

The Biopsychosocial Model of Low Back Pain and Patient-Centered Outcomes Following Lumbar Fusion

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Lumbar fusion is a surgical procedure performed to eliminate painful motion in a spinal segment by joining, or fusing, two or more vertebrae. Although the surgery has a high rate of producing radiographic fusion, many patients report pain, functional disability, an inability to return to work, and prolonged opioid pain reliever use following the procedure. Using the biopsychosocial model of low back pain as a framework, this review of the literature describes the biological, psychological, and social factors that have been associated with these negative outcomes. The findings suggest that at least some of the variability in post-operative outcomes may be due to preoperative patient characteristics, and evidence the theorized relationship between biopsychosocial factors and low back disability. The review also highlights a gap in the literature regarding biopsychosocial predictors of prolonged opioid use following lumbar fusion.

Lumbar fusion is a common surgical procedure performed to eliminate painful motion in a spinal segment by joining, or fusing, two or more vertebrae. Although the surgery has a high rate of producing radiographic fusion, many patients report negative outcomes following the procedure, including pain, functional disability, an inability to return to work, and prolonged opioid pain reliever use. These apparent discrepancies between technical success and patient-centered outcomes have raised questions about the efficacy and medical necessity of lumbar fusion, and have resulted in restrictive payer policies (Cheng et al., 2011; Phillips, Slosar, Youssef, Andersson, & Papatheofanis, 2013). However, researchers have identified associations between specific biopsychosocial factors and surgical outcomes, suggesting that at least some of the variability in outcomes is due to preoperative patient characteristics. Accordingly, it may be possible to identify patients at risk for negative outcomes prior to surgery. Using the biopsychosocial model of low back pain as a framework, this article presents a review of the literature to identify the biological, psychological, and social factors that have been associated with patient-centered outcomes following lumbar fusion.

Biopsychosocial Model of Low Back Pain

The biopsychosocial model of low back pain provides a useful framework to conceptualize how biological, psychological, and social factors can influence patient outcomes following lumbar fusion (see Figure 1). The model is based on a holistic philosophical view that illness is multidimensional and that how an individual experiences and interprets alterations in health must consider the influence of biological, psychological, and social variables (Engel, 1977). When the biopsychosocial model was introduced in the 1970s, it challenged the prevailing biomedical model of disease. The latter model reflects a reductionist philosophical view that disease is the consequence of aberrant biological processes, and that the diagnosis and treatment of disease need only consider these processes (Engel, 1977). Hence, clinicians and researchers espousing the biomedical model would focus an investigation of low back pain on lumbar spinal anomalies, biochemical defects, and neurophysiological abnormalities (i.e., biological factors), whereas individuals espousing the biopsychosocial model would explore a variety of factors, ranging from depression and anxiety (i.e., psychological factors) to educational level and employment status (i.e., social factors).

Although the biomedical model provides a sound pathophysiological basis for the study of disease, critics of the model have long noted its inability to explain variations in the human experience of illness (Engel, 1977; Waddell, 1987). For instance, all individuals with diabetes mellitus share similar endocrine dysfunction; however, their management of the illness varies, and reflects differences in dietary habits, exercise capacity,

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The authors and planners have disclosed no potential conflicts of interest, financial or otherwise.

DOI: 10.1097/NOR.0000000000000350

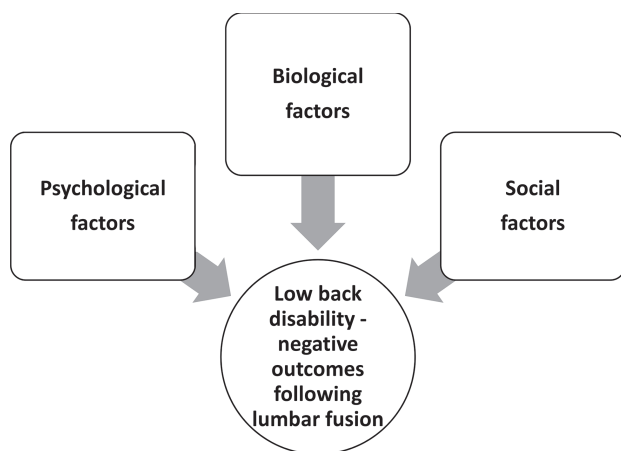


FIGURE 1. Biopsychosocial model of low back pain. Squares represent the three dimensions of the biopsychosocial model: biological, psychological, and social. The circle represents the convergence of these factors to produce low back disability, which, in this model, is conceptualized as negative outcomes following lumbar fusion.

readiness to adopt change, health literacy, etc. Likewise, as noted by renowned Scottish surgeon Gordon Waddell (1987), many individuals share similar findings on lumbar spine imaging studies; however, their clinical presentation may be strikingly different, with some individuals remaining asymptomatic, some reporting only mild pain, and others describing excruciating pain.

In proposing the biopsychosocial model for low back pain, Waddell (1987) noted that technological advances in the detection and treatment of lumbar spinal disorders during the latter half of the 20th century had not decreased the worldwide prevalence of low back disorders. Paradoxically, improved understanding of spinal disorders had been accompanied by a dramatic increase in the rate of low back disability, particularly in Western countries. This observation convinced Waddell (1987) that the biomedical model was an inadequate model for the study of low back disorders, and that a new, broader model was needed.

In describing how the biopsychosocial model should be applied to low back complaints, Waddell (1987) differentiated low back pain from low back disability. He described low back pain as a benign, self-limited disease that results from a physical abnormality, and produces signs and symptoms proportionate to the abnormality. In contrast, he described low back disability as an illness that results from the dynamic interplay of biological, psychological, and social factors, and is characterized by distress and illness behaviors disproportionate to any identifiable abnormality. Accordingly, when studying outcomes following lumbar fusion, low back disability can be conceptualized as negative surgical outcomes, such as pain and functional disability that persist despite successful wound healing and fusion consolidation. Such outcomes are not easily attributed to a single physical abnormality; rather, they reflect the convergence of an individual's perceptions, interpretations, and responses to pain.

In the 25 years since Waddell first advocated the use of the biopsychosocial model, it has become the dominant framework for the study of low back pain and disability (Pincus et al., 2013). Its use has also been endorsed by the National Institutes of Health Task Force on Research Standards for Chronic Low Back Pain (Deyo et al., 2014). In adopting this model, clinicians and researchers commit to exploring multifactorial contributors to low back disability, and to developing treatment strategies that are not solely aimed at correcting a biomedical defect or deviation, but also to address an individual's attitudes, beliefs, psychological distress, and illness behaviors (Waddell, 1987).

Spinal Fusion in the United States

Spinal fusion is a frequently performed surgical procedure in U.S. hospitals. During a recent 11-year period, the number of fusion procedures increased every year, from 287,600 procedures in 2001 to 488,300 procedures in 2011 (Weiss & Elixhauser, 2014). This 70% increase in spinal fusion positioned the procedure as the sixth most frequently performed surgical procedure in U.S. hospitals (Weiss, Elixhauser, & Andrews, 2014). Among all fusion procedures, fusion of the lumbar spine is the most commonly performed, and is the exclusive focus of this review. In comparison, fusion of the cervical spine is only slightly less common than lumbar fusion, whereas fusion of the thoracic spine is much less common and comprises fewer than 10% of all fusion procedures (Rajaei, Bae, Kanim, & Delamarter, 2012).

Lumbar fusion is indicated for patients with spinal instability resulting from disease, surgical intervention, or both (Halpern & Grady, 2014). In the United States, most patients undergoing lumbar fusion have a degenerative condition, such as degenerative disc disease, stenosis, or spondylolisthesis (Rajaei et al., 2012). However, lumbar fusion may also be appropriate for patients with traumatic injuries, flat-back syndrome, pseudoarthrosis, adjacent segment degeneration, recurrent disc herniation, spinal deformity, and infection or tumor involving the spine (International Society for the Advancement of Spine Surgery, 2011; North American Spine Society, 2014).

The goal of lumbar fusion is the elimination of painful, abnormal motion. This is frequently accomplished with internal fixation devices (i.e., pedicle and facet screws, rods, and cages) and graft material (i.e., autograph and allograph). The fixation devices stabilize and immobilize the affected spinal segment, and the graft material provides a bridge across the defect. Once these elements are in place, the patient's osteoblasts form new bone across the defect to lock the involved vertebral components together into a solid mass of new bone. This process, known as arthrodesis, must occur in all fused segments to yield long-term stability (Halpern & Grady, 2014). Thus, from a radiographic perspective, the achievement of arthrodesis is considered a successful fusion, whereas failure to achieve arthrodesis, known as pseudoarthrosis, is considered a failed fusion (Halpern & Grady, 2014).

Lumbar Fusion Outcomes

During the nearly 100 years since lumbar fusion was first described, a range of outcomes has been reported in the literature. Early reports of the surgery exclusively considered arthrodesis rates (Malkin, 1935, 1936). Mid-20th-century studies incorporated subjective outcomes, such as symptom relief and work capacity (Spadea & Hamlin, 1952; Tunturi et al., 1979). More recent studies have examined clinician-based outcomes, including complication rates (Bydon et al., 2014; Cheng et al., 2015; Goz, Weinreb, Schwab, Lafage, & Errico, 2014; Joseph, Smith, La Marca, & Park, 2015; Nguyen, Randolph, Talmage, Succop, & Travis, 2011; Peng, Yue, Poh, Yeo, & Tan, 2009; Rouben, Casnellie, & Ferguson, 2011; Talia, Wong, Lau, & Kaye, 2015), inpatient hospital length of stay (Goz et al., 2014; Peng et al., 2009; Rouben et al., 2011), and cost (Bydon et al., 2015; Goz et al., 2014). In addition, following a recommendation from the Institute of Medicine (IOM, 2001) for more patient-centered care, studies have also explored patient-based outcomes, including pain intensity (Abbott, Tyni-Lenne, & Hedlund, 2011; Adogwa et al., 2012; Mendenhall et al., 2014; Peng et al., 2009; Rao, Loganathan, Yeung, & Mobbs, 2015; Rouben et al., 2011; Soriano et al., 2010), functional disability (Abbott et al., 2011; Adogwa et al., 2012; Mendenhall et al., 2014; Nguyen et al., 2011; Peng et al., 2009; Rao et al., 2015; Rouben et al., 2011; Soriano et al., 2010), work status (Mendenhall et al., 2014; Nguyen et al., 2011; Rouben et al., 2011), and postoperative opioid use (Mendenhall et al., 2014; Nguyen et al., 2011; Rouben et al., 2011).

Biopsychosocial Factors and Patient-Centered Outcomes

The spine literature reflects early recognition that psychological and social factors could influence patient outcomes. Shaw and Taylor (1956) attributed a participant's failure to achieve symptomatic relief, despite successful arthrodesis, to a suspicion that the patient, "seems to be a hysteric and perhaps should not have been operated on" (Shaw & Taylor 1956, p. 493). Tunturi and Pattiala (1980) reported statistically significant associations between social factors (i.e., number of children and population of the place of residence) and return to work. However, because these researchers neither explained the clinical significance of their findings nor theorized how psychological and social factors influenced their outcomes, their studies did little to elucidate the role of biopsychosocial factors in predicting lumbar fusion outcomes and, instead, were met with criticism.

Farfan and Kirkaldy-Willis (1981) criticized lumbar fusion studies for failing to explain patient selection, surgical indication, and factors contributing to pseudoarthrosis, and remarked, "The literature on spinal fusion is totally inadequate...." (Farfan & Kirkaldy-Willis, 1981, p. 211). Turner et al. (1992) similarly criticized the literature, and noted the absence of studies examining psychosocial factors. In response to these critiques, modern researchers have adopted a more holistic approach to spine research, and have incorpo-

rated biopsychosocial variables into their studies. Many researchers have also expanded their studies to include more of the outcomes that are considered by patients to be of greatest importance. For example, Carragee and Cheng (2010) asked patients to specify the absolute worst level of pain intensity, functional disability, work capacity, and medication requirement that they would consider acceptable following lumbar fusion. Such attention to patient-centered outcomes reflects a growing appreciation of the need to align healthcare delivery with patients' preferences and needs. Accordingly, this review will present eight recent studies that examined the influence of biopsychosocial variables on patient-centered outcomes, focusing on pain intensity, functional disability, return to work, and prolonged opioid pain reliever use. The studies were identified through a search of the PubMed and CINAHL databases from 2011 to 2015 using the terms *spinal fusion*; *pain*; *functional disability*; *return to work*; and *analgesics, opioid*. Only the abstracts of articles written in English were reviewed, and only articles that described original research and met the following criteria were included: (a) enrolled adult patients undergoing lumbar fusion; (b) evaluated postoperative pain intensity, functional disability, return to work, and/or prolonged postoperative opioid use; and (c) had a postoperative follow-up period of at least 12 months. A manual check of reference lists identified three additional studies that met inclusion criteria and were included in the review despite having been published prior to 2011. A description of the instruments used to measure the four outcomes (see Table 1) and recommendations for further research is also presented.

PAIN INTENSITY

Most lumbar fusions are performed on patients with pain in the low back and lower extremities due to degenerative conditions that are unrelieved with nonoperative treatment (i.e., physical therapy and interventional pain management procedures). Thus, pain assessment is an essential component of pre- and postoperative care. Among the most commonly used measures of low back pain is the visual analogue scale (VAS). The VAS is a single-item instrument consisting of a 100-mm horizontal line, with the anchors "no pain" and "worst pain imaginable" on which respondents indicate their relative position (Chapman et al., 2011; Scrimshaw & Maher, 2001).

The reliability of the VAS has been adequately supported in studies examining chronic low back pain (Chapman et al., 2011) and other painful musculoskeletal conditions (Crossley, Bennell, Cowan, & Green, 2004). The validity of the VAS has been demonstrated by its strong correlation with the numeric rating scale—another one-dimensional measure of pain intensity (Breivik et al., 2008). In addition, when used with patients undergoing lumbar surgery, postoperative VAS scores have strongly correlated with postoperative patient satisfaction ratings (Zanoli, Stromqvist, & Jonsson, 2001). The VAS has also been shown to be more responsive to clinical change in pain intensity than both the verbal categorical rating scale (i.e., none, mild, moderate, and severe;

TABLE 1. SUMMARY OF STUDY DESIGNS AND INSTRUMENTS USED TO EXAMINE BIOPSYCHOSOCIAL FACTORS AND PATIENT-CENTERED OUTCOMES

Authors	Design and Follow-up (Months)	Pain Intensity	Functional Disability	Return to Work	Prolonged, Postoperative Opioid Use
Abbott et al., 2011	Prospective cohort (24–36)	VAS	ODI		
Adogwa et al., 2012	Retrospective cohort (24)	VAS	ODI		
Mendenhall et al., 2014	Prospective cohort (24)	VAS	ODI	Time to RTW	Time to narcotic independence
Nguyen et al., 2011	Historical cohort (24)		Permanent total disability status per workers compensation system (yes/no)	Return to employment 2 years after date of surgery as part-time, full-time worker with same or different employer (yes/no)	Average oral opioid dose converted to daily morphine equivalent units
Peng et al., 2009	Prospective cohort (24)	VAS	ODI		
Rao et al., 2015	Prospective cohort (mean 20)	VAS	ODI		
Rouben et al., 2011	Retrospective cohort (minimum 36)	VAS	ODI	RTW (yes/no)	Opioid use for spine-related pain (yes/no)
Soriano et al., 2010	Prospective cohort (12)	VAS	ODI		

Note. ODI = Oswestry Disability Index; RTW = return to work; VAS = visual analogue scale.

Breivik et al., 2008) and the McGill Pain Questionnaire (Scrimshaw & Maher, 2001). For these reasons, the VAS is considered the gold standard for measuring pain intensity in spine-related studies (Chapman et al., 2011; VanDenKerkhof, Peters, & Bruce, 2013).

Of the eight reviewed studies, seven studies compared preoperative pain intensity to postoperative pain intensity, and all reported significantly improved VAS scores following lumbar fusion (Abbott et al., 2011; Adogwa et al., 2012; Mendenhall et al., 2014; Peng et al., 2009; Rao et al., 2015; Rouben et al., 2011; Soriano et al., 2010). Reviewed studies also identified significant associations between a variety of biopsychosocial factors and postoperative pain intensity. Abbott et al. (2011) conducted a prospective cohort study of patients who underwent lumbar fusion for spinal stenosis, spondylolisthesis, or degenerative disc disease. They found that high levels of preoperative pain predicted higher levels of postoperative back pain intensity. They also found that high levels of preoperative leg pain—but not preoperative back pain—and a positive straight leg raise (i.e., pain in the sciatic distribution between 30° and 70° passive flexion of the straight leg) predicted lower levels of postoperative back pain. They attributed the latter finding to the likelihood that preoperative leg pain, as compared with back pain, was due to a structural defect that the surgery had corrected. Rao et al. (2015) also conducted a prospective cohort study and exclusively evaluated outcomes following anterior lumbar interbody fusion. They noted that although all patients experienced significant improvement in pain intensity following surgery, the magnitude of pain relief varied by surgical indication. Patients with degenerative disc disease, spondylolisthesis, and scoliosis reported greater

improvement in pain intensity than did patients with failed posterior fusion and adjacent segment disease. Soriano et al. (2010) also found that the magnitude of pain relief varied by surgical indication. In their prospective cohort study, they found that patients with disc herniation reported greater improvement in pain intensity than did patients with degenerative spinal stenosis or spondylolisthesis. Rao et al. (2015) and Rouben et al. (2011) further reported that magnitude of pain relief varied by payer status. Rao et al. (2015) reported that patients claiming workers' compensation benefits did not report statistical improvement in VAS scores. In contrast, Rouben et al. (2011) reported that all patients reported statistical improvement in VAS scores; nevertheless, the degree of improvement was less in patients receiving workers' compensation benefits compared with patients who did not receive workers' compensation benefits.

For several factors, no significant association with postoperative pain intensity was detected; these included age (Rouben et al., 2011; Soriano et al. 2010), sex (Soriano et al., 2010), body mass index (Rao et al., 2015; Rouben et al., 2011; Soriano et al., 2010), smoking (Rao et al., 2015; Rouben et al., 2011), and surgical technique (Peng et al., 2009).

FUNCTIONAL DISABILITY

The Oswestry Disability Index (ODI) is one of the most widely used measures of functional disability in patients with low back pain (Chapman et al., 2011). The instrument deliberately focuses on physical activities, rather than the psychological sequelae of acute or chronic pain (Fairbank & Pynsent, 2000). It includes 10 items, each

with 6 response options, presented in a self-report scaled response format. Options are ordered so that each statement describes a greater degree of difficulty in the task than the preceding statement. Responses are scored from 0 to 5, and then summed (Fairbank & Pynsent, 2000). The summed score is doubled, and expressed as a percentage, with scores ranging from 0 (no disability) to 100 (complete disability). Prior studies of patients with low back pain have yielded adequate evidence of the reliability, validity, and responsiveness of the ODI in this population (Chapman et al., 2011; Fairbank & Pynsent, 2000).

Of the six studies that compared preoperative level of functional disability with postoperative level of functional disability, all reported significantly improved ODI scores (Adogwa et al., 2012; Mendenhall et al., 2014; Peng et al., 2009; Rao et al., 2015; Rouben et al., 2011; Soriano et al., 2010). Reviewed studies also revealed associations between biopsychosocial factors and functional disability. Soriano et al. (2010) reported that lower postoperative functional disability was associated with higher educational level and optimistic preoperative expectations. Abbott et al. (2011) reported that lower postoperative functional disability was associated with higher self-perceived effectiveness of coping strategies to control pain. Lower postoperative functional disability was also associated with higher preoperative leg pain (Abbott et al., 2011). This finding paralleled the relationship observed between lower postoperative pain intensity and higher preoperative leg pain, and was similarly attributed to the likelihood that leg pain was due to a structural defect that was corrected during surgery. Conversely, greater postoperative functional disability was associated with higher levels of pain catastrophizing (Abbott et al., 2011).

Several studies examined the degree of change in preoperative and postoperative ODI scores. Less improvement in functional disability was associated with higher levels of depression (Adogwa et al., 2012) and higher preoperative back pain intensity (Soriano et al., 2010). Conversely, greater improvement in functional disability was predicted by better emotional health (Soriano et al., 2010).

In two reviewed studies, the magnitude of functional improvement varied by surgical indication. Soriano et al. (2010) reported that patients with disc herniation reported greater improvement in functional disability than did patients with other lumbar spine disorders. Rao et al. (2015) reported that patients with degenerative disc disease and spondylolisthesis reported greater improvement in functional disability than did patients with scoliosis, failed posterior fusion, and adjacent segment disease. Conversely, Rouben et al. (2011) did not detect statistically significant differences in functional improvement among patients with varied surgical indications.

For several factors, no significant association with functional disability was detected; these included age (Rouben et al., 2011; Soriano et al., 2010), sex (Soriano et al., 2010), body mass index (Rao et al., 2015; Rouben et al., 2011; Soriano et al., 2010), smoking (Rao et al., 2015; Rouben et al., 2011), surgical technique (Peng et al., 2009), and payer status (Rouben et al., 2011).

RETURN TO WORK

Unlike pain intensity and functional disability, there are no well-established instruments to measure return to

work. Therefore, researchers develop their own operational definitions and measurement tools, a situation that results in disparate reporting (Chapman et al., 2011). Such reporting is evidenced by the three reviewed studies that reported return-to-work outcomes following lumbar fusion. Nguyen et al. (2011) reported a 26% return-to-work rate and Rouben et al. (2011) reported a 97% return-to-work rate. Mendenhall et al. (2014) did not calculate a return-to-work rate, but instead reported that the median (interquartile range) time of missed work was 6 (4–10) months. Further examination of these data reveals important differences in sampling and data analysis. Although Nguyen et al. (2011) included their entire sample in calculating a return-to-work rate, Rouben et al. (2011) included only the subset of participants who were working “immediately before surgery” (Rouben et al., 2011, p. 292). Furthermore, although Mendenhall et al. (2014) included their entire sample in reporting time to return to work, their sample was exclusively composed of participants who were working prior to surgery. Thus, the outcomes reported by Rouben et al. (2011) and Mendenhall et al. (2014) may reflect the inclusion of only working patients who may have been healthier, possibly less symptomatic, and perhaps quicker to recuperate from surgery than nonworking patients. This lack of parity in enrollment and reporting makes it difficult to compare results across studies.

Differing inclusion criteria may also have influenced the results of the reviewed studies. Only 8% of the patients in the Rouben et al. (2011) study had compensable work-related injuries, whereas 100% of the patients in the Nguyen et al. (2011) study had such injuries. Thus, the low return-to-work rate reported by Nguyen et al. (2011) may reflect, at least in part, the influence of financial incentives related to workers’ compensation benefits. This possibility is supported by a closer examination of the Rouben et al. (2011) results. Although 97% of all working patients in the Rouben et al. (2011) study returned to work, only 57% of patients receiving workers’ compensation benefits returned to work. Furthermore, patients receiving workers’ compensation benefits had a longer delay in returning to work compared with the entire sample. The mean return-to-work time for workers’ compensation patients was 17 weeks, with a median time of 18 weeks, whereas the mean time for all workers was 11 weeks, with a median time of 8 weeks (Rouben et al., 2011). These results are consistent with other studies that have reported significant associations between workers’ compensation programs and poor physical and psychological function (Murgatroyd, Casey, Cameron, & Harris, 2015).

Only Nguyen et al. (2011) explored possible associations between biopsychosocial factors and return to work. They reported that surgical complications, reoperation, total number of days off work before surgery, legal representation, total daily morphine equivalent units (MEQ), and current smoking were negative predictors of return to work; whereas a higher average preinjury weekly wage was the only positive predictor of return to work. Age, body mass index, sex, education level, marital status, surgical indication, and surgical technique did not significantly predict return to work (Nguyen et al., 2011).

PROLONGED, POSTOPERATIVE OPIOID PAIN RELIEVER USE

Similar to return to work, the lack of widely accepted instruments to measure postoperative opioid pain reliever use has resulted in heterogeneous reporting. Nguyen et al. (2011) quantified opioid utilization by converting oral opioid dose to MEQ. They reported both average daily morphine dose and whether a patient was, or was not, using opioid pain relievers 90 days following lumbar fusion. However, the researchers noted that reported morphine dose was an underestimation of total opioid dose because only oral opioids—and not opioids administered via nasal spray or via transdermal and parental routes—were included in the calculation (Nguyen et al., 2011). In contrast, neither Rouben et al. (2011) nor Mendenhall et al. (2014) calculated opioid dose. Instead, Rouben et al. (2011) dichotomized the variable (i.e., using opioids/not using opioids) and Mendenhall et al. (2014) reported time to opioid independence. Among the reviewed studies, these were the only studies that reported opioid use rates. Nguyen et al. (2011) reported that 85% of patients undergoing lumbar fusion used opioids throughout the study (pre- and postlumbar fusion), and 76% continued to use opioids at 90 days postlumbar fusion. Rouben et al. (2011) reported that 100% of patients used opioids prior to surgery, and 31% continued to use opioids at 6 months postlumbar fusion. Mendenhall et al. (2014) did not calculate an opioid use rate, but reported that median (interquartile range) duration of postoperative opioid use was 6 (1.4–12.2) months.

Despite the routine prescribing of opioids following surgery (Dorian, 2014), none of the reviewed studies examined biopsychosocial factors associated with prolonged, postoperative opioid use.

Discussion

This review demonstrated how the biopsychosocial model can frame an investigation of lumbar fusion outcomes, and identified significant associations between biological, psychological, and social factors and pain intensity, functional disability, and return to work. These findings indicate that at least some of the variability in patient-centered outcomes can be explained by preoperative patient characteristics, and suggest that patients experiencing negative outcomes following lumbar fusion may benefit from psychological and social interventions.

Unfortunately, the review did not identify biopsychosocial predictors of opioid use. The lack of data regarding prolonged opioid use following lumbar fusion represents an important gap in the spine literature. Ninety percent of patients scheduled for lumbar fusion consider chronic opioid dependency to be an unacceptable surgical outcome (Carragee & Cheng, 2010). Moreover, the use of opioids to treat chronic, noncancer pain is not supported by high-quality evidence and may portend serious harm.

Between 1999 and 2010, opioid use in the United States increased 300%, with opioid prescribing for chronic, noncancer pain fueling much of the increase (Centers for Disease Control and Prevention, 2014; Von Korff, Kolodny, Deyo, & Chou, 2011). Although the

increase was intended to decrease suffering, the assumptions of safety upon which increased opioid prescribing was based have not been supported by experience. Instead, long-term opioid therapy is now linked to serious consequences, including pharmacological adverse effects, opioid use disorders, and drug poisoning deaths.

Pharmacological adverse effects of long-term opioid therapy include constipation, sedation, clouded mentation, pruritus, myoclonus, respiratory depression, falls leading to fracture, hypogonadism, sexual dysfunction, osteoporosis, immunosuppression, and physical dependence (Chou et al., 2009; Deyo, VonKorff, & Duhrkoop, 2015; Freynhagen, Geisslinger, & Schug, 2013; Labianca et al., 2012; Von Korff et al., 2011). Long-term therapy may also decrease the pain-relieving efficacy of opioid medication through drug tolerance and hyperalgesia—a paradoxical response to opioids that worsens pain sensitivity (Freynhagen et al., 2013; Labianca et al., 2012). Long-term opioid therapy is also associated with opioid use disorders and opioid overdose (Paulozzi, Zhang, Jones, & Mack, 2014). Consequently, as opioid prescribing for chronic, noncancer pain increased in recent years, there was a six-fold increase in admissions to substance abuse treatment programs (Paulozzi, Jones, Mack, & Rudd, 2011) and a tripling of opioid-related drug poisoning deaths (Rudd, Aleshire, Zibbell, & Gladden, 2016). In fact, one study identified opioid-related drug poisoning as the most common cause of death within 3 years of lumbar fusion (Juratli, Mirza, Fulton-Kehoe, Wickizer, & Franklin, 2009). Thus, given the potential sequelae of long-term opioid use, the identification of biopsychosocial predictors of prolonged opioid use following lumbar fusion should be a research priority.

The ability to identify which patients are at risk of prolonged, postoperative opioid use during the preoperative period would enable clinicians to target those patients with strategies designed to curtail opioid use as quickly as possible following surgery. This ability would have particular relevance for nurses and nurse practitioners given their roles in perioperative patient care. Nurses are responsible for patient education and the promotion of patient self-management. Thus, they could educate patients about opioid safety and promote nonpharmacological pain management strategies, such as progressive physical activity, relaxation therapy, imagery, and distraction (Strayer & Hickey, 2014). Nurse practitioners are among the most high-volume prescribers of all U.S. healthcare specialties (Centers for Medicare & Medicaid Services, 2015). Thus, they could incorporate nonopioid pain relievers into patients' medication regimens and emphasize functional improvement rather than pain relief when establishing therapy goals. Nurse practitioners could also identify patients receiving multiple opioid prescriptions by consulting prescription drug-monitoring databases and could monitor patients for signs of opioid use disorder (Chou et al., 2009; Deyo et al., 2015). Such interventions could curtail the use of opioid pain relievers, identify patients for whom psychotherapeutic intervention or opioid use disorder treatment may be warranted, and promote safer surgical recovery.

Conclusion

Biological, psychological, and social factors are associated with pain intensity, functional disability, and return to work following lumbar fusion. These relationships support the biopsychosocial model of low back pain that posits that low back disability is not solely determined by degree of anatomical defect, but rather results from the interaction of biological, psychological, and social factors. However, whether these same factors are associated with prolonged, postoperative opioid use remains unknown. Despite high rates of postoperative opioid use, there are scant data regarding biopsychosocial predictors of this important outcome. For this reason, additional research is warranted. Knowing which patients are at risk for prolonged opioid use following lumbar fusion would enable clinicians to intervene during the perioperative period to promote nonpharmacological pain relief measures and early discontinuation of opioid pain relievers. In addition, research examining associations between biopsychosocial factors and prolonged opioid use may yield additional support for the biopsychosocial model of low back pain by evidencing the theorized relationship between biological, psychological, and social factors and low back disability.

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March/April 2017 CE Tests: Erratum

In the March/April 2017 issue of *Orthopaedic Nursing*, the Categories of the three CE tests listed below were incorrectly listed as “B,” whereas they should have been listed as “A.”

The tests were for the following articles:

Smith, M.A., Walsh, C., Levin, B., Eten, K., & Yager, M. (2017). Orthopaedic snafus: when adverse events happen in orthopaedics. *Orthopaedic Nursing*, 36(2), 98–109.

Pagnotta, G., Rich, E., Echhardt, P., Lavin, P., & Burriesci, R. (2017). The effect of a rapid rehabilitation program on patients undergoing unilateral total knee arthroplasty. *Orthopaedic Nursing*, 36(2), 112–121.

Mori, C., Hageman, D., & Zimmerly, K. (2017). Nursing care of the patient undergoing an anterior approach to total hip arthroplasty. *Orthopaedic Nursing*, 36(2), 124–130.

Categories are correct as displayed on <http://nursing.ceconnection.com> for *Orthopaedic Nursing*, and the correct Category appears on the CE certificate of anyone who has passed a test from the journal.

The Publisher regrets these errors, which were mistakenly introduced during final processing and after the editor’s final review.

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- CE test: The effect of a rapid rehabilitation program on patients undergoing unilateral total knee arthroplasty. (2017). *Orthopaedic Nursing*, 36(2), 122–123.
- CE test: Nursing care of the patient undergoing an anterior approach to total hip arthroplasty. (2017). *Orthopaedic Nursing*, 36(2), 131–132.