain intensity	Numerical rating scale
Pain-related interference on daily functioning	Interference items of the Brief Pain Inventory (PBI)
Impact of pain on sleep	Chronic Pain Sleep Inventory
Pain coping	Pain Catastrophizing Scale
Depression	Beck Depression Inventory- Version 1
Anger	Numerical rating scale
Health-related quality of life	SF-12-V2
Patient's global impression of change re: 1) pain, 2) functioning level, 3) quality of life	Rating scale
Patient's perceived amount of pain relief	Pain relief numerical scale
Patient's satisfaction with treatment at the Pain Clinic	Rating scale
Consumption habits re: cigarettes, alcohol, illicit drugs	Questions drawn from the Enquete sociale et de santé- Institut de la statistique du Québec
Demographics • Current living conditions • Civil status • Current work status • Family income • Source of income • Disability benefits • Litigation	

Appendix 2

A2.1 Variables and Measurement Tools Included in the Québec Pain Registry. Nurse Questionnaire (initial visit)

Variable
Date of referral to the Pain Clinic
Type of specialist who referred the patient + name and city
Name and city of the patient's family physician
Reason of consultation, referral diagnosis, and exams performed
Treating doctor's name at the Pain Clinic
Duration of the patient's pain (n of months/year)
Circumstances surrounding the onset of the pain (accident, surgery, illness, etc)
Patient's current status at the Pain Clinic
Frequency of visits in the past week/month
Pain quality: neuropathic component using the DN4 Questionnaire.
Current and past treatments in the last six or 12 months for pain excluding medication, anesthetic blocks, surgery, psychological techniques, physical therapies and their helpfulness
Current medication for pain (type, dose, and frequency) including natural products and their helpfulness
Side effects with current treatment and the severity of the side effects
Current medication for reasons other than pain including natural products
Allergies and intolerances to medications
Pain medication used in the past 6 or 12 months but stopped and the reason for stopping
Type of health care professionals consulted in the past 6 or 12 months inside the Pain Clinic or hospital and the number of visits
Change in medical condition in the past 6 or 12 months other than pain
Number of visits to the emergency department as a result of pain in the past 6 months
Number of pain-related hospitalizations, including the number of days spent in the hospital in the past 6 months
Past and current medical history
Need of mobility support inside and outside of home
Family history of chronic pain (father, mother, brothers/sisters + type of pain)
Pain diagnosis made at the Pain Clinic

A2.2 Variables and Measurement Tools Included in the Québec Pain Registry. Nurse Questionnaire (follow up visit)

Variable
Patient's status at the Pain Clinic- Continues to be treated (yes – no), if not, to whom was he referred
Frequency (N of days in the past week/month)
Pain quality: neuropathic component
Current and past treatments (last 6 or 12 months) for pain excluding medication (anesthetic blocks), surgery, psychological techniques, physical therapies, other types
Current medication for pain (type, dose, frequency) including natural products
Side effects with current treatment: type and severity
Current medication (type) for reason other than pain including natural products
Allergies and intolerances for medications
Pain medication used in the past 6 (or 12) months but stopped + reason for stopping
Type of health care professionals consulted in the past 6 (or 12) health months at the Pain Clinic or inside the hospital for pain problems
Change in medical condition in the past 6 (or 12) months
Number of visits to the emergency department because of pain in the past 6 months
Number of pain-related hospitalizations and number of days in the past 6 months
Need of mobility support inside and outside home, if yes, type and relation to pain
Pain diagnosis made at the Pain Clinic